Foreign Language Interface User Guide and Reference Manual

Version 6.0

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LispWorks Foreign Language Interface User Guide and Reference Manual

Version 6.0

December 2009

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Preface

This manual documents the Foreign Language Interface (FLI), which provides a toolkit for the development of interfaces between Common Lisp and other programming languages, and supersedes the Foreign Function Interface (FFI).

The manual is divided into three sections: a user guide to the FLI which includes illustrative examples indicating how to use the FLI for a variety of purposes, a reference section providing complete details of the functions, macros, variables and types that make up the FLI, and a guide to the Foreign Parser.

The user guide section starts by describing the ideas behind the FLI, followed by a few simple examples presenting some of the more commonly used features of the FLI. The next chapter explains the existing type system, and includes examples showing how to define new types. This is followed by a chapter explaining the FLI implementation of pointers. The final chapter of the section examines some of the more advanced topics within the FLI.

The reference section consists of a chapter documenting the functions and macros that constitute the FLI, and a chapter documenting the FLI variables and types.

The Foreign Parser section describes a helper tool for generating FLI definitions from a C header file.

1

Introduction to the FLI

The Foreign Language Interface (FLI) is an extension to LispWorks which allows you to call functions written in a foreign language from LispWorks, and to call Lisp functions from a foreign language. The FLI currently supports C (and therefore also the Win32 API for Windows users).

The main problem in interfacing different languages is that they usually have different type systems, which makes it difficult to pass data from one to the other. The FLI solves the problem of interfacing Lisp with C. It consists of FLI types that have obvious parallels to the C types and structures, and FLI functions that allow LispWorks to define new FLI types and set their values. The FLI also contains functions for passing FLI objects to C, and functions for receiving data from C.

1.1 An example of interfacing to a foreign function

The following example shows how to use the FLI to call a C function. The function to interface with, **`FahrenheitToCelsius`**, takes one integer as its argument (the temperature in Fahrenheit) and returns the result as a single float (the temperature in Celsius).

The example consists of three stages: defining a foreign language interface to the C function, loading the foreign code into the Lisp image, and calling the C function to obtain the results.

1.1.1 Defining the FLI function

The FLI provides the macro **define-foreign-function** for creating interfaces to foreign functions. It takes the name of the function you wish to interface to, the argument types the function accepts, and the result type the function returns.

Given the following C declaration to **FahrenheitToCelsius**:

```
float FahrenheitToCelsius( int );
```

The FLI interface is as follows:

```
(fli:define-foreign-function
    (fahrenheit-to-celsius "FahrenheitToCelsius" :source)
    ((fahrenheit :int))
  :result-type :float
  :language :ansi-c
  )
```

The first argument to **define-foreign-function** declares that **fahrenheit-to-celsius** is the name of the Lisp function that is generated to interface with the C function **FahrenheitToCelsius**. The **:source** keyword is a directive to the **define-foreign-function** name mangler that Fahrenheit-**ToCelsius** is the name of the C function as seen in the source files. On some platforms the actual symbol name available in the foreign object file we are inferfacing with could include character prefixes such as "." and "_", and so the **:source** keyword encoding allows you to write cross-platform portable foreign language interfaces.

The second argument to **define-foreign-function**, **((fahrenheit :int))**, is the argument list for the foreign function. In this case, only one argument is required. The first part of each argument descriptor is the lambda argument name. The rest of the argument describes the type of argument we are trying to interface to and how the conversion from Lisp to C is performed. In this case the foreign type **:int** specifies that we are interfacing between a Lisp integer and a C type "int".

The **:result-type** keyword tells us that the conversion required between the C function and Lisp uses the foreign type **:float**. This tells Lisp that C will return a result of type "float", which needs to be converted to a Lisp single-float.

The final keyword argument, **:language**, specifies which language the foreign function was written in. In this case the example uses ANSI C. This keyword determines how single-floating point values are passed to and returned from C functions as described for **define-foreign-function**.

1.1.2 Loading foreign code

Once an interface has been created, the object code defining those functions (and indeed any variables) must be made available to LispWorks.

LispWorks for Windows can load Windows Dynamic Link Libraries (**.DLL** files).

LispWorks for Linux and LispWorks for FreeBSD can load shared libraries (typically **.so** files).

LispWorks for Macintosh can load Mach-O dynamically-linked shared libraries (typically **.dylib** files).

LispWorks for UNIX can either load object files (usually suffixed with "**.o**") directly into the Lisp image, extract any required object files from the available archive libraries (usually suffixed with "**.a**"), or load in shared libraries (usually suffixed with "**.so**").

Throughout this manual we shall refer to these dynamic libraries as DLLs.

On all platforms the function **register-module** is the LispWorks interface to DLL files. It is used to specify which DLLs are looked up when searching for foreign symbols. Here are example forms to register a connection to a DLL.

On Windows:

```
(fli:register-module "MYDLL.DLL")
```

On Linux:

```
(fli:register-module "mylib.so")
```

On Macintosh:

```
(fli:register-module "mylib.dylib")
```

Note: LispWorks for UNIX 6.0 also provides the loader function **link-load:read-foreign-modules** familiar to users of LispWorks 4.3 and earlier. However, this is now deprecated in favor of **register-module**.

1.1.3 Calling foreign code

Calling the foreign code is the simplest part of using the FLI. The interface to the C function, defined using **define-foreign-function**, is called like any other Lisp function. In our example, the **fahrenheit-to-celsius** function takes the temperature in Fahrenheit as its only argument, and returns the temperature in Celsius.

1.2 Using the FLI to get the cursor position

Note: The rest of the examples in this chapter only work in LispWorks for Windows.

The following example shows how to use the FLI to call a C function in a Win32 library. The function we are going to call returns the screen position of the mouse pointer, or cursor. The example consists of three stages: setting up the correct data types to pass and receive the data, defining and calling a FLI function to call the Win32 function, and collecting the values returned by the Win32 function to find where the cursor is.

1.2.1 Defining FLI types

The example uses the FLI to find the position of the cursor using the Windows function **GetCursorPos**, which has the following C prototype:

```
BOOL GetCursorPos( LPPOINT )
```

The **LPPOINT** argument is a pointer to the **POINT** structure, which has the following C definition:

```
typedef struct tagPOINT {
    LONG x;
    LONG y;
} POINT;
```

First we use the **define-c-typedef** macro to define a number of basic types which are needed to pass data to and from the Windows function.

```
(fli:define-c-typedef bool (:boolean :int))

(fli:define-c-typedef long :long)
```

This defines two types, **BOOL** and **LONG**, which are used to associate a Lisp boolean value (**t** or **nil**) with a C boolean of type **int**, and a Lisp **bignum** with a C **long**. These are required because the Windows function **GetCursorPos** returns a boolean to indicate if it has executed successfully, and the cursor's *x* and *y* positions are specified in a **long** format in the **POINT** structure.

Next, we need to define a structure for the FLI which is used to get the coordinates of the cursor. These coordinates will consist of an *x* and a *y* position. We use the **define-c-typedef** macro for this, and the resulting Lisp FLI code has obvious parallels with the C **tagPOINT** structure.

```
(fli:define-c-struct tagpoint
  (x long)
  (y long))
```

The **tagPOINT** structure for the FLI, corresponding to the C structure of the same name, has been defined. This now needs to be further defined as a type for the FLI, using **define-c-typedef**.

```
(fli:define-c-typedef point (:struct tagpoint))
```

Finally, a pointer type to point to the structure is required. It is this FLI pointer which will be passed to the Windows function **GetCursorPos**, so that **GetCursorPos** can change the **x** and **y** values of the structure pointed to.

```
(fli:define-c-typedef lppoint (:pointer point))
```

All the required FLI types have now been defined. Although it may seem that there is a level of duplicity in the definitions of the structures, pointers and types in this section, this was necessary to match the data structures of the C functions to which the FLI will interface. We can now move on to the definition of FLI functions to perform the interfacing.

1.2.2 Defining a FLI function

This next step uses the **define-foreign-function** macro to define a FLI function, or interface function, to be used to call the **GetCursorPos** function. An interface function takes its arguments, converts them into a C format, calls the

foreign function, receives the return values, and converts them into a suitable Lisp format.

```
(fli:define-foreign-function (get-cursor-position "GetCursorPos")
  ((lp-point lppoint))
  :result-type bool)
```

In this example, the defined FLI function is **get-cursor-position**. It takes as its argument a pointer of type **lppoint**, converts this to a C format, and calls **GetCursorPos**. It takes the return value it receives from **GetCursorPos** and converts it into the FLI **bool** type we defined earlier.

We have now defined all the types and functions required to get the cursor position. The next step is to allocate memory for an instance of the **tagPOINT** structure using **allocate-foreign-object**. The following line of code binds **location** to a pointer that points to such an instance.

```
(setq location (fli:allocate-foreign-object :type 'point))
```

Finally, we can use our interface function **get-cursor-position** to get the cursor position:

```
(get-cursor-position location)
```

1.2.3 Accessing the results

The position of the cursor is now stored in a **POINT** structure in memory, and **location** is a pointer to that location. To find out what values are stored we use the **foreign-slot-value** accessor, which returns the value stored in the specified field of the structure.

```
(fli:foreign-slot-value location 'x)

(fli:foreign-slot-value location 'y)
```

1.3 Using the FLI to set the cursor position

A similar Windows function, **SetCursorPos**, can be used to set the cursor position. The **SetCursorPos** function takes two **LONG**s. The following code defines an interface function to call **SetCursorPos**.

```
(fli:define-foreign-function (set-cursor-position "SetCursorPos")
    ((x :long)
     (y :long))
  :result-type :boolean)
```

For example, the cursor position can now be set to be near the top left corner by simply using the following command:

```
(set-cursor-position 20 20)
```

For a more extravagant example, define and execute the following function:

```
(defun test-cursor ()
  (dotimes (x 10)
    (dotimes (d 300)
      (let ((r (/ (+ d (* 300 x)) 10.0)))
           (set-cursor-position
              (+ 300 (floor (* r (cos (/ (* d pi) 150.0)))))
              (+ 300 (floor (* r (sin (/ (* d pi) 150.0)))))
           )))))

(test-cursor)
```

1.4 An example of dynamic memory allocation

In the previous example our defined interface function **get-cursor-position** used the function **allocate-foreign-object** to allocate memory for an instance of a **POINT** structure. This memory is now reserved, with a pointer to its location bound to the variable **location**. More detailed information on pointers is available in Chapter 3, "FLI Pointers". To free the memory associated with the foreign object requires the use of the function **free-foreign-object**.

```
(fli:free-foreign-object location)
```

There are other methods for dealing with the question of memory management. The following example defines a Lisp function that returns the *x* and *y* coordinates of the cursor without permanently tying up memory for structures that are only used once.

```
(defun current-cursor-position ()
  (fli:with-dynamic-foreign-objects ()
    (let ((lppoint (fli:allocate-dynamic-foreign-object
                    :pointer-type 'lppoint)))
      (if (get-cursor-position lppoint)
        (values t (fli:foreign-slot-value lppoint 'x)
                  (fli:foreign-slot-value lppoint 'y))
        (values nil 0 0)))))
```

On calling **current-cursor-position** the following happens:

1. The macro **with-dynamic-foreign-objects** is called, which ensures that the lifetime of any allocated objects is within the scope of the code specified in its body.
2. The function **allocate-dynamic-foreign-object** is called to create an instance of the relevant data structure required to get the cursor position. Refer to it using the **lppoint** pointer.
3. The previously defined foreign function **get-cursor-position** is called with **lppoint**.
4. Provided the call to **GetCursorPos** was successful the function **foreign-slot-value** is called twice, once to return the value in the **x** slot and again to return the value in the **y** slot. If the call was unsuccessful then **0 0 nil** is returned.

1.5 Summary

In this chapter an introduction to some of the FLI functions and types was presented. Some examples demonstrating how to interface LispWorks with Windows and C functions were presented. The first example involved defining a foreign function using **define-foreign-function** to call a C function that converts between Fahrenheit and Celsius. The second involved setting up foreign types, using the FLI macros **define-c-typedef** and **define-c-struct**, and defining a foreign function using the FLI macro **define-foreign-function**, with which to obtain data from the Windows function **GetCursorPos**. The third example consisted of defining a foreign function to pass data to the Windows function **SetCursorPos**. A further example illustrated how to manage the allocation of memory for creating instances of foreign objects more carefully using the FLI macro **with-dynamic-foreign-objects**.

2

FLI Types

A central aspect of the FLI is implementation of foreign language types. FLI variables, function arguments and temporary objects have predictable properties and structures which are analogous to the properties and structures of the types found in C. The FLI can translate Lisp data objects into FLI data objects, which are then passed to the foreign language, such as C. Similarly, data can be passed from C or the Windows functions to the FLI, and then translated into a suitable Lisp form. The FLI types can therefore best be seen as an intermediate stage in the passing of data between Lisp and other languages.

Here are some of the features and sorts of foreign types:

- Consistency — Foreign types behave in a consistent and predictable manner. There is only one definition for any given foreign type.
- Parameterized types — these can be created using a **`deftype`**-like syntax. The macro **`define-foreign-type`** provides a simple mechanism for creating parameterized types.
- Encapsulated types — the ability to define a new foreign type as an extension to an existing type definition is provided. All types are converters between Lisp and the foreign language. New types can be defined to add an extra level of conversion around an existing type. The macro **`define-foreign-converter`** and the foreign type **`:wrapper`** provide this functionality.

- Generalized accessors — the FLI does not create named accessors. Instead, several generalized accessors use information stored within the foreign type object in order to destructure the foreign object. These accessors are **foreign-slot-value**, **foreign-aref** and **dereference**. This makes it possible to handle type definitions corresponding to C types defined using unnamed structures, as we do not rely on specialized accessors for the given type.
- Documentation for types — foreign type definitions can now include documentation strings.
- Specialized type constructors — to make the definition of the Lisp to C interfaces even easier several type constructor macros are provided to mimic the C type constructors **typedef**, **enum**, **struct**, and **union**. The new FLI constructors are **define-c-typedef**, **define-c-enum**, **define-c-struct** and **define-c-union**. Note that the equivalent foreign types for most standard C types are already available within the FLI.

There are two fundamental sorts of FLI types: *immediate* and *aggregate*. Immediate types, which correspond to the C fundamental types, are so called because they are basic data types such as integers, booleans and bytes which have a direct representation in the computer memory. Aggregate types, which correspond to the C derived types, consist of a combination of immediate types, and possibly of smaller aggregate types. Examples of aggregate types are arrays and structures. Any user-defined type is an aggregate type.

2.1 Immediate types

The immedate types are the basic types used by the FLI to convert between Lisp and a foreign language.

The immediate types of the FLI are **:boolean**, **:byte**, **:char**, **:const**, **:double**, **:enum**, **:float**, **:int**, **:lisp-double-float**, **:lisp-float**, **:lisp-single-float**, **:long**, **:pointer**, **:short**, **:signed** and **:unsigned**. For details on each immediate type, see the relevant reference entry.

2.1.1 Integral types

Integral types are the FLI types that represent integers. They consist of the following: **:int**, **:byte**, **:long**, **:short**, **:signed**, **:unsigned** and **:enum**, along

with integer types converting to types with particular sizes defined by ISO C99 such as **:int8**, **:uint64** and **:intmax**.

Integral types can be combined in a list for readability and compatibility purposes with the foreign language, although when translated to Lisp such combinations are usually returned as a Lisp **integer**, or a **fixnum** for byte sized combinations. For example, a C **unsigned long** can be represented in the FLI as an **(:unsigned :long)**.

2.1.2 Floating point types

The FLI provides several different immediate types for the representation of floating point numbers. They consist of the following: **:float**, **:double**, **:lisp-double-float**, **:lisp-float**, and **:lisp-single-float**. The floating types all associate equivalent Lisp and C types, except the **:lisp-float**, which can take a modifier to cause an associations between different floating types. A **:lisp-float** associates a Lisp **float** with a C **float** by default, but a declaration of **(:lisp-float :double)** corresponds to a C **double**, for example.

Note: be sure to use **:language :ansi-c** when passing float arguments to and from C using **define-foreign-function** and so on.

2.1.3 Character types

The FLI provides the **:char** type to interface a Lisp **character** with a C **char**.

2.1.4 Boolean types

The FLI provides the **:boolean** type to interface a Lisp boolean value (**t** or **nil**) with a C **int** (0 corresponding to **nil**, and any other value corresponding to **t)**. The **:boolean** type can be modified to make it correspond with other C types. For example, **(:boolean :byte**) would associate a Lisp boolean with a C **byte**, and **(:boolean :long)** would associate a Lisp boolean with a C **long**.

2.1.5 Pointer types

Pointers are discussed in detail in Chapter 3, "FLI Pointers". Further details can also be found in the reference entry for **:pointer**.

2.2 Aggregate types

Aggregate types are types such as arrays, strings and structures. The internal structure of an aggregate type is not transparent in the way that immediate types are. For example, two structures may have the same size of 8 bytes, but one might partition its bytes into two integers, whereas the other might be partitioned into a byte, an integer, and another byte. The FLI provides a number of functions to manipulate aggregate types. A feature of aggregate types is that they are usually accessed through the use of pointers, rather than directly.

2.2.1 Arrays

The FLI has two predefined array types: the **:c-array** type, which corresponds to C arrays, and the **:foreign-array** type. The two types are the same in all aspects but one: if you attempt to pass a **:c-array** by value through a foreign function, the starting address of the array is what is actually passed, whereas if you attempt to pass a **:foreign-array** in this manner, an error is raised.

For examples on the use of FLI arrays refer to **:c-array** and **:foreign-array** in Chapter 6.

2.2.2 Strings

The FLI provides two foreign types to interface Lisp and C strings, **:ef-wc-string** and **:ef-mb-string**.

The **:ef-mb-string** converts between a Lisp string and an external format C multi-byte string. A maximum number of bytes must be given as a limit for the string size.

The **:ef-wc-string** converts between a Lisp string and an external format C wide character string. A maximum number of characters must be given as a limit for the string size.

For more information on converting Lisp strings to foreign language strings see the string types **:ef-mb-string**, **:ef-wc-string**, and the string functions **convert-from-foreign-string**, **convert-to-foreign-string**, and **with-foreign-string**.

2.2.3 Structures and unions

The FLI provides the **:struct** and **:union** types to interface Lisp objects with the C **struct** and **union** types.

To define types to interface with C structures, the FLI macro **define-c-struct** is provided. In the next example it is used to define a FLI structure, **tagpoint**:

```
(fli:define-c-struct tagpoint
  (x :long)
  (y :long)
  (visible (:boolean :byte))
```

This structure would interface with the following C structure:

```
typedef struct tagPOINT {
    LONG x;
    LONG y;
    BYTE visible;
} POINT;
```

The various elements of a structure are known as *slots*, and can be accessed using the FLI foreign slot functions, **foreign-slot-names**, **foreign-slot-type**, and **foreign-slot-value**. For example, the next commands set **point** equal to an instance of **tagPOINT**, and set the Lisp variable **names** equal to a list of the names of the slots of **tagPOINT**.

```
(setq point (fli:allocate-foreign-object :type 'tagpoint))

(setq names (fli:foreign-slot-names point))
```

The next command finds the type of the first element in the List **names**, and sets the variable **name-type** equal to it.

```
(setq name-type (fli:foreign-slot-type point (car names)))
```

Finally, the following command sets **point-to** equal to a pointer to the first element of **point**, with the correct type.

```
(setq point-to (fli:foreign-slot-pointer point (car names)
                                         :type name-type))
```

The above example demonstrates some of the functions used to manipulate FLI structures. The FLI **:union** type is similar to the **:struct** type, in that the FLI slot functions can be used to access instances of a union. The convenience

FLI function **define-c-union** is also provided for the definition of specific union types.

2.3 Parameterized types

The **define-foreign-type** and **define-foreign-converter** macros allow the definition of parameterized types. For example, assume you want to create a foreign type that matches the Lisp type **unsigned-byte** when supplied with an argument of one of 8, 16, or 32. The following code achieves this:

```
(fli:define-foreign-type unsigned-byte (&optional (bitsize '*))
  (case bitsize
    (8 '(:unsigned :byte))
    (16 '(:unsigned :short))
    (32 '(:unsigned :int))
    (otherwise (error "Illegal foreign type (~s ~s)"
                      'unsigned-byte bitsize))))
```

This defines the new foreign type **unsigned-byte** that can be used anywhere within the FLI as one of

- **(unsigned-byte 8)**
- **(unsigned-byte 16)**
- **(unsigned-byte 32)**

Specifying anything else returns an error.

2.4 Encapsulated types

With earlier version of the foreign function interface it was not possible to create new foreign types that encapsulated the functionality of existing types. The only way in which types could be abstracted was to create “wrapper” functions that filtered the uses of a given type. The FLI contains the ability to encapsulate foreign types, along with the ability to create parameterized types. This enables you to easily create more advanced and powerful type definitions.

2.4.1 Passing Lisp objects to C

There are occasions when it is necessary to pass Lisp object references through to C and then back into Lisp again. An example of this is the need to specify Lisp arguments for a GUI action callback.

Using either the foreign type **:wrapper** or the macro **define-foreign-converter** a new foreign type can be created that wraps an extra level of conversion around the Lisp to C or C to Lisp process.

2.4.2 An example

For example, let us assume that we want to pass Lisp object handles through to C and then back to Lisp again. Passing C a pointer to the Lisp object is not sufficient, as the Lisp object might be moved at any time, for example due to garbage collection. Instead, we could assign each Lisp object to be passed to C a unique **int** handle. Callbacks into Lisp could then convert the handle back into the Lisp object. This example is implemented in two ways: using the **:wrapper** type and using **define-foreign-converter**.

:wrapper *Type*

Allows the specification of automatic conversion functions between Lisp and an instance of a FLI type.

:wrapper *fli-type* **&key** *lisp-to-foreign foreign-to-lisp*

Using **:wrapper** we can wrap Lisp to C and C to Lisp converters around the converters of an existing type:

```
(fli:define-foreign-type lisp-object-wrapper ()
  "A mechanism for passing a Lisp object handle to C.
   Underlying C type is Lint"
 `(:wrapper :int
   :lisp-to-foreign find-index-for-object
   :foreign-to-lisp find-object-from-index))
```

If the **:lisp-to-foreign** and **:foreign-to-lisp** keyword arguments are not specified, no extra conversion is applied to the underlying foreign type, causing it to behave like a standard **:int** type.

See the reference entry for **:wrapper** for more examples.

A second method uses **define-foreign-converter**, which is specifically designed for the creation of new converter types (that is, types which wrap extra levels of conversion around existing types). A simple use of **define-foreign-converter** is to only wrap extra levels of conversion around existing Lisp to foreign and foreign to Lisp converters.

```
(fli:define-foreign-converter lisp-object-wrapper () object
  :foreign-type :int
  :lisp-to-foreign `(find-index-for-object ,object)
;; object will be the Lisp Object
  :foreign-to-lisp `(find-object-from-index ,object)
;; object will be the :int object
  :documentation "Foreign type for converting from lisp objects to
integers handles to lisp objects which can then be manipulated in
C. Underlying foreign type : 'C' int")
```

The definition of **lisp-object-wrapper** using **define-foreign-converter** is very similar to the definition using **:wrapper**, and indeed the **:wrapper** type could be defined using **define-foreign-converter**.

See the reference entry for **define-foreign-converter** for more information.

2.5 The void type

The FLI provides the **:void** type for interfacing with the C **void** type. In accordance with ANSI C, it behaves like an **unsigned char**. In practice you will probably want to interface with a C **void *** , for which you should use the FLI construction **(:pointer :void)**.

2.6 Summary

In this chapter the various FLI data types have been examined. FLI types perform a translation on data passed between Lisp objects and C objects, and there are two main sorts of FLI types: immediate and aggregate. Immediate types have a simple representation in computer memory, and represent objects such as integers, floating point number and bytes. Aggregate types have a more complicated structure in memory, and consist of structures, arrays, strings, and unions. Parameterized and encapsulated types were also discussed. Finally, a number of FLI types that perform specific functions, such as the **:void** type and the **:wrapper** type, were examined.

3

FLI Pointers

Pointers are a central part of the C type system, and because Lisp does not provide them directly, one of the core features of the FLI is a special pointer type that is used to represent C pointers in Lisp. This chapter discusses how to use FLI pointers by examining some of the functions and macros which allow you to create and manipulate them.

A *FLI pointer* is a FLI object containing a memory address and a type specification. The implication is that the pointer points to an object of the type specified at the memory address, although a pointer can point to a memory location not containing an allocated FLI object, or an object that was allocated with a different type. Pointers can also point to other pointers, and even to functions.

3.1 Creating and copying pointers

This section discusses how to create a FLI pointer, how to copy it, and where the memory is actually allocated.

3.1.1 Creating pointers

Many FLI functions when called return a pointer to the object created. For example, a form such as

```
(fli:allocate-foreign-object :type :int)
```

will return something similar to the following:

```
#<Pointer to type :INT = #x007608A0>
```

This is a FLI pointer object, pointing to an object at address **#x007608A0** of type **:int**. Note that the memory address is printed in hexadecimal format, but when you use the FLI pointer functions and macros discussed in this chapter, numeric values are interpreted as base 10 unless you use Lisp reader syntax such as **#x**. .

To use the pointer in the future it needs to be bound to a Lisp variable. This can be done by using **setq**.

```
(setq point1 (fli:allocate-foreign-object :type :int)
```

A pointer can be explicitly created, rather than being returned during the allocation of memory for a FLI object, by using **make-pointer**. In the next example a pointer is made pointing to an **:int** type at the address **100**, and is bound to the Lisp variable **point2**.

```
(setq point2 (fli:make-pointer :address 100 :type :int))
```

For convenience you may wish to define your own pointer types, for example:

```
(fli:define-foreign-pointer my-pointer-type :int)

(setq point3
      (fli:make-pointer :address 100
                        :pointer-type 'my-pointer-type))
```

point3 contains the same type and address information as **point2**.

3.1.2 Copying pointers

Suppose the Lisp variable **point3** is bound to a FLI pointer as in "Creating pointers" on page 19. To make a copy of the pointer it is not sufficient to do the following:

```
(setq point4 point3)
```

This simply sets **point4** to contain the same pointer object as **point3**. Thus if the pointer is changed using **point3**, a similar change is observed when looking in **point4**. To create a distinct copy of the pointer object you should use

copy-pointer, which returns a new pointer object with the same address and type as the old one, as the following example shows.

```
(setq point5 (fli:copy-pointer point3))
```

3.1.3 Allocation of FLI memory

Foreign objects do take up memory. If a foreign object is no longer needed, it should be deallocated using **free-foreign-object**. This should be done only once for each foreign object, regardless of the number of pointer objects that contain its address. After freeing a foreign object, any pointers or copies of pointers containing its address will give unpredicable results if the memory is accessed.

FLI memory is allocated using **malloc()** so it comes from the C heap.

The FLI pointer object itself is a Lisp object, but the memory it points to does not show up in the output of **room**. Therefore you must use Operating System tools to see the virtual address size of the program.

3.2 Pointer testing functions

A number of functions are provided for testing various properties of pointers. The most basic, **pointerp**, tests whether an object is a pointer. In the following examples the first expression returns **nil**, because 7 is a number, and not a pointer. The second returns **t** because **point4** is a pointer.

```
(fli:pointerp 7)

(fli:pointerp point4)
```

The address pointed to by a pointer is obtained using **pointer-address**. For example, the following expression returns the address pointed to by **point4**, which was defined to be **100**.

```
(fli:pointer-address point4)
```

Pointers which point to address **0** are known as *null pointers*. Passing the Lisp object **nil** instead of a pointer results in **nil** being treated as a null pointer. The function **null-pointer-p** tests whether a pointer is a null pointer or not. If the pointer is a null pointer the value **t** is returned. We know that **point4**

points to address **100** and is therefore not a null pointer. As a result, the following expression returns **nil**.

```
(fli:null-pointer-p point4)
```

Another testing function is **pointer-eq** which returns **t** if two pointers point to the same address, and **nil** if they do not. In the previous section we created **point3** by making a copy of **point1**, and so both point to the same address. Therefore the following expression returns **t**.

```
(fli:pointer-eq point1 point3)
```

Two functions are provided to return information about the object pointed to by a pointer, **pointer-element-type** and **pointer-element-size**. In practice, it is the pointer which holds the information as to the type of the object at a given memory location—the memory location itself only contains data in the form of bytes. Recall that **point1** was defined in the previous section as a pointer to an **:int**. As a result the following two lines of code return **4** (the size of an **:int**) and **:int**.

```
(fli:pointer-element-size point1)

(fli:pointer-element-type point1)
```

The question of pointer types is discussed further in the next section.

3.3 Pointer dereferencing and coercing

The **dereference** function returns the value stored at the location held by a pointer, provided the type of the object is an immediate type and not a structure or an aggregate type. For now, you can consider immediate data types to be the simple types such as **:int**, **:byte**, and **:char**, and aggregate types to consist of structures defined using **:struct**. Full details about types are given in Chapter 2, "FLI Types", and the use of the **dereference** function with aggregate types is discussed further in Chapter 4, "Advanced Uses of the FLI".

The **dereference** function supports the **setf** function which can therefore be used to set values at the address pointed to by the pointer. In the following example an integer is allocated and a pointer to the integer is returned. Then

dereference and **setf** are used to set the value of the integer to **12**. Finally, the value of the integer is returned using **fli:dereference**.

```
(setq point5 (fli:allocate-foreign object :type :int))

(setf (fli:dereference point5) 12)

(fli:dereference point5)
```

The function **dereference** has an optional **:type** keyword which can be used to return the value pointed to by a pointer as a different type. This is known as coercing a pointer. The default value for **:type** is the type the pointer is specified as pointing to. In the next example the value at **point5** is returned as a Lisp boolean even thought it was set as an **:int**. Because the value at **point5** is not 0, it is returned as **t**.

```
(fli:dereference point5 :type '(:boolean :int))
```

Recall that at the end of the previous section the function **pointer-element-type** was demonstrated. What follows is an example which uses this function to clarify the issue of pointers and types.

The first action consists of allocating an integer, and setting up a pointer to this integer:

```
(setq pointer-a (fli:allocate-foreign-object :type :int))
```

Now we use **fli:copy-pointer** to make a copy of **pointer-a**, but with the type of the new pointer changed to be a **:byte**. We call this pointer **pointer-b**.

```
(setq pointer-b (fli:copy-pointer pointer-a :type :byte))
```

We now have two pointers which point to the same memory location, but one thinks it is pointing to an **:int**, and the other thinks it is pointing to a **:byte**. Test this by using the following two commands:

```
(fli:pointer-element-type pointer-a)

(fli:pointer-element-type pointer-b)
```

Similar commands using **pointer-element-size** show that **pointer-a** is pointing to an element of size 4, and **pointer-b** to an element of size 1.

So far we have seen the use of the **:type** keyword to specify how to set up or dereference a pointer to obtain values in the format we want. There is, how-

ever, a further level of abstraction in pointer typing which uses the **:pointer-type** keyword instead of the **:type** keyword.

The following two commands produce identical pointers, but one uses the **:type** keyword, and the other uses the **:pointer-type** keyword:

```
(fli:make-pointer :address 0 :type :int)

(fli:make-pointer :address 0 :pointer-type '(:pointer :int))
```

In the instance above there is no advantage in using the **:pointer-type** option. However, **:pointer-type** can be very useful when used in combination with a defined type, as the next example shows.

Imagine you are writing a program with many statements creating pointers to a certain type, for example **:byte**, and this is done using the **:type** keyword. If half way through coding the type to be pointed to was changed to a **:char**, every individual statement would need to be changed. However, if a general pointer type had been defined at the start and all the statements had used the **:pointer-type** keyword to refer to that particular type, only one statement would need to be changed: the initial definition of the pointer type. The following code illustrates this:

```
(fli:define-c-typedef my-pointer-type (:pointer :byte))

(fli:make-pointer :address 0 :pointer-type 'my-pointer-type)
...
(fli:make-pointer :address 100 :pointer-type 'my-pointer-type)
```

The above code consists of a definition of a new pointer type, called **my-pointer-type**, which points to a **:byte**. Following it are one hundred lines of code using **my-pointer-type**. If you decide that all the pointers made should actually point to a **:char**, only the first line needs to be changed, as shown below:

```
(fli:define-c-typedef my-point-type (:pointer :char))
```

The program can now be re-compiled. The use of **:pointer-type** with pointers is thus analogous to the use of constants instead of absolute numbers in programming.

3.4 An example of dynamic pointer allocation

When a pointer is created, using **make-pointer**, or due to the allocation of a foreign object, memory is put aside to store the details of the pointer. However, if a pointer is only needed within the scope of a particular section of code, there is a FLI macro, **with-coerced-pointer**, which can be used to create a temporary pointer which is automatically deallocated at the end of the code. The next example illustrates the use of this macro.

To start with, we need an object to use the temporary pointer on. The following code allocates ten consecutive integers, and sets their initial values.

```
(setf array-obj
      (fli:allocate-foreign-object :type :int
                  :nelems 10
                  :initial-contents
                  '(0 1 2 3 4 5 6 7 8 9)))
```

When the ten integers are created, **allocate-foreign-object** returns a pointer to the first one. The next piece of code uses **with-coerced-pointer** to create a copy of the pointer, which is then used to print out the contents of the ten integers. At the end of the printing, the temporary pointer is automatically deallocated.

```
(fli:with-coerced-pointer (temp) array-obj
  (dotimes (x 10)
    (print (fli:dereference temp))
    (fli:incf-pointer temp)))
```

The above example also illustrates the use of the **incf-pointer**, which increases the address stored in a pointer by the size of the object pointed to. There is a similar function called **decf-pointer**, which decreases the address held by a pointer in a similar fashion.

3.5 More examples of allocation and pointer allocation

The functions **allocate-dynamic-foreign-object**, **allocate-foreign-object**, **alloca**, and **malloc** can take the keyword arguments **:type** and **:pointer-type**. It is important to understand the difference between these two arguments.

The **:type** argument is used to specify the name of the FLI type to allocate. Once such an object has been allocated a foreign pointer of type **(:pointer** *type***)** is returned, which points to the allocated type. Without this pointer it would not be possible to refer to the object.

The **:pointer-type** argument is used to specify a FLI pointer type. If it is used then the value *pointer-type* should be of the form **(:pointer** *type*) or be defined as a FLI pointer type. The function then allocates an object of type *type*, and a pointer to the object of type *type* is returned.

In this first example you can see how to allocate an integer in C, and in LispWorks using the **:type** and the **:pointer-type** arguments.

```
C   > (int *)malloc(sizeof(int))

FLI > (fli:allocate-foreign-object :type :int)
      => #<Pointer to type :INT = #x007E1A60>

FLI > (fli:allocate-foreign-object
                  :pointer-type '(:pointer :int))
      => #<Pointer to type :INT = #x007E1A60>
```

3.6 Summary

In this chapter the use of FLI pointers was examined. A number of FLI functions useful for copying, creating and testing the properties of a pointer were presented. The use of the **dereference** function for obtaining the value pointed to by a pointer was examined, as was the coercing of a pointer—namely dereferencing a pointer to an object in a manner which returns the value found there as a different type. Finally, an example of the use of the **with-coerced-pointer** macro was given to illustrate the use of temporary pointers for efficient memory management.

In the next chapter some advanced topics of the FLI are examined in greater detail.

4

Advanced Uses of the FLI

Note: The some of the examples in this chapter only work for LispWorks for the Windows.

This is the final chapter of the user guide section of this manual. It provides a selection of examples which demonstrate some of the more advanced uses of the FLI.

4.1 Passing a string to a Windows function

The following example shows how to define a Lisp function which calls a Win32 API function to change the title of the active window. It demonstrates the use of **`define-foreign-function`** and **`with-foreign-string`** to pass a Lisp string to a Windows function.

The first step involves defining a FLI type to correspond to the Windows **`hwnd`** type, which is the window handle type.

```
(fli:define-c-typedef fli-hwnd
  (:unsigned :long))
```

The next step consists of the foreign function definitions. The first foreign function returns the window handle of the active window, by calling the Windows function **`GetActiveWindow`**. It takes no arguments.

```
(fli:define-foreign-function (get-act-window "GetActiveWindow")
    ()
  :result-type fli-hwnd
  :documentation "Returns the window handle of the active window
for the current thread. If no active window is associated with the
current thread then it returns 0.")
```

The next foreign function uses the Windows function **SetWindowText** to set the text of the active window titlebar. It takes a window handle and a pointer to a FLI string as its arguments.

```
(fli:define-foreign-function (set-win-text "SetWindowText" :dbcs)
    ((hwnd fli-hwnd)
     (lpstring :pointer))
  :result-type :boolean
  :documentation "Sets the text of the window titlebar.")
```

The foreign function **set-win-text** returns a boolean to indicate whether it has successfully changed the title bar.

The required FLI data types and foreign functions have been defined. What is now required is a Lisp function which uses them to change the titlebar of the active window. The next function does this:

```
(defun set-active-window-text (new-text)
  (let ((active-window (get-act-window))
        (external-format (if (string= (software-type)
                                      "Windows NT")
                             :unicode
                           :ascii)))
    (unless (zerop active-window)
      (fli:with-foreign-string (new-ptr element-count byte-count
                                :external-format external-format)
                               new-text
        (declare (ignore element-count byte-count))
        (set-win-text active-window new-ptr)))))
```

The function **set-active-window-text** takes a Lisp string as its argument, and does the following:

1. It calls the foreign function **get-act-window** to set the variable **active-window** to be the handle of the active window. If no window is active, this will be zero.

2. The variable **external-format** is set to be **:unicode** if the operating system is Windows NT (which expects strings to be passed to it in unicode format), otherwise it is set to be **:ascii**.
3. If **active-window** is zero, then there is no active window, and the function terminates, returning **nil**.
4. If **active-window** is not zero, then it contains a window handle, and the following happens:

   The function uses **with-foreign-string** to convert the Lisp string argument of the function into a FLI string, and a pointer to the FLI string is allocated, ready to be handed to the foreign function **set-win-text** that we defined earlier. The encoding of the string is **external-format**, which is the encoding suitable for the operating system running on the computer. Once the window title has been set, **with-foreign-string** automatically deallocates the memory that was allocated for the FLI string and the pointer. The function then terminates, returning **t**.

You can test that this is what happens by entering the command:

```
(set-active-window-text "A new title for the active window")
```

See **with-foreign-string**, page 152, for more details on the use of foreign strings.

4.2 Modifying, passing and returning strings

4.2.1 Use of Reference Arguments

LISP and C cannot in general share memory so the FLI needs to make a temporary foreign object from the Lisp String, pass that to C, and then convert the data in that foreign object back to a Lisp object when C returns.

4.2.2 Modifying a string in a C function

Here is the C code for the example. On return, the argument string has been modified (the code assumes there is enough space after the string for the extra characters).

Windows version:

```
#include <stdio.h>
#include <string.h>

__declspec(dllexport) void __cdecl modify(char *string) {
  char temp[256];
  sprintf(temp, "'%s' modified in a C function", string);
  strcpy(string, temp);
}
```

Linux/Unix/Macintosh version:

```
#include <stdio.h>
#include <string.h>

void modify(char *string) {
  char temp[256];
  sprintf(temp, "'%s' modified in a C function", string);
  strcpy(string, temp);
}
```

Here are three approaches to calling **modify** from Lisp:

1. Use a fixed size buffer in **define-foreign-function**. This uses the **:reference** type, which automatically allocates a temporary foreign object, fills it with data converted from the Lisp object, passes a pointer to C and converts the data in the foreign object back into a new Lisp object on return. Note that the Lisp object passed to the function is not modified. This is the neatest way, provided you can bound the size of the result string at compile-time.

```
(fli:define-foreign-function (dff-modify "modify" :source)
    ((string (:reference (:ef-mb-string :limit 256))))
  :calling-convention :cdecl)

(dff-modify "Lisp String")
=>
"'Lisp String' modified in a C function"
```

2. Use a fixed size buffer from **with-dynamic-foreign-objects**. In this case, we do most of the conversion explicitly and define the foreign function as taking a **:pointer** argument. This is a good approach if you don't know the maximum length when the function is defined, but will know it at compile-time for each call to the function.

```
(fli:define-foreign-function (wdfo-modify "modify" :source)
    ((string :pointer))
  :calling-convention :cdecl)
```

```
(fli:with-dynamic-foreign-objects
    ((c-string (:ef-mb-string :limit 256)
               :initial-element "Lisp String"))
  (wdfo-modify c-string)
  (fli:convert-from-foreign-string c-string))
=>
"'Lisp String' modified in a C function"
```

3. With a variable size buffer from **allocate-dynamic-foreign-object**. In this case, we do all of the conversion explicitly because we need to make an array of the right size, which is only known after the foreign string has been created (the extra 100 bytes are to allow for what the C function inserts into the string). Note that, in order to support arbitrary external formats, the code makes no assumptions about the length of the temporary array being the same as the length of the Lisp string: it does the conversion first using **with-foreign-string**, which works out the required number of bytes. The use of **with-dynamic-foreign-objects** provides a dynamic scope for call to **allocate-dynamic-foreign-object** - on exit, the foreign object will be freed automatically.

```
(fli:with-foreign-string (temp element-count byte-count)
    "Lisp String"
  (fli:with-dynamic-foreign-objects ()
    (let ((c-string (fli:allocate-dynamic-foreign-object
                     :type '(:unsigned :byte)
                     :nelems (+ byte-count 100))))
      (fli:replace-foreign-object c-string temp :nelems byte-
count)
      (wdfo-modify c-string)
      (fli:convert-from-foreign-string c-string))))
```

4.2.3 Passing a constant string

Use of the **:reference-pass** type in this example converts the Lisp string to a foreign string on calling, but does not convert the string back again on return.

Here is the C code for the example. It uses the argument string but returns an integer.

Windows version:

```
#include <string.h>
#include <ctype.h>

__declspec(dllexport) int __cdecl count_upper(const char *string)
{
  int count;
  int len;
  int ii;
  count = 0;
  len = strlen(string);
  for (ii = 0; ii < len ; ii++)
      if (isupper(string[ii]))
         count++;
  return count;
}
```

Linux/Unix/Macintosh version:

```
#include <string.h>
#include <ctype.h>

int count_upper(const char *string)
{
  int count;
  int len;
  int ii;
  count = 0;
  len = strlen(string);
  for (ii = 0; ii < len ; ii++)
      if (isupper(string[ii]))
         count++;
  return count;
}
```

Here is the foreign function definition using **:reference-pass**:

```
(fli:define-foreign-function (count-upper "count_upper" :source)
                             ((string (:reference-pass :ef-mb-
string)))
                             :result-type :int
                             :language :c
                             :calling-convention :cdecl)

(count-upper "ABCdef")
=>
3
```

4.2.4 Returning a string via a buffer

In this example no Lisp string is needed when calling. The **:reference-return** type converts a foreign string of lowercase ASCII characters to a Lisp string on return. Here is the C code for the example.

Windows version:

```
#include <string.h>
#include <stdlib.h>

__declspec(dllexport) void __cdecl random_string(int length, char
*string)
{
  int ii;
  for (ii = 0; ii < length ; ii++)
      string[ii] = 97 + rand() % 26;
  string[length] = 0;
}
```

Linux/Unix/Macintosh version:

```
#include <string.h>
#include <stdlib.h>

void random_string(int length, char *string)
{
  int ii;
  for (ii = 0; ii < length ; ii++)
      string[ii] = 97 + rand() % 26;
  string[length] = 0;
}
```

In this foreign function definition the **:reference-return** type must specify a size, since memory is allocated for it before calling the C function. Note also the use of **:lambda-list** so that the caller doesn't have to pass a dummy argument for the return-string, and **:result-type nil** correponding to the void declaration of the C function.

```
(fli:define-foreign-function (random-string
                              "random_string"
                              :source)
   ((length :int)
    (return-string (:reference-return
                    (:ef-mb-string
                     :limit 256))))
 :result-type nil
 :lambda-list (length &aux return-string)
 :calling-convention :cdecl)

(random-string 3)
=>
"uxw"

(random-string 6)
=>
"fnfozv"
```

4.2.5 Calling a C function that takes an array of strings

Suppose you have a C function declared like this:

```
extern "C" void foo( const char** StringArray);
```

To call this from Lisp you need to first allocate the foreign memory for each piece of data, that is the array itself and each string. Assuming that **foo** does not capture any of the pointers, you can give this memory dynamic extent as follows:

```
(defun convert-to-dynamic-foreign-array (strings)
  (let* ((count (length strings))
         (array
          (fli:allocate-foreign-object
           :nelems (1+ count) ; assume NULL terminated
           :type '(:pointer :char))))
    (dotimes (index count)
      (setf (fli:dereference array :index index)
            (fli:convert-to-dynamic-foreign-string
             (elt strings index))))
    (setf (fli:dereference array :index count) nil)
    array))

(fli:define-foreign-function (%foo foo)
    ((string-array (:pointer (:pointer :char)))))
(defun foo (strings)

  (fli:with-dynamic-foreign-objects ()  ; provide a dynamic scope
    (%foo (convert-to-dynamic-foreign-array strings))))
```

4.2.6 Foreign string encodings

The **:ef-mb-string** type is capable of converting between the internal encoding of LispWorks strings (Unicode) and various encodings that may be expected by the foreign code. The encoding on the foreign side is specified by the **:external-format** argument, which takes an External Format specification.. See the *LispWorks User Guide and Reference Manual* for a more detailed description of external formats.

Conside a variant of the last example where the returned string contains characters beyond the ASCII range.

Windows version:

```
#include <string.h>
#include <stdlib.h>

__declspec(dllexport) void __cdecl random_string2(int length,
char *string)
{
  int ii;
  for (ii = 0; ii < length ; ii++)
      string[ii] = 225 + rand() % 26;
  string[length] = 0;
}
```

Linux/Unix/Macintosh version:

```
#include <string.h>
#include <stdlib.h>

void random_string2(int length, char *string)
{
  int ii;
  for (ii = 0; ii < length ; ii++)
      string[ii] = 225 + rand() % 26;
  string[length] = 0;

}
```

A foreign function defined like **random-string** above is inadequate by itself here because the default external format is that for the default C locale, ASCII. This will signal error when it encounters a non-ASCII character code. There are two approaches to handling non-ASCII characters.

1. Pass an appropriate external format, in this case it is Latin-1:

```
(fli:define-foreign-function (random-string2
                              "random_string2"
                              :source)
   ((length :int)
    (return-string (:reference-return
                    (:ef-mb-string
                     :limit 256
                     :external-format :latin-1))))
 :result-type nil
 :lambda-list (length &aux return-string)
 :calling-convention :cdecl)

(random-string2 3)
=>
"òãö"

(random-string2 6)
=>
"óãøççâ"
```

2. Set the locale, using **set-locale**. This sets the C locale and switches the FLI to use an appropriate default wherever an external-format argument is accepted.

```
(fli:define-foreign-function (random-string
                              "random_string2"
                              :source)
   ((length :int)
    (return-string (:reference-return
                    (:ef-mb-string
                     :limit 256))))
 :result-type nil
 :lambda-list (length &aux return-string)
 :calling-convention :cdecl)
```

On a Windows system with current Code Page for Western European languages:

```
(fli:set-locale)
=>
(win32:code-page :id 1252)
```

On a Unix/Linux system with a Latin-1/ISO8859-1 default locale:

```
(fli:set-locale)
=>
:latin-1
```

After the default external-format has been switched:

```
(random-string 6)
=>
"ðèñçèõ"
```

If you do not actually wish to set the C locale, you can call **`set-locale-encodings`** which merely switches the FLI to use the specified external formats where an external-format argument is accepted.

4.2.7 Foreign string line terminators

You can specify the line terminator in foreign string conversions via the **`:eol-style`** parameter in the *external-format* argument.

By default foreign strings are assumed to have lines terminated according to platform conventions: Linefeed on Unix/Linux/MacOS, and Carriage-Return followed by Linefeed on Windows. That is, *eol-style* defaults to **`:lf`** and **`:crlf`** respectively. This means that unless you take care to specify the external format **`:eol-style`** parameter, you may get unexpected string length when returning a Lisp string.

Consider the following C code example on Windows:

```
#include <string.h>
#include <stdlib.h>
#include <stdio.h>

__declspec(dllexport) int __cdecl crlf_string(int length, char
*string)
{
  int ii;
  int jj;
  for (ii = 0; ii < length ; ii++)
       if (ii % 3 == 1) {
         string[ii] = 10;
         printf("%d\n", ii);
        } else
       if ((ii > 0) && (ii % 3 == 0)) {
         string[ii] = 13;
         printf("%d\n", ii);
        } else
       if (ii % 3 == 2) {
         string[ii] = 97 + rand() % 26 ;
         printf("%d\n", ii);
        }
  string[length] = 0;
  return length;
}
```

Call this C function from Lisp:

```
(fli:define-foreign-function (crlf-string
                              "crlf_string"
                              :source)
   ((length :int)
    (return-string (:reference-return
                    (:ef-mb-string
                     :limit 256
                     :external-format :latin-1))))
 :lambda-list (length &aux return-string)
 :calling-convention :cdecl
 :result-type :int)

(multiple-value-bind (length string)
                  (crlf-string 99)
               (format t "~&C length ~D, Lisp string length ~D~%"
length (length string)))
=>
C length 99, Lisp string length 67
```

Each two character CR LF sequence in the foreign string has been mapped to a single LF character in the Lisp string. If you want to return a Lisp string and not do line terminator conversion, then you must specify the *eol-style* as in this example:

```
(fli:define-foreign-function (crlf-string
                              "crlf_string"
                              :source)
   ((length :int)
    (return-string (:reference-return
                    (:ef-mb-string
                     :limit 256
                    :external-format (:latin-1 :eol-style :lf)))))
 :lambda-list (length &aux return-string)
 :calling-convention :cdecl
 :result-type :int)

(multiple-value-bind (length string)
                     (crlf-string 99)
                (format t "~&C length ~D, Lisp string length ~D~%"
length (length string)))
=>
C length 99, Lisp string length 99
```

4.2.8 Win32 API functions that handle strings

Functions in the Win32 API that handle strings come in two flavors, one for ANSI strings and one for Unicode strings. Windows ME only supports the ANSI functions but Windows XP/Vista/7 support both. The functions are named with a single letter suffix, an **A** for the ANSI functions and a **W** for the Unicode functions. So for example both **CreateFileA** and **CreateFileW** exist. In C, this is finessed by the use of #define in the header files.

There are two ways to handle this:

- Always use the **A** functions. This will allow your code to work on all supported versions of Windows, but will prevent the use of Unicode on Windows XP/Vista/7 (this is typically only a problem if you are handling mixed language data), or
- Use *encoding* **:dbcs** in **define-foreign-function**. This will cause it to switch between ANSI and Unicode versions depending on the operating system.

In either case, as well as calling the correct function, you must encode/decode any string arguments/results correctly, to match the **A** or **W** in the function name. The foreign types **win32:tstr**, **win32:lpctstr** and **win32:lptstr** correspond to the typical ones found in the Win32 API. For more information about

these foreign types, see their manual pages in the *LispWorks User Guide and Reference Manual*.

4.2.9 Mapping Nil to a Null Pointer

If you wish a string argument to accept **nil** and pass it as a null pointer, or to return a null pointer as Lisp value **nil**, use the **:allow-null** argument to the **:reference** types.

The C function strcap in the following example modifies a string, but also accepts and returns a null pointer if passed.

Windows version:

```
#include <string.h>
#include <ctype.h>

__declspec(dllexport) char* __cdecl strcap(char *string)
{
  int len;
  int ii;
  if (string) {
     len = strlen(string);
     if (len > 0) {
        for (ii = len - 1; ii > 0; ii--)
            if (isupper(string[ii]))
               string[ii] = tolower(string[ii]);
        if (islower(string[0]))
           string[0] = toupper(string[0]);
     }
  }
  return string;
}
```

Linux/Unix/Macintosh version:

```
#include <string.h>
#include <ctype.h>

char* strcap(char *string)
{
  int len;
  int ii;
  if (string) {
     len = strlen(string);
     if (len > 0) {
        for (ii = len - 1; ii > 0; ii--)
            if (isupper(string[ii]))
               string[ii] = tolower(string[ii]);
        if (islower(string[0]))
           string[0] = toupper(string[0]);
     }
  }
  return string;
}
```

With this following foreign function definition:

```
(fli:define-foreign-function (strcap "strcap" :source)
    ((string (:reference :ef-mb-string)))
  :language
  :c
  :calling-convention
  :cdecl)

(strcap "abC")
=>
"Abc"
```

However `(strcap nil)` signals error because the `:ef-mb-string` type expects a string.

Using `:allow-null` allows `nil` to be passed:

```
(fli:define-foreign-function (strcap "strcap" :source)
    ((string (:reference :ef-mb-string :allow-null t)))
  :language
  :c
  :calling-convention
  :cdecl)

(strcap nil)
=>
nil
```

Note that **with-foreign-string**, **convert-to-foreign-string** and **convert-from-foreign-string** also accept an **:allow-null** argument. So another way to call strcap and allow the null pointer is:

```
(fli:define-foreign-function (strcap "strcap" :source)
    ((string :pointer))
  :language
  :c
  :calling-convention
  :cdecl)

(defun c-string-capitalize (string)
  (fli:with-foreign-string (ptr elts bytes :allow-null t)
      string
    (declare (ignore  elts bytes))
    (strcap ptr)
    (fli:convert-from-foreign-string ptr :allow-null t)))

(c-string-capitalize "abC")
=>
"Abc"

(c-string-capitalize nil)
=>
nil
```

4.3 Lisp integers

Lisp integers cannot be used directly in the FLI unless they are known to be of certain sizes that match foreign types such as **:int**.

However, the FLI provides a mechanism to convert any Lisp integer into a foreign array of bytes and to convert that array back to an equivalent Lisp integer. This would allow the integer to be stored in an database for example and then retrieved later.

The macro **with-integer-bytes** and the function **convert-integer-to-dynamic-foreign-object** generates the array of bytes and also to determine its length. The function **make-integer-from-bytes** converts the foreign array back to an integer. The layout of the bytes is unspecified, so these operations must be used for all such conversions.

4.4 Defining new types

The FLI provides the **define-foreign-type** macro for defining new FLI types, using the basic FLI types that you have seen in Chapter 2. The next example shows you how to define a new array type that only takes an odd number of dimensions.

```
(fli:define-foreign-type odd-array (element &rest dimensions)
   (unless (oddp (length dimensions))
     (error "Can't define an odd array with even dimensions - try
adding an extra dimension!"))
                `(:c-array ,element ,@dimensions))
```

The new array type is called **odd-array**, and takes a FLI type and a sequence of numbers as its arguments. When trying to allocate an **odd-array**, if there are an even number of items in the sequence then an error is raised. If there are an odd number of items then an instance of the array is allocated. The next command raises an error, because a 2 by 3 array has an even dimension.

```
(fli:allocate-foreign-object :type '(odd-array :int 2 3))
```

However, adding an extra dimension and defining a 2 by 3 by 4 array works:

```
(fli:allocate-foreign-object :type '(odd-array :int 2 3 4))
```

For more information on defining types see **define-foreign-type**, page 88.

4.5 Foreign callables and foreign functions

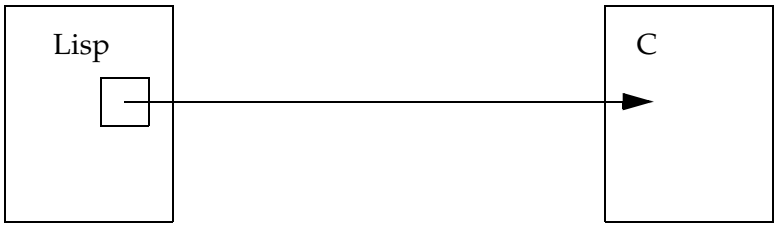
The two main macros for interfacing LispWorks with a foreign language are **define-foreign-callable** which defines Lisp functions that can be called from the foreign language, and **define-foreign-function** which defines a short linking function that can call functions in a foreign language.

In Chapter 1, "Introduction to the FLI" we defined a foreign function for calling the Win32 function **SetCursorPos**. The code for this example is repeated here.

```
(fli:define-foreign-function (set-cursor-position "SetCursorPos")
    ((x :long)
     (y :long))
  :result-type :boolean)
```

Figure 4.1 is an illustration of **set-cursor-position**, represented by a square, calling the C code which constitutes **SetCursorPos**.

Figure 4.1 A FLI foreign function calling some C code.



The next diagram, Figure 4.2, illustrates a callable function. Whereas a foreign function consists of a Lisp function name calling some code in C, a callable function consists of Lisp code, represented by an oval in the diagram, which can be called from C.

Figure 4.2 C calling a callable function in Lisp.

Callable functions are defined using **fli:define-foreign-callable**, which takes as its arguments, amongst other things, the name of the C function that will call Lisp, the arguments for the callable function, and a body of code which makes up the callable function.

To call a Lisp function from C or C++ you need to define it using **fli:define-foreign-callable**. Then call **fli:make-pointer** with the **:symbol-name** argument and pass the result to C or C++ as a function pointer.

For the purpose of creating a self-contained illustration in Lisp, the following Lisp code defines a foreign callable function that takes the place of the Windows function **SetCursorPos**.

```
(fli:define-foreign-callable ("SetCursorPos"
                              :result-type :boolean)
  ((x :long) (y :long))
  (capi:display-message
     "The cursor position can no longer be set"))
```

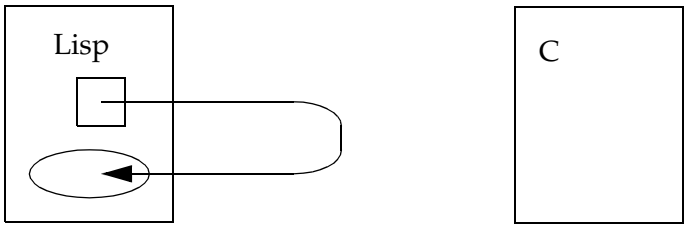
Supposing you had the above foreign callable defined in a real application, you would use

```
(make-pointer :symbol-name "SetCursorPos")
```

to create a foreign pointer which you pass to foreign code so that it can call the Lisp definition of **SetCursorPos**.

Figure 4.3 illustrates what happens when **set-cursor-position** is called. The foreign function **set-cursor-position** (represented by the square) calls what it believes to be the Windows function **SetCursorPos**, but the callable function (represented by the oval), also called **SetCursorPos**, is called instead. It pops up a CAPI pane displaying the message "The cursor position can no longer be set".

Figure 4.3 A FLI foreign function calling a callable function.



For more information on calling foreign code and defining foreign callable functions see "Strings and foreign callables" on page 46, **define-foreign-function**, page 81, and **define-foreign-callable**, page 71.

4.5.1 Strings and foreign callables

To interface to a C function which takes a pointer to a string *form* and puts a string in the memory pointed to by *result*, declared like this:

```
void evalx(const char *form, char *result);
```

you would define in Lisp:

```
(fli:define-foreign-function evalx
    ((form (:reference-pass :ef-mb-string))
     (:ignore (:reference-return
               (:ef-mb-string :limit 1000)))))
```

and call

```
(evalx "(+ 2 3)")
=>
"5"
```

Now suppose instead that you want your C program to call a similar routine in a LispWorks for Windows DLL named "evaluator", like this:

```
{
 typedef void (_stdcall *evalx_func_type)(const char *form, char
*result);
 HINSTANCE dll = LoadLibrary("evaluator");
 evalx_func_type evalx = (evalx_func_type) GetProcAddress(dll,
"evalx");
 char result[1000];
 evalx("(+ 2 3)", result);
 printf("%s\n", result);
}
```

You would put this foreign callable in your DLL built with LispWorks:

```
(fli:define-foreign-callable
    ("evalx" :calling-convention :stdcall)
    ((form (:reference :ef-mb-string
            :lisp-to-foreign-p nil
            :foreign-to-lisp-p t))
     (result (:reference (:ef-mb-string :limit 1000)
              :lisp-to-foreign-p t
              :foreign-to-lisp-p nil)))
  (multiple-value-bind (res err)
      (ignore-errors (read-from-string form))
    (setq result
          (if (not (fixnump err))
              (format nil "Error reading: ~a"
                      err)
            (multiple-value-bind (res err)
                (ignore-errors (eval res))
              (if (and (not res) err)
                  (format nil "Error evaluating: ~a"
                          err)
                (princ-to-string res)))))))
```

Note: you could use **:reference-return** and **:reference-pass** in the foreign callable definition, but we have shown **:reference** with explicit *lisp-to-foreign-p* and *foreign-to-lisp-p* arguments to emphasise the direction of each conversion.

For information on how to create a LispWorks DLL, see "Creating a dynamic library" in the *LispWorks User Guide and Reference Manual*.

4.6 Using DLLs within the LispWorks FLI

In order to use functions defined in a dynamically linked library (DLL) within the LispWorks FLI, the functions need to be exported from the DLL.

4.6.1 Using C DLLs

You can export C functions in three ways:

1. Use a **__declspec(dllexport)** declaration in the C file.

   In this case you should also make the functions use the **cdecl** calling convention, which removes another level of name mangling.

2. Use an **/export** directive in the link command.

3. Use a **.def** file.

An example of method 3 follows. Let us assume you have the following C code in a file called **example.c**.

```
int _stdcall MultiplyMain(void *hinstDll,unsigned long
                          dwReason,void *reserved)
 {
  return(1);
 }

int multiply (int i1, int i2)
 { int result;
  result = i1 * i2 * 500;
  return result;
 }
```

Then you can create a DLL by, for example, using a 32 bit C compiler such as lcc.

```
lcc -O -g2 example.c
lcclnk.exe -dll -entry MultiplyMain example.obj
example.def -subsystem
windows
```

You now need to create a **multiply.def** file that contains the following line

```
exports multiply=multiply
```

to export the function **multiply** as the symbol **multiply**. If you only include the line "**exports multiply**" then the name of the external symbol is likely to be "**_multiply**" or "**_multiply@8**" depending on whether the function is compiled as **__cdecl** or **__stdcall**. The addition of the "**= multiply**" overrides the internal function name with the new name.

If you run Windows then you can view the list of exported symbols from a given DLL by selecting the DLL from an explorer, then right clicking on it and selecting QuickView. This brings up some text about the DLL.

Finally, you should use the LispWorks FLI to define your C function in your Lisp code. This definition should look something like:

```
(fli:define-foreign-function (multiply "multiply")
     ((x :int)
      (y :int))
   :result-type int
   :module :my-dll
   :calling-convention :cdecl)
```

Note that the **define-foreign-function** also includes a **:calling-convention** keyword to specify that the function we are interfacing to is defined as using the **__cdecl** calling convention.

4.6.2 Using C++ DLLs

You must make the exported names match the FLI definitions. To do this:

- If you can alter the C++ code, wrap **extern "C" {}** around the C++ function definitions, or
- Create a second DLL with C functions that wrap around each C++ function, and make those C functions accessible as described in "Using C DLLs" on page 48.

Note: watch out for the calling convention of the exported function, which must match the `:calling-convention` in the FLI definitions.

4.7 Interfacing to graphics functions

If you use graphics functionality via the FLI on Windows be aware that you may need to call the function `gp:ensure-gdiplus`. See the *LispWorks CAPI Reference Manual* for a detailed explanation.

This condition does not apply on non-Windows platforms.

4.8 Summary

In this chapter a number of more advanced examples have been presented to illustrate various features of the FLI. The use of the FLI to pass strings dynamically to Win32 API functions was examined, as was the definition of new FLI types and the use of callable functions and foreign functions.

The next two chapters form the reference section of this manual. They provide reference entries for the functions, macros, and types which make up the FLI.

5

Function and Macro Reference

align-of *Function*

Summary	Returns the alignment in bytes of a foreign type.	
Package	**fli**	
Signature	**align-of** *type-name* **=>** *alignment*	
Arguments	*type-name*	A foreign type whose alignment is to be determined.
Values	*alignment*	The alignment of the foreign type *type-name* in bytes.

Description The function **align-of** returns the alignment in bytes of the foreign language type named by *type-name*.

Example The following example shows types with various alignments.

```
(fli:align-of :char)
=>
1

(fli:align-of :int)
=>
4

(fli:align-of :double)
=>
8

(fli:align-of :pointer)
=>
4
```

See also **allocate-foreign-object**
free-foreign-object

alloca *Function*

Summary A synonym for **allocate-dynamic-foreign-object**.

Package **fli**

Signature **alloca &key** *type pointer-type initial-element initial-contents nelems* **=>** *pointer*

Description The function **alloca** is a synonym for **allocate-dynamic-foreign-object**.

See also **allocate-dynamic-foreign-object**

allocate-dynamic-foreign-object *Function*

Summary Allocates memory for an instance of a foreign object within the scope of a **with-dynamic-foreign-objects** macro.

Package **fli**

Signature **allocate-dynamic-foreign-object &key** *type pointer-type initial-element initial-contents fill nelems size-slot* **=>** *pointer*

Arguments

type	A FLI type specifying the type of the object to be allocated. If *type* is supplied, *pointer-type* must not be supplied.
pointer-type	A FLI pointer type specifying the type of the pointer object to be allocated. If *pointer-type* is supplied, *type* must not be supplied.
initial-element	A keyword setting the initial value of every element in the newly allocated object to *initial-element*.
initial-contents	A list of forms which initialize the contents of each element in the newly allocated object.
fill	An integer between 0 to 255.
nelems	An integer specifying how many copies of the object should be allocated. The default value is 1.
size-slot	A symbol naming a slot in the object.

Values

pointer	A pointer to the specified *type* or *pointer-type*.

Description

The function **allocate-dynamic-foreign-object** allocates memory for a new instance of an object of type *type* or an instance of a pointer object of type *pointer-type* within the scope of the body of the macro **with-dynamic-foreign-objects**.

The object is initialized as if by **allocate-foreign-object**.

Once this macro has executed, the memory allocated using **allocate-dynamic-foreign-object** is therefore automatically freed for other uses.

Example A full example using **with-dynamic-foreign-objects** and **allocate-dynamic-foreign-object** is given in "An example of dynamic memory allocation" on page 7.

See also **allocate-foreign-object**
with-dynamic-foreign-objects

allocate-foreign-object *Function*

Summary Allocates memory for an instance of a foreign object.

Package **fli**

Signature **allocate-foreign-object &key** *type pointer-type initial-element initial-contents fill nelems size-slot* **=>** *pointer*

Arguments

type	a FLI type specifying the type of the object to be allocated. If *type* is supplied, *pointer-type* must not be supplied.
pointer-type	A FLI pointer type specifying the type of the pointer object to be allocated. If *pointer-type* is supplied, *type* must not be supplied.
initial-element	A keyword setting the initial value of every element in the newly allocated object to *initial-element*.
initial-contents	A list of forms which initialize the contents of each element in the newly allocated object.
fill	An integer between 0 to 255.
nelems	An integer specifying how many copies of the object should be allocated. The default value is 1.
size-slot	A symbol naming a slot in the object.

Values

pointer A pointer to the specified *type* or *pointer-type*.

Description

The function **allocate-foreign-object** allocates memory for a new instance of an object of type *type* or an instance of a pointer object of type *pointer-type*. Memory allocated in this manner must be explicitly freed using **free-foreign-object** once the object is no longer needed.

An integer value of *fill* is initializes all the bytes of the object. If *fill* is not supplied, the object is not initialized unless *initial-element* or *initial-contents* is passed.

A supplied value of *size-slot* applies if the type is a struct or union type. The slot *size-slot* is set to the size of the object in bytes. This occurs after the *fill*, *initial-element* and *initial-contents* arguments are processed. If *nelems* is greater than 1, then the slot *size-slot* is initialized in each element. If *size-slot* is not supplied, then no such setting occurs.

Notes

Memory allocated by **allocate-foreign-object** is in the C heap. Therefore *pointer* (and any copy) cannot be used after **save-image** or **deliver**.

Example

In the following example a structure is defined and an instance with a specified initial value of 10 is created with memory allocated using **allocate-foreign-object**. The **dereference** function is then used to get the value that **point** points to, and finally it is freed.

```
(fli:define-c-typedef LONG :long)

(setq point (fli:allocate-foreign-object
             :type 'LONG
             :initial-element 10))

(fli:dereference point)

(fli:free-foreign-object point)
```

See also

allocate-dynamic-foreign-object
free-foreign-object

cast-integer *Function*

Summary Casts an integer to a given type.

Package **fli**

Signature **cast-integer** *integer type* **=>** *result*

Arguments
integer A Lisp integer.
type A foreign type.

Values
result A Lisp integer.

Description The function **cast-integer** casts the integer *integer* to the foreign type *type*.

type must be a FLI integer type, either primitive or derived.

Example
```
(format nil "~B"
        (fli:cast-integer -1 '(:unsigned :int)))
=>
"11111111111111111111111111111111"
```

See also **:signed**
:unsigned

connected-module-pathname *Function*

Summary Returns the real pathname of a connected module.

Package **fli**

Signature **connected-module-pathname** *name* **=>** *pathname*

Arguments
name A string or symbol.

Values
pathname A pathname or **nil**.

Description

The function **connected-module-pathname** returns the real pathname of the connected module registered with name *name*.

If no module *name* is registered, or if the module *name* is not connected, then **connected-module-pathname** returns **nil**.

Example

```
(fli:connected-module-pathname "gdi32")
=>
#P"C:/WINNT/system32/GDI32.dll"

(fli:register-module :user-dll
                     :real-name "user32"
                     :connection-style :immediate)
=>
:user-dll

(fli:connected-module-pathname :user-dll)
=>
#P"C:/WINNT/system32/USER32.dll"

(fli:disconnect-module :user-dll)
=>
t

(fli:connected-module-pathname :user-dll)
=>
nil
```

See also

disconnect-module

register-module

convert-from-foreign-string *Function*

Summary

Converts a foreign string to a Lisp string.

Package

fli

Signature

convert-from-foreign-string *pointer* **&key** *external-format length null-terminated-p allow-null* **=>** *string*

Arguments	*pointer*	A pointer to a foreign string.
	external-format	An external format specification.
	length	The length of the string to convert.
	null-terminated-p	If **t**, it is assumed the string terminates with a null character. The default value for *null-terminated-p* is **t**.
	allow-null	A boolean. The default is false.
Values	*string*	A Lisp string, or **nil**.

Description

The function **convert-from-foreign-string**, given a pointer to a foreign string, converts the foreign string to a Lisp string. The pointer does not need to be of the correct type, as it will automatically be coerced to the correct type as specified by *external-format*.

The *external-format* argument is interpreted as by **with-foreign-string**.

Either *length* or *null-terminated-p* must be non-nil. If *null-terminated-p* is true and *length* is not specified, it is assumed that the foreign string to be converted is terminated with a null character.

If *allow-null* is true, then if a null pointer *pointer* is passed, **nil** is returned.

See also

convert-to-foreign-string
set-locale
set-locale-encodings
with-foreign-string

convert-integer-to-dynamic-foreign-object *Function*

Summary

Converts a Lisp integer to foreign bytes.

Signature **convert-integer-to-dynamic-foreign-object** *integer* **=>** *pointer*, *length*

Arguments

integer	An integer.

Values

pointer	A foreign pointer.
length	An integer.

Description The function **convert-integer-to-dynamic-foreign-object** makes a dynamic foreign object containing the bytes of *integer* and returns *pointer* pointing to the first byte of that object and *length* which is the number of bytes in that object. The layout of the bytes is unspecified, but the bytes and the length are sufficient to reconstruct *integer* by calling **make-integer-from-bytes**.

See also **with-integer-bytes**
make-integer-from-bytes

convert-to-foreign-string *Function*

Summary Converts a Lisp string to a foreign string.

Signature **convert-to-foreign-string** *string* **&key** *external-format null-terminated-p allow-null into limit allocation* **=>** *pointer*

convert-to-foreign-string *string* **&key** *external-format null-terminated-p allow-null into limit allocation* **=>** *pointer*, *length*, *byte-count*

Package **fli**

Arguments

string	A Lisp string.
external-format	An external format specification.
null-terminated-p	If **t**, the foreign string terminates with a null character. The default value is **t**.

	allow-null	A boolean. The default is **nil**.
	into	A foreign array, or **nil**. The default is **nil**.
	limit	A non-negative fixnum, or **nil**. The default is **nil**.
	allocation	A keyword, either **:dynamic** or **:static**. The default is **:static**.
Values	*pointer*	A FLI pointer to the foreign string.
	length	The length of the foreign string (including the terminating null character if there is one).
	byte-count	The number of bytes in the foreign string.

Description

The function **convert-to-foreign-string** converts a Lisp string to a foreign string, and returns a pointer to the string.

The *external-format* argument is interpreted as by **with-foreign-string**.

The *null-terminated-p* argument specifies whether the foreign string is terminated with a null character. It defaults to **t**.

If *allow-null* is non-nil, then if *string* is **nil** a null pointer *pointer* is returned.

If *into* is passed, then it is a foreign array which gets filled with elements converted from the characters of *string* up to *limit*.

If *limit* is a fixnum, then only the characters of *string* below index *limit* are converted.

If *allocation* is **:dynamic**, then **convert-to-foreign-string** allocates memory for the string and pointer within the scope of the body of **with-dynamic-foreign-objects** and additional values, *length* and *byte-count* are returned. This is equivalent to using **convert-to-dynamic-foreign-string**. Otherwise, the allocation is static.

See also **convert-from-foreign-string**
set-locale
set-locale-encodings
with-foreign-string

convert-to-dynamic-foreign-string *Function*

Summary Converts a Lisp string to a foreign string within the scope of the body of a **with-dynamic-foreign-objects** macro.

Package **fli**

Signature **convert-to-dynamic-foreign-string** *string* **&key** *external-format null-terminated-p allow-null* **=>** *pointer, length, byte-count*

Arguments

string	A Lisp string.
external-format	An external format specification.
null-terminated-p	If **t**, the foreign string terminates with a null character. The default value is **t**.
allow-null	A boolean. The default is **nil**.

Values

pointer	A FLI pointer to the foreign string.
length	The length of the string (including the terminating null character if there is one).
byte-count	The number of bytes in the converted string.

Description The function **convert-to-dynamic-foreign-string** converts a Lisp string to a foreign string, and returns a pointer to the string and the length of the string. The memory allocation for the string and pointer is within the scope of the body of a **with-dynamic-foreign-objects** command.

The *external-format* argument is interpreted as by **with-foreign-string**.

The *null-terminated-p* keyword specifies whether the foreign string is terminated with a null character. It defaults to **t**.

If *allow-null* is non-nil, then if *string* is **nil** a null pointer *pointer* is returned.

See also

allocate-dynamic-foreign-object
convert-from-foreign-string
convert-to-foreign-string
set-locale
set-locale-encodings
with-dynamic-foreign-objects
with-foreign-string

copy-pointer *Function*

Summary

Returns a copy of a pointer object.

Package

fli

Signature

copy-pointer *pointer* **&key** *type pointer-type* **=>** *copy*

Arguments

pointer	A pointer to copy.
type	The type of the object pointer to by *pointer*.
pointer-type	The type of *pointer*.

Values

copy	A copy of *pointer*.

Description

The function **copy-pointer** returns a copy of *pointer*.

Example

In the following example a pointer **point1** is created, pointing to a **:char** type. The variable **point2** is set equal to **point1** using **setq**, whereas **point3** is set using **copy-pointer**. When **point1** is changed using **incf-pointer**, **point2** changes as well, but **point3** remains the same.

```
(setq point1 (fli:allocate-foreign-object :type
                                          :char))

(setq point2 point1)

(setq point3 (fli:copy-pointer point1))

(fli:incf-pointer point1)
```

The results of this can be seen by evaluating **point1**, **point2**, and **point3**.

The reason for this behavior is that **point1** and **point2** are Lisp variables containing the same foreign object; a pointer to a **char**, whereas **point3** contains a copy of the foreign pointer object.

See also **make-pointer**

decf-pointer *Function*

Summary Decreases the address held by a pointer.

Package **fli**

Signature **decf-pointer** *pointer* **&optional** *delta* **=>** *pointer*

Arguments

pointer	A FLI pointer.
delta	An integer. The default is 1.

Values

pointer	The pointer passed.

Description The function **decf-pointer** decreases the address held by the pointer. If *delta* is not given the address is decreased by the size of the type pointed to by the pointer. The address can be decreased by a multiple of the size of the type by specifying a value for *delta*.

The function **decf-pointer** is often used to move a pointer through an array of values.

Example

In the following example an array with 10 entries is defined. A copy of the pointer to the array is made, and is incremented and decremented.

```
(setq array-obj
      (fli:allocate-foreign-object :type :int
        :nelems 10
        :initial-contents '(0 1 2 3 4 5 6 7 8 9)))

(setq point1 (fli:copy-pointer array-obj))

(dotimes (x 9)
  (fli:incf-pointer point1)
  (print (fli:dereference point1)))

(dotimes (x 9)
  (fli:decf-pointer point1)
  (print (fli:dereference point1)))
```

See also

incf-pointer

define-c-enum *Macro*

Summary

Defines a FLI enumerator type specifier corresponding to the C **enum** type.

Package

fli

Signature

define-c-enum *name-and-options* **&rest** *enumerator-list* **=>** *list*

name-and-options **::=** *name* | **(***name option****)**

option **::= (:foreign-name** *string***)**

enumerator-list **::= {***entry-name* | **(***entry-name entry-value***)}***

Arguments

name — A symbol naming the new enumeration type specifier

	string	A string specifying the foreign name of the type
	enumerator-list	A sequence of symbols, possibly with integer values, constituting the enumerator type
	entry-name	A symbol
	entry-value	An integer value for an *entry-name*
Values	*list*	The list **(:enum** *name***)**

Description

The macro **define-c-enum** is used to define a FLI enumerator type specifier, which corresponds to the C **enum** type. It is a convenience function, as an enumerator type could also be defined using **define-foreign-type**.

Each entry in the *enumerator-list* can either consist of a symbol, in which case the first entry has an integer value of 0, or of a list of a symbol and its corresponding integer value.

Example

In the following example a FLI enumerator type specifier is defined, and the corresponding definition for a C enumerator type follows.

```
(define-c-enum colors red green blue)

enum colors { red, green, blue};
```

The next example illustrates how to start the enumerator value list counting from 1, instead of from the default start value of 0.

```
(define-c-enum half_year (jan 1) feb mar apr may jun)

enum half_year { jan = 1, feb, mar, apr, may, jun }
```

See also

define-c-struct
define-c-typedef
define-c-union
define-foreign-type
enum-symbol-value

define-c-struct *Macro*

Summary Defines a FLI structure type specifier corresponding to the C **struct** type.

Package **fli**

Signature

define-c-struct *name-and-options* **&rest** *descriptions* **=>** *list*

name-and-options **::=** *name* **|** **(***name option****)**

option **::= (:foreign-name** *string***)**

descriptions **::= {***slot-description* **|** *byte-packing***}***

slot-description **::= {***slot-name* **|** **(***slot-name slot-type***)}**

byte-packing **::= (:byte-packing** *nbytes***)**

nbytes **::= integer**

Arguments

name	A symbol naming the new structure type specifier
string	A string specifying the foreign name of the structure.
slot-description	A symbol, or a list of symbol and type description, naming a slot in the structure
slot-name	A symbol naming the slot
slot-type	The foreign type of the slot
byte-packing	A list specifying byte packing for the subseqent slots
nbytes	The number of 8-bit bytes to pack

Values

list	The list **(:struct** *name***)**

Description The macro **define-c-struct** is used to define a FLI structure type specifier, which corresponds to the C **struct** type. It is a convenience function, as a structure type could also be defined using **define-foreign-type**.

A structure is an aggregate type, or collection, of other FLI types. The types contained in a structure are referred to as slots, and can be accessed using the **define-foreign-type** and **foreign-slot-value** functions.

Some C compilers support pragmas such as

```
#pragma pack(1)
```

which causes fields in a structure to be aligned on a byte boundary even if their natural alignment is larger. This can be achieved from Lisp by specifying suitable *byte-packing* forms in the structure definition, as in the example below. Each *byte-packing* form specifies the packing for each *slot-description* that follows it in the **define-c-struct** form. It is important to use the same packing as the C header file containing the foreign type.

Example

The first example shows a C structure definition and the corresponding FLI definition:

```
struct a-point {
  int x;
  int y;
  byte color;
  char ident;
};

(fli:define-c-struct a-point (x :int)
                             (y :int)
                             (color :byte)
                             (ident :char))
```

The second example shows how you might retrieve data in Lisp from a C function that returns a structure:

```
struct 3dvector
{
 float x;
 float y;
 float z;
 }

static 3dvector* vector;

3dvector* fn ()
{
 return vector;
 }

(fli:define-c-struct 3dvector
  (x :float)
  (y :float)
  (z :float))

(fli:define-foreign-function fn ()
  :result-type (:pointer (:struct 3dvector)))

(let ((vector (fn)))
  (fli:with-foreign-slots (x y z) vector
    (values x y z)))
```

Finally an example to illustrate byte packing. This structure will require 4 bytes of memory because the field named *a-short* will be aligned on a 2 byte boundary and hence a byte will be wasted after the *a-byte* field:

```
(fli:define-c-struct foo ()
  (a-byte (:unsigned :byte))
  (a-short (:unsigned :short)))
```

After adding the *byte-packing* form, the structure will require only 3 bytes:

```
(fli:define-c-struct foo
  (:byte-packing 1)
  (a-byte (:unsigned :byte))
  (a-short (:unsigned :short)))
```

See also

define-c-enum

define-c-typedef

define-c-union

define-foreign-type
foreign-slot-names
foreign-slot-type
foreign-slot-value

define-c-typedef *Macro*

Summary — Defines FLI type specifiers corresponding to type specifiers defined using the C **typedef** command.

Package — **fli**

Signature — **define-c-typedef** *name-and-options type-description* **=>** *name*

name-and-options **::=** *name* **|** **(***name option****)**

option **::= (:foreign-name** *string***)**

Arguments

name	A symbol naming the new FLI type
string	A string specifying the foreign name of the type
type-description	A symbol or list defining the new type

Values

name	The name of the new FLI type

Description — The **define-c-typedef** macro is used to define FLI type specifiers, which corresponds to those defined using the C function **typedef**. It is a convenience function, as types can also be defined using **define-foreign-type**.

Example — In the following example three types are defined using the FLI function **define-c-typedef**, and the corresponding C definitions are then given.

```
(fli:define-c-typedef intptr (:pointer :int))
(fli:define-c-typedef bar (:struct (one :int)))
```

These are the corresponding C **typedef** definitions:

```
typedef int *intptr;
typedef struct (int one;) bar;
```

See also

define-c-enum
define-c-struct
define-c-union
define-foreign-type

define-c-union *Macro*

Summary

Defines a FLI union type corresponding to the C **union** type.

Package

fli

Signature

define-c-union *name-and-options* **&rest** *slot-descriptions* **=>** *list*

name-and-options **::=** *name* **|** **(***name option****)**

option **::= (:foreign-name** *string***)**

slot-descriptions **::= {***slot-name* **|** **(***slot-name slot-type***)}***

Arguments

name	A symbol naming the new union type descriptor
string	A string specifying the foreign name of the type
slot-descriptions	A sequence of symbols, possibly with type descriptions, naming the slots of the union.
slot-name	A symbol naming the slot.
slot-type	The FLI type of the slot.

Values

list	The list **(:union** *name***)**.

Description

The macro **define-c-union** is used to define a FLI union type specifier, which corresponds to the C **union** type. It is a convenience function, as a union type could also be defined using **define-foreign-type**.

A union is an aggregate type, or collection, of other FLI types. The types contained in a union are referred to as slots, and can be accessed using the **foreign-slot-type** and **foreign-slot-value** functions.

Example

In the following example a union is defined using **define-c-union**, and the corresponding C code is given.

```
(fli:define-c-union a-point (x :int)
                            (color :byte)
                            (ident :char))

union a-point {
  int x;
  byte color;
  char ident;
};
```

See also

define-c-enum
define-c-struct
define-c-typedef
define-foreign-type

define-foreign-callable *Macro*

Summary

Defines a Lisp function which can be called from a foreign language.

Package

fli

Signature

define-foreign-callable (*foreign-name* **&key** *encode language result-type result-pointer no-check calling-convention*) (*{args}**) **&body** *body* **=>** *lisp-name*

args **::=** {*arg-name*} | (*arg-name arg-type*)

language **::= :c** | **:ansi-c**

Arguments

foreign-name A string or symbol naming the Lisp callable function created.

encode — By default, LispWorks performs automatic name encoding to translate *foreign-name*

If you want to explicitly specify an encoding, the *encode* option can be one of the following:

:source tells LispWorks that *foreign-name* is the function name to call from the foreign source code. This is the default value of *encode* if *foreign-name* is a string.

:object tells LispWorks that *foreign-name* is the literal name to be called in the foreign object code.

:lisp tells LispWorks that if *foreign-name* is a Lisp symbol, it must be translated and encoded. This is the default value of *encode* if *foreign-name* is a symbol.

:dbcs modifies the function name on Windows, as described for **define-foreign-function**.

language — The language in which the foreign calling code is written. The default is **:ansi-c**.

result-type — The FLI type of the Lisp foreign callable function's return value which is passed back to the calling code.

result-pointer — A variable which will be bound to a foreign pointer into which the result should be written when the result-type is an aggregate type.

no-check — If **nil**, the result of the foreign callable function, produced by *body*, is checked to see if matches the *result-type*, and an error is raised if they do not match. Setting *no-check* to **t** overrides this check.

calling-convention

Specifies the calling convention used on Windows.

args — The arguments of the Lisp foreign callable function. Each argument can consist either of an *arg-name*, in which case LispWorks assumes it is an **:int**, or an *arg-name* and an *arg-type*, which is a FLI type.

body — A list of forms which make up the Lisp foreign callable function.

Values

lisp-name — A string or symbol naming the Lisp callable function created.

Description

The macro **define-foreign-callable** defines a Lisp function that can be called from a foreign language, for example from a C function. When the Lisp function is called, data passed to it is converted to the appropriate FLI representation, which is translated to an appropriate Lisp representation for the Lisp part of the function. Once the callable function exits, any return values are converted back into a FLI format to be passed back to the calling language.

When you use **:reference** with **:lisp-to-foreign-p t** as an *arg-type*, you need to set *arg-name* to the value that you want to return in that reference. That value is then converted and stored into the pointer supplied by the calling foreign function. This is done after the visible body of your **define-foreign-callable** form returns.

calling-convention is ignored on non-Windows platforms, where there is no calling convention issue. On Windows, **:stdcall** is the calling convention used to call Win32 API functions and matches the C declarator **"__stdcall"**. This is the default value. **:cdecl** is the default calling convention for C/C++ programs and matches the C declarator **"__cdecl"**.

When *result-type* is an aggregate type, an additional variable is bound in the body to allow the value of the function to be returned (the value returned by the body is ignored). This argument is named after the *result-pointer* argument or is named **result-pointer** in the current package if unspecified. While the body is executing, the variable will be bound to a foreign pointer that points to an object of the type *result-type*. The body must set the slots in this foreign object in order for the value to be returned to the caller.

To make a function pointer referencing a foreign callable named **"Foo"**, use:

```
(make-pointer :symbol-name "Foo")
```

Notes

1. For a delivered application where the string name of your foreign callable is not passed in *dll-exports*, be aware that a call to **make-pointer** like that above will not retain the foreign callable in a delivered application. Internally a Lisp symbol named **|%FOREIGN-CALLABLE/Foo|** is used so you could retain that explicitly (see the *LispWorks Delivery User Guide* for details, and take care to specify the package). However it is simpler to name the foreign callable with your Lisp symbol, and pass that to **make-pointer**. This call will keep your foreign callable in the delivered application:

   ```
   (make-pointer :symbol-name 'foo :functionp t)
   ```

2. If you specify any of the FLI float types **:float**, **:double**, **:lisp-float**, **:lisp-single-float** and so on, then the value of *language* should be **:ansi-c**.

Example

The following example demonstrates the use of foreign callable. A foreign callable function, **square**, is defined, which takes an integer as its argument, and returns the square of the integer.

```
(fli:define-foreign-callable
  ("square" :result-type :int)
  ((arg-1 :int)) (* arg-1 arg-1))
```

The foreign callable function, **square**, can now be called from a foreign language. We can mimic a foreign call by using the **define-foreign-function** macro to define a FLI function to call **square**.

```
(fli:define-foreign-function (call-two "square")
  ((in-arg :int)) :result-type :int)
```

The **call-two** function can now be used to call **square**. The next command is an example of this.

```
(call-two 9)
```

This last example shows how the address of a foreign callable can be passed via a pointer object, which is how you use foreign callables in practice. The foreign library in this example is libgsl:

```
(fli:define-foreign-callable ("gsl-error-handler")
    ((reason (:reference-return :ef-mb-string))
     (file (:reference-return :ef-mb-string))
     (lineno :integer)
     (gsl-errno :integer))
  (error
   "Error number ~a inside GSL [file: ~a, lineno ~a]:
~a"
   gsl-errno file lineno reason))

(fli:define-foreign-function gsl-set-error-handler
    ((func :pointer))
  :result-type :pointer)
```

To set the error handler, you would do:

```
(gsl-set-error-handler
 (fli:make-pointer :symbol-name "gsl-error-handler"))
```

See also

define-foreign-function

define-foreign-variable

make-pointer

define-foreign-converter *Macro*

Summary Defines a new FLI type specifier that converts to or from another type specifier.

Package `fli`

Signature **`define-foreign-converter`** *type-name lambda-list object-names* **`&key`** *foreign-type foreign-to-lisp lisp-to-foreign predicate tested-value error-form documentation* **`=>`** *type-name*

Arguments

type-name	A symbol naming the new FLI type.
lambda-list	A lambda list which is the argument list of the new FLI type.
object-names	A symbol or a list of two symbols
foreign-type	A macroexpansion form that evaluates to a FLI type descriptor
foreign-to-lisp	A macroexpansion form to convert between Lisp and the FLI.
lisp-to-foreign	A macroexpansion form to convert between the FLI and Lisp.
predicate	A macroexpansion form to check if a Lisp object is of this type.
tested-value	A macroexpansion form to give an error if a Lisp object is not of this type.
error-form	A macroeXpansion form to give an error if *predicate* returns false.
documentation	A string.
object-names ::= *object-name* | (*lisp-object-name foreign-object-name*)	

Values

type-name	The name of the new FLI converter type

Description

Note: this macro is for advanced use of the FLI type system. See **`define-foreign-type`** for simple aliasing of FLI type descriptors.

The macro **`define-foreign-converter`** defines a new FLI type specifier *type-name* that wraps another FLI type specifier and optionally performs data conversion and type checking. The string *documentation* is associated with *type-name* with the **`define-foreign-type`** documentation type.

The lambda list of the new FLI type specifier is *lambda-list* and its variables are available for use in the *foreign-type*, *foreign-to-lisp*, *lisp-to-foreign*, *predicate* and *tested-value* forms.

If *object-names* is a symbol *object-name*, then it provides the name of a variable for use in all of the macroexpansion forms. Otherwise *object-names* should be a list of the form (*lisp-object-name foreign-object-name*), where *lisp-object-name* provides the name of a variable for use in the *lisp-to-foreign*, *predicate* and *tested-value* forms and *foreign-object-name* provides the name of a variable for use in the *foreign-to-lisp* form.

When the new FLI type is used, the *foreign-type* form is evaluated to determine the underlying FLI type descriptor to be converted. It can use variables bound by *lambda-list*, but not *object-names*.

When *type-name* is used to convert a foreign value to Lisp (for example when as the *result-type* in **`define-foreign-function`**), the *foreign-to-lisp* form is evaluated to determine how the conversion should be made. It works like a macroexpansion function, so should return a form that converts the foreign value, which will be bound to *object-name* (or *foreign-object-name*). It can use variables bound by *lambda-list*.

When *type-name* is used to convert a Lisp value to a foreign value (for example in the argument list of **`define-foreign-function`**), the type of the Lisp value can be checked before conversion using *tested-value* and *predicate* and then converted using *lisp-to-foreign* as detailed below.

If *tested-value* is specified, it is used as a macroexpansion function that returns a form that must return *object-name* (or *lisp-object-name*) if it is of the required type or give an error. It can use variables bound by *lambda-list*, but not *object-names*.

Otherwise, if *predicate* is specified, it is used as a macroexpansion function that returns a form that must return true if *object-name* (or *lisp-object-name*) is of the required type. If *predicate* is specified, then *error-form* can be specified as a macroexpansion function that signals an error about *object-name* (or *lisp-object-name*) not being of the required type. If *error-form* is omitted, a default error is signaled. Both *predicate* and *error-form* can use variables bound by *lambda-list*, but not *object-names*.

If both *tested-value* and *predicate* are omitted, then no type checking is performed.

After type checking, *lisp-to-foreign* is used as a macroexpansion function that returns a form that converts the Lisp object *object-name* (or *lisp-object-name*) to the underlying FLI type *foreign-type*. It can use variables bound by *lambda-list*, but not *object-names*.

Examples

This defines a FLI type **(real-double *lisp-type*)**, which allows any real value in Lisp to be passed to foreign code as a double precision float. When a foreign value is converted to Lisp, it is coerced to *type*:

```
(fli:define-foreign-converter real-double (lisp-type)
    object
  :foreign-type :double
  :foreign-to-lisp `(coerce ,object ',lisp-type)
  :lisp-to-foreign `(coerce ,object 'double-float)
  :predicate `(realp ,object))
```

This defines a FLI type **int-signum**, which uses -1, 0 and 1 for values on the foreign side. There is no *foreign-to-lisp* form specified, so it will return these values to Lisp too:

```
(fli:define-foreign-converter int-signum () object
  :foreign-type :int
  :lisp-to-foreign `(signum ,object))
```

This defines a FLI type **(bigger-in-lisp** *n***)**, which is an integer type for values that are *n* bigger in Lisp than on the foreign side.

```
(fli:define-foreign-converter bigger-in-lisp
    (&optional (n 1))
    object
  :foreign-type :int
  :foreign-to-lisp `(+ ,object ,n)
  :lisp-to-foreign `(- ,object ,n)
  :predicate `(integerp ,object))

(fli:with-dynamic-foreign-objects ((x :int 10))
  (fli:dereference x :type '(bigger-in-lisp 2)))  =>  12
```

See also

define-foreign-type
define-opaque-pointer
:wrapper

define-foreign-forward-reference-type *Macro*

Summary — Defines a FLI type specifier if it is not already defined.

Package — **fli**

Signature — **define-foreign-forward-reference-type** *type-name lambda-list* **&body** *forms* **=>** *type-name*

Arguments — These are interpreted as in **define-foreign-type**.

Values — *type-name* The name of the FLI type.

Description — The macro **define-foreign-forward-reference-type** defines a new FLI type called *type-name*, unless *type-name* is already defined. This macro is useful when a type declaration is needed but the full definition is not yet available.

See also **define-foreign-type**
define-opaque-pointer

define-foreign-funcallable *Macro*

Summary Defines a Lisp function which, when passed a pointer to a foreign function, calls it.

Package **fli**

Signature **define-foreign-funcallable** *the-name args* **&key** *lambda-list documentation result-type language no-check calling-convention* **=>** *the-name*

args **::= ({***arg***}*)**

Arguments *the-name* A symbol naming the Lisp function.

The other arguments are interpreted as by **define-foreign-function**.

Description This is like **define-foreign-function**, but creates a function with an extra argument at the start of the argument list for the address to call.

Example Define a caller for this shape:

```
(fli:define-foreign-funcallable
 call-with-string-and-int
 ((string (:reference-pass :ef-mb-string))
  (value :int)))
```

printf is defined here:

```
(fli:register-module "msvcrt")
```

Call printf. Note that the output goes to console output which is hidden by default:

```
(let ((printf-func
       (fli:make-pointer :symbol-name "printf")))
  (call-with-string-and-int
   printf-func "printf called with %d" 1234))
```

See also **define-foreign-function**

define-foreign-function *Macro*

Summary Defines a Lisp function which acts as an interface to a foreign function.

Package **fli**

Signature **define-foreign-function** *name* **({***arg***}*) &key** *lambda-list documentation result-type language no-check calling-convention module* **=>** *lisp-name*

name **::=** *lisp-name* **|** **(***lisp-name foreign-name* **[***encoding***])**

encoding **::= :source | :object | :lisp | :dbcs**

arg **::=** *arg-name* **|** **(***arg-name arg-type***) | (:constant** *value value-type***) | &optional | &key | ((***arg-name default***)** *arg-type***) | (:ignore** *arg-type***)**

language **::= :c | :ansi-c**

calling-convention **::= :stdcall | :cdecl**

Arguments

lisp-name	A symbol naming the defined Lisp function.
foreign-name	A string or a symbol specifying the foreign name of the function.
arg-name	A variable.
arg-type	A foreign type name.
value	A Lisp object.
value-type	A foreign type name.

lambda-list The lambda list to be used for the defined Lisp function.

documentation A documentation string for the foreign function.

result-type A foreign type.

result-pointer The name of the keyword argument that is added to the lambda-list of the Lisp function when the result-type is an aggregate type.

language The language in which the foreign source code is written. The default is **:ansi-c**.

no-check If **nil**, the types of the arguments provided when the Lisp function is called are compared with the expected types and an error is raised if they do not match. Setting *no-check* to **t** overrides this check.

If the compilation safety level is set to 0 then *no-check* is automatically set to **t**. The default value for *no-check* is **nil**.

calling-convention

Specifies the calling convention used on Windows.

module A symbol or string naming the module in which the foreign symbol is defined.

Values

lisp-name A symbol naming the defined Lisp function.

Description

The macro **define-foreign-function** defines a Lisp function *lisp-name* which acts as an interface to a foreign language function, for example a C function. When the Lisp function is called its arguments are converted to the appropriate foreign representation before being passed to the specified foreign function. Once the foreign function exits, any return values

are converted back from the foreign format into a Lisp format.

encoding specifies how the Lisp function name is translated into the function name in the foreign object code. Its values are interpreted as follows:

`:source` — *foreign-name* is the name of the function in the foreign source code. This is the default value of *encoding* when *foreign-name* is a string.

`:object` — *foreign-name* is the literal name of the function in the foreign object code.

`:lisp` — If *foreign-name* is a Lisp symbol, it must be translated and encoded. This is the default value of *encoding* if *foreign-name* is a symbol.

`:dbcs` — A suffix is automatically appended to the function name depending on the Windows operating system that LispWorks runs in. The suffix is "**`A`**" for Windows 95-based systems and "**`W`**" for Windows NT-based systems.

The number and types of the arguments of *lisp-name* must be given. Lisp arguments may take any name, but the types must be accurately specified and listed in the same order as in the foreign function, unless otherwise specified using *lambda-list*.

If the *arg-name* syntax of *arg* is used, then **`define-foreign-function`** assumes that it is of type **`:int`**. Otherwise *arg-type* or *value-type* specifies the foreign type of the argument.

If *arg* is of the form **`(:constant`** *value value-type*`)` then *value* is always passed through to the foreign code, and *arg* is omitted from the lambda list of *lisp-name*.

If *arg* is **`&optional`** or **`&key`**, then the lambda list of the Lisp function *lisp-name* will contain these lambda-list-keywords

too. Any argument following **&optional** or **&key** can use the **((***arg-name default***)** *arg-type***)** syntax to provide a default value *default* for *arg-name*.

If *arg* is of the form **(:ignore** *arg-type***)** then **nil** is always passed through to the foreign code and *arg* is omitted from the lambda list of *lisp-name*. This is generally only useful when *arg-type* is a **:reference-return** type, where the value **nil** will be ignored.

When *language* is **:ansi-c** the foreign code is expected to be written in ANSI C. In particular single floats are passed through as single-floats whereas *language* **:c** causes them to be passed through as double floats. Similarly **:c** causes double floats to be returned from C and **:ansi-c** causes a single-floats to be returned. In both cases the type returned to Lisp is determined by *result-type*.

lambda-list allows you to define the order in which the Lisp function *lisp-name* takes its arguments to be different from the order in which the foreign function takes them, and to use standard lambda list keywords such as **&optional** even if they do not appear in *args*. If *lambda-list* is not supplied, the lambda list of *lisp-name* is generated from the list of *arg*s.

The **:reference**, **:reference-pass** and **:reference-return** types are useful with **define-foreign-function**. It is fairly common for a C function to return a value by setting the contents of an argument passed by reference (that is, as a pointer). This can be handled conveniently by using the **:reference-return** type, which dynamically allocates memory for the return value and passes a pointer to the C function. On return, the pointer is dereferenced and the value is returned as an extra multiple value from the Lisp function.

The **:reference-pass** type can be used to automatically construct an extra level of pointer for an argument. No extra results are returned.

The **:reference** type is like **:reference-return** but allows the initial value of the reference argument to be set.

result-type optionally specifies the type of the foreign function's return value. When *result-type* is an aggregate type, an additional keyword argument is placed in the lambda-list of the Lisp function. This keyword is named after the *result-pointer* argument or is called **:result-pointer** if unspecified. When calling the Lisp function, a foreign pointer must be supplied as the value of this keyword argument, pointing to an object of type *result-type*. The result of the foreign call is written into this object and the foreign pointer is returned as the primary value from the Lisp function. This allows the caller to maintain control over the lifetime of this object (in C this would typically be stored in a local variable). If *result-type* is **:void** or is omitted, then no value is returned.

calling-convention is ignored on non-Windows platforms, where there is no calling convention issue. On Windows, **:stdcall** is the calling convention used to call Win32 API functions and matches the C declarator **"__stdcall"**. This is the default value. **:cdecl** is the default calling convention for C/C++ programs and matches the C declarator **"__cdecl"**.

If *module* is the name of a module registered using **register-module** then that module is used to look up the symbol. Otherwise *module* should be a string, and a module named *module* is automatically registered and used to look up the symbol. Such automatically-registered modules have *connection-style* **:manual** - this prevents them being used by other **define-foreign-function** forms which do not specify a module.

Notes

The *module* argument is not accepted in LispWorks for UNIX. This restriction applies to LispWorks for UNIX only (not LispWorks for Linux, FreeBSD, or x86/x64 Solaris).

Compatibility note

In LispWorks 4.4 and previous versions, the default value for *language* is **:c**. In LispWorks 5.0 and later, the default value is **:ansi-c**.

Example

A simple example of the use of **define-foreign-function** is given in "Defining a FLI function" on page 5. More detailed examples are given in Chapter 4, "Advanced Uses of the FLI".

Here is an example using the **:reference-return** type.

Unix/Linux/Macintosh version:

```
int cfloor(int x, int y, int *remainder)
{
  int quotient = x/y;
  *remainder = x - y*quotient;
  return quotient;
}
```

Windows version:

```
__declspec(dllexport) int __cdecl cfloor(int x, int y,
int *remainder)
{
  int quotient = x/y;
  *remainder = x - y*quotient;
  return quotient;
}
```

In this foreign function definition the main result is the quotient and the second return value is the remainder:

```
(fli:define-foreign-function cfloor
    ((x :int)
     (y :int)
     (rem (:reference-return :int)))
 :result-type :int)

(cfloor 11 5 t)
=>
2,1
```

This example illustrates a use of the lambda list keyword **&optional** and a default value for the optional argument:

```
(define-foreign-function one-or-two-ints
    ((arg-one :int)
     &optional
     ((arg-two 42) :int)))
```

The call **(one-or-two-ints 1 2)** passes 1 and 2.

The call **(one-or-two-ints 1)** passes 1 and 42.

See also

define-foreign-callable
define-foreign-funcallable
define-foreign-variable
register-module

define-foreign-pointer *Macro*

Summary

Defines a new FLI pointer type.

Package

fli

Signature

define-foreign-pointer *name-and-options points-to-type* **&rest** *slots* **=>** *type-name*

name-and-options **::=** *type-name* **|** **(***type-name* **(***option****))**

option **::=** **(***option-name option-value***)**

Arguments

type-name	A symbol naming the new FLI type.
option-name	**:allow-null** or a **defstruct** option.
option-value	A symbol.
points-to-type	A foreign type.
slots	Slots of the new type.

Values

type-name	The name of the new FLI pointer type.

Description

The macro **define-foreign-pointer** defines a new FLI pointer type called *type-name*.

type-name is a subtype of **pointer**.

The option **:allow-null** takes an *option-value* of either **t** or **nil**, defaulting to **nil**. It controls whether the type *type-name* accepts **nil**.

The other allowed options are the **defstruct** options **:conc-name**, **:constructor**, **:predicate**, **:print-object**, **:print-function**. In each case the symbol supplied as *option-value* provides the corresponding operator for *type-name*.

define-foreign-type *Macro*

Summary Defines a new FLI type specifier.

Package **fli**

Signature

define-foreign-type *name-and-options lambda-list* **&body** *forms* **=>** *name*

name-and-options **::=** *name* **|** **(***name option*__*__**)**

option **::= (:foreign-name** *string***)**

Arguments

name	A symbol naming the new FLI type
string	A string specifying the foreign name of the type
lambda-list	A lambda list which is the argument list of the new FLI type
forms	One or more Lisp forms which provide a definition of the new type

Values

name	The name of the new FLI type

Description The macro **define-foreign-type** defines a new FLI type called *name*. The *forms* in the definition can be used to deter-

mine the behavior of the type, depending on the arguments supplied to the *lambda-list*.

Example

In the following example an integer array type specifier is defined. Note that the type takes a list as its argument, and uses this to determine the size of the array.

```
(fli:define-foreign-type :int-array (dimensions)
  `(:c-array :int ,@dimensions))

(setq number-array (fli:allocate-foreign-object
                    :type '(:int-array (2 2))))
```

In the next example a boolean type, called **:bool**, with the same size as an integer is defined.

```
(fli:define-foreign-type :bool () `(:boolean :int))

(fli:size-of :bool)
```

See also

define-c-typedef
define-foreign-converter
define-foreign-forward-reference-type
foreign-type-equal-p

define-foreign-variable *Macro*

Summary

Defines a Lisp function to access a variable in foreign code.

Package

fli

Signature

define-foreign-variable *the-name* **&key** *type accessor language no-check module* **=>** *lisp-name*

the-name **::=** *lisp-name* **|** **(***lisp-name foreign-name* **[***encoding***])**

encoding **::= :source | :object | :lisp | :dbcs**

accessor **::= :value | :address-of | :read-only | :constant**

language **::= :c | :ansi-c**

Arguments

the-name Names the Lisp function which is used to access the foreign variable.

lisp-name A symbol naming the Lisp accessor.

foreign-name A string or a symbol specifying the foreign name of the variable.

encoding An option controlling how the Lisp variable name is translated to match the foreign variable name in the foreign DLL. The *encoding* option can be one of the following:

`:source` tells LispWorks that *foreign-name* is the name of the variable in the foreign source code. This is the default value of *encoding* when *foreign-name* is a string.

`:object` tells LispWorks that *foreign-name* is the literal name of the variable in the foreign object code.

`:lisp` tells LispWorks that if *foreign-name* is a Lisp symbol, it must be translated and encoded. This is the default value of *encoding* if *foreign-name* is a symbol.

`:dbcs` modifies the variable name on Windows, as described for **`define-foreign-function`**.

type The FLI type corresponding to the type of the foreign variable to which Lisp is interfacing.

accessor An option specifying what kind of accessor is generated for the variable. It can be one of the following:

`:value` gets the value of the foreign variable directly. This is the default value when *type* is a non-aggregate type. (There is no default *accessor* for aggregate types.)

		:address-of returns a FLI pointer to the foreign variable. **:read-only** ensures that no **setf** method is defined for the variable, which means that its value can be read, but it cannot be set. **:constant** is like **:read-only** and will return a constant value. For example, this is more efficient for a variable that always points to the same string.
	language	The language in which the foreign source code for the variable is written. The default is **:ansi-c**.
	no-check	If **nil**, the types of the arguments provided when the Lisp function is called are compared with the expected types and an error is raised if they do not match. Setting *no-check* to **t** overrides this check.
	module	A string or symbol naming the module in which the foreign variable is defined.
Values	*lisp-name*	A symbol naming the Lisp accessor.

Description

The macro **define-foreign-variable** defines a Lisp accessor which can be used to get and set the value of a variable defined in foreign code.

If the foreign variable has a type corresponding to an FLI aggregate type, then *accessor* must be supplied (there is no default). If *accessor* is **:value**, then a copy of the object is allocated using **allocate-foreign-object**, and the copy is returned. In general, it is more useful to use *accessor* **:address-of** for aggregate types, to allow the original aggregate to be updated.

Notes

If you specify any of the FLI float types **:float**, **:double**, **:lisp-float**, **:lisp-single-float** and so on, then the value of *language* should be **:ansi-c**.

module is processsed as for **define-foreign-function**.

Example

The following example illustrates how to use the FLI to define a foreign variable, given the following C variable in a DLL:

```
int num;
```

The first example defines a Lisp variable, **num1**, to interface with the C variable **num**.

```
(fli:define-foreign-variable (num1 "num") :type :int)
```

The following commands return the value of **num**, and increase its value by 1:

```
(num1)

(incf (num1))
```

In the next example, the Lisp variable **num2** interfaces with **num** in a read-only manner.

```
(fli:define-foreign-variable (num2 "num")
  :type :int :accessor :READ-ONLY)
```

In this case, the next command still returns the value of **num**, but the second command raises an error, because **num2** is read-only.

```
(num2)

(incf (num2))
```

The final example defines a Lisp variable, **num3**, which accesses **num** through pointers.

```
(fli:define-foreign-variable (num3 "num")
  :type :int :accessor :address-of)
```

As a result, the next command returns a pointer to **num**, and to obtain the actual value stored by **num**, **num3** needs to be dereferenced.

```
(num3)

(fli:dereference (num3))
```

See also **define-foreign-callable**
define-foreign-function

define-opaque-pointer *Macro*

Summary Defines an opaque foreign pointer type.

Package **fli**

Signature **define-opaque-pointer** *pointer-type structure-type*

Arguments
pointer-type A symbol.
structure-type A symbol.

Description The macro **define-opaque-pointer** defines an opaque foreign pointer type and foreign structure type. An opaque pointer is a pointer to a structure which does not have a structure description. It is the equivalent to the C declaration

```
typedef struct structure-type *pointer-type;
```

An opaque pointer is useful for dealing with pointers that are returned by foreign functions and are then passed to other foreign functions. It checks the type of the foreign pointer, and thus prevents passing pointers of the wrong type.

Example Using the C standard file* pointer:

```
(fli:define-opaque-pointer file-pointer file)

(fli:define-foreign-function fopen
    ((name (:reference-pass :ef-mb-string))
     (mode (:reference-pass :ef-mb-string)))
  :result-type file-pointer)

(fli:define-foreign-function fgetc
    ((file file-pointer))
  :result-type :int)

(fli:define-foreign-function fclose
    ((file file-pointer)))

(fli:define-foreign-function fgets
    ((string
      (:reference-return (:ef-mb-string :limit 200)))
     (:constant 200 :int)
     (file file-pointer))
  :result-type (:pointer-integer :int)
  :lambda-list (file &aux string))

(defun print-a-file (name)
  (let ((file-pointer (fopen name "r")))
    (if (fli:null-pointer-p file-pointer)
        (error "failed to open ~a" name)
      (unwind-protect
          (loop (multiple-value-bind (res line)
                    (fgets file-pointer)
                  (when (zerop res) (return))
                  (princ line)))
        (fclose file-pointer)))))
```

See also **define-foreign-type**

dereference *Function*

Summary Accesses and returns the value of a foreign object.

Package **fli**

Signature

dereference *pointer* **&key** *index type copy-foreign-object* **=>** *value*

(setf dereference) *value pointer* **&key** *index type copy-foreign-object* **=>** *value*

Arguments

pointer An instance of a FLI pointer.

index An integer. If *index* is supplied, **dereference** assumes that *pointer* points to one element in an array of object, and returns the element at the *index* position in the array.

type The foreign object type that *pointer* points to. If the specified type is different to the actual type, **dereference** returns the value of the object in the format of *type* where possible.

copy-foreign-object

This option is only important when dealing with aggregate FLI types, which cannot be returned by value.

If set to **t**, **dereference** makes a copy of the aggregate object pointed to by *pointer* and returns the copy.

If set to **nil**, **dereference** returns the aggregate object directly.

If set to **:error** then **dereference** signals an error. This is the default value for *copy-foreign-object*.

Values

value The value of the dereferenced object at *pointer*.

Description

The function **dereference** accesses and returns the value of the FLI object pointed to by *pointer*, unless *pointer* points to an aggregate type. In the case of aggregates, the return value is specified by using the *copy-foreign-object* option.

An error is signaled if *value* is an aggregate type and *copy-foreign-object* is not set accordingly.

The value of an object at *pointer* can be changed using **(setf dereference)**. See the examples section for an example of this.

An error is signaled if *pointer* is a null pointer. You can use **null-pointer-p** to detect null pointers.

Example

In the following example a **LONG** type is defined and an instance, pointed to by **point**, with a specified initial value of 10 is created with memory allocated using **allocate-foreign-object**. The **dereference** function is then used to get the value that **point** points to.

```
(fli:define-c-typedef LONG :long)

(setq point (fli:allocate-foreign-object
             :type 'LONG
             :initial-element 10))

(fli:dereference point)
```

Finally, the value of the object of type **LONG** is changed to 20 using **(setf dereference)**.

```
(setf (fli:dereference point) 20)
```

In the next example, a boolean FLI type is defined, but is accessed as a **char**.

```
(fli:define-c-typedef BOOL (:boolean :int))

(setq point2 (fli:allocate-foreign-object :type 'BOOL))

(fli:dereference point2 :type :char)
```

See also

allocate-foreign-object
free-foreign-object
foreign-slot-value
null-pointer-p

disconnect-module *Function*

Summary — Disconnects the DLL associated with a registered module.

Package — **fli**

Signature — **disconnect-module** *name* **&key** *verbose remove* **=>**

Arguments

name	A symbol or string.
verbose	Either **nil** or a stream. Default value: **nil**.
remove	A boolean. Default value: **nil**.

Values — None.

Description — The function **disconnect-module** disconnects the DLL associated with a registered module specified by *name* and registered with **register-module**.

When disconnecting, if *verbose* is set to a recognized stream, then **disconnect-module** with send disconnection information to that stream.

If *remove* is **nil** then after disconnection the module will be in the same state as it was when first registered by **register-module**, that is, lookups for foreign symbols can still automatically reconnect the DLL. If *remove* is **t** then *name* is removed from the list of registered modules. Any foreign symbols which refer to the module will then be reset as unresolved symbols.

See also — **register-module**

enum-symbol-value
enum-value-symbol
enum-values
enum-symbols
enum-symbol-value-pairs *Functions*

Summary Finds values and symbols in a FLI enumerator type.

Package **fli**

Signature
enum-symbol-value *enum-type symbol* **=>** *value*
enum-value-symbol *enum-type value* **=>** *symbol*
enum-values *enum-type* **=>** *values*
enum-symbols *enum-type* **=>** *symbols*
enum-symbol-value-pairs *enum-type* **=>** *pairs*

Arguments

enum-type	A FLI enumerator type defined by **define-c-enum**.
symbol	A symbol.
value	An integer.

Values

value	An integer or **nil**.
symbol	A symbol or **nil**.
values	A list.
symbols	A list.
pairs	A list of conses.

Description The function **enum-symbol-value** returns the value *value* of symbol *symbol* in the FLI enumerator type *enum-type*, or **nil** if *enum-type* does not contain *symbol*.

The function **enum-value-symbol** returns the symbol *symbol* in the FLI enumerator type *enum-type* at value *value,* or **nil** if *value* is out of range for *enum-type*.

The functions **enum-values**, **enum-symbols** and **enum-symbol-value-pairs** respectively return a list of the values, symbols and pairs for the *enum-type*, where a pair is a cons of symbol and value.

enum-type must be defined by **define-c-enum**.

Example

```
(fli:define-c-enum colors red green blue)
=>
(:ENUM COLORS)

(fli:enum-symbol-value 'COLORS 'red)
=>
0

(fli:enum-value-symbol 'COLORS 0)
=>
RED

(fli:define-c-enum half_year (jan 1) feb mar apr may
jun)
=>
(:ENUM HALF_YEAR)

(fli:enum-symbol-value 'HALF_YEAR 'feb)
=>
2

(fli:enum-value-symbol 'HALF_YEAR 2)
=>
FEB

(fli:enum-symbol-value-pairs 'HALF_YEAR)
((JAN . 1) (FEB . 2) (MAR . 3) (APR . 4) (MAY . 5) (JUN
. 6))
```

See also

define-c-enum

fill-foreign-object *Function*

Summary — Fills a foreign object, given a pointer to it.

Package — **fli**

Signature — **fill-foreign-object** *pointer* **&key** *nelems byte* **=>** *pointer*

Arguments

pointer	A foreign pointer.
nelems	A non-negative integer. The default is **1**.
byte	An integer. The default is **0**.

Values

pointer	The foreign pointer.

Description — The function **fill-foreign-object** fills the pointer *pointer* with the value *byte*. If *nelems* is greater than 1, an array of objects starting at *pointer* is filled.

Example

```
(fli:with-dynamic-foreign-objects ()
  (let ((pp (fli:allocate-dynamic-foreign-object
             :type :char
             :initial-element 66
             :nelems 6)))
    (fli:fill-foreign-object pp :nelems 3 :byte 65)
    (loop for i below 6 collect
          (fli:dereference pp :type :char :index i))))
=>
(#\A #\A #\A #\B #\B #\B)
```

See also — **replace-foreign-object**

foreign-aref *Function*

Summary — Accesses and returns the value at a specified point in an array.

Package — **fli**

Signature

foreign-aref *array* **&rest** *subscripts* **=>** *value*

(setf foreign-aref) *value array* **&rest** *subscripts* **=>** *value*

Arguments

array	A FLI array or a pointer to a FLI array.
subscripts	A list of valid array indices for *array*.

Values

value	An element of *array*.

Description

The function **foreign-aref** accesses a specified element in an array and returns its value if the element is an immediate type. If it is an aggregate type, such as a **:struct**, **:union**, or **:c-array**, an error is signaled. The function **foreign-array-pointer** should be used to access such embedded aggregate data.

The value of an element in an array can be changed using **(setf foreign-aref)**. See the examples section for an example of this.

Example

In the first example, a 3 by 3 integer array is created, and **(setf foreign-aref)** is used to set all the elements to 42.

```
(setq array1 (fli:allocate-foreign-object
              :type '(:c-array :int 3 3)))

(dotimes (x 3)
         (dotimes (y 3)
                  (setf (fli:foreign-aref array1 x y)
                        42)))
```

Next, **foreign-aref** is used to dereference the value at position **2 2** in **array1**. Remember that the count for the indices of an array start at **0**.

```
(fli:foreign-aref array1 2 2)
```

In the following example, an array of arrays of integers is created. When an element is dereferenced, a copy of an array of integers is returned.

```
(setq array2 (fli:allocate-foreign-object
              :type '(:c-array (:c-array :int 3) 3)))

(fli:foreign-array-pointer array2 2)
```

The array returned can be bound to the variable **array3**, and accessed using **foreign-aref** again. This time an integer is returned.

```
(setq array3 *)

(fli:foreign-aref array3 1)
```

See also

foreign-array-dimensions
foreign-array-element-type
foreign-array-pointer
foreign-typed-aref

foreign-array-dimensions *Function*

Summary

Returns a list containing the dimensions of an array.

Package

fli

Signature

foreign-array-dimensions *array-or-type* **=>** *dimensions*

Arguments

array-or-type — A FLI array, a pointer to a FLI array or the name of a FLI array type.

Values

dimensions — A list containing the dimensions of *array-or-type*.

Description

The function **foreign-array-dimensions** takes a FLI array, a pointer to a FLI array or the name of a FLI array type as its argument and returns a list containing the dimensions of the array.

Examples In the following example an instance of a 3 by 4 array is created, and these dimensions are returned using the **foreign-array-dimensions** function.

```
(setq array1 (fli:allocate-foreign-object
              :type '(:c-array :int 3 4)))

(fli:foreign-array-dimensions array1)
```

See also **foreign-aref**
foreign-array-element-type
foreign-array-pointer

foreign-array-element-type *Function*

Summary Returns the type of the elements of an array.

Package **fli**

Signature **foreign-array-element-type** *array-or-type* **=>** *type*

Arguments *array-or-type* A FLI array, a pointer to a FLI array or the name of a FLI array type.

Values *type* The type of the elements of *array-or-type*.

Description The function **foreign-array-element-type** takes a FLI array, a pointer to a FLI array or the name of a FLI array type as its argument and returns the type of the elements of that array.

Examples In the following example a 3 by 4 array with integer elements is defined, and the **foreign-array-element-type** function is used to confirm that the elements of the array are indeed integers.

```
(setq array1 (fli:allocate-foreign-object
              :type '(:c-array :int 3 4)))

(fli:foreign-array-element-type array1)
```

See also **foreign-aref**
foreign-array-dimensions
foreign-array-pointer

foreign-array-pointer *Function*

Summary Returns a pointer to a specified element in an array.

Package **fli**

Signature **foreign-array-pointer** *array* **&rest** *subscripts* **=>** *pointer*

Arguments
array A FLI array or a pointer to a FLI array.
subscripts A list of valid array indices for *array*.

Values
pointer A pointer to the element at position *subscripts* in *array*.

Description The function **foreign-array-pointer** returns a pointer to a specified element in an array. The value pointed to can then be obtained by dereferencing the pointer returned, or set to a specific value using **(setf dereference)**.

Examples In this example a 3 by 2 array of integers is created, and a pointer to the element at position **2 0** is returned using **foreign-array-pointer**.

```
(setq array1 (fli:allocate-foreign-object
              :type '(:c-array :int 3 2)))

(setq array-ptr (fli:foreign-array-pointer array1 2 0))
```

The **(setf dereference)** function can now be used to set the value pointed to by **array-ptr**.

```
(setf (fli:dereference array-ptr) 42)
```

See also **foreign-aref**
foreign-array-dimensions
foreign-array-element-type

foreign-slot-names *Function*

Summary Returns a list of the slot names in a foreign structure.

Package **fli**

Signature **foreign-slot-names** *object* **=>** *slot-names*

Arguments

object	A foreign object or a pointer to a foreign object.

Values

slot-names	A list containing the slot names of *object*.

Description The **foreign-slot-names** function returns a list containing the slot names of a foreign object defined by **define-c-struct**. If *object* is not a structure, an error is signaled.

Example In the following example a structure with three slots is defined, an instance of the structure is made, and **foreign-slot-names** is used to return a list of the slot names.

```
(fli:define-c-struct POS
  (x :int)
  (y :int)
  (z :int))

(setq my-pos (fli:allocate-foreign-object :type 'POS))

(fli:foreign-slot-names my-pos)
```

See also **define-c-struct**
foreign-slot-value

foreign-slot-offset *Function*

Summary Returns the offset of a slot in a FLI object.

Package **fli**

Signature **foreign-slot-offset** *object-or-type slot-name* **=>** *offset*

Arguments

object-or-type	A foreign object, a pointer to a foreign object, or a foreign structure or union type.
slot-name	A symbol or a list of symbols identifying the slot to be accessed, as described for **foreign-slot-value**.

Values

offset	The offset, in bytes, of the slot *slot-name* in the FLI object *object*.

Description The function **foreign-slot-offset** returns the offset, in bytes, of a slot in a FLI object. The offset is the number of bytes from the beginning of the object to the start of the slot. For example, the offset of the first slot in any FLI object is 0.

Example The following example defines a structure, creates an instance of the structure pointed to by **dir**, and then finds the offset of the third slot in the object.

```
(fli:define-c-struct COMPASS
  (east :int)
  (west (:c-array :char 20))
  (north :int)
  (south :int))

(fli:foreign-slot-offset 'COMPASS 'north)

(setq dir (fli:allocate-foreign-object :type 'COMPASS))

(fli:foreign-slot-offset dir 'north)
```

See also **foreign-slot-value**
foreign-slot-pointer
size-of

foreign-slot-pointer *Function*

Summary Returns a pointer to a specified slot of an object.

Package **fli**

Signature **foreign-slot-pointer** *object slot-name* **&key** *type object-type* **=>** *pointer*

Arguments

object	A foreign object, or a pointer to a foreign object.
slot-name	A symbol or a list of symbols identifying the slot to be accessed, as described for **foreign-slot-value**.
type	The type of the slot *slot-name*.
object-type	The FLI structure type that contains *slot-name*. If this is passed, the compiler might be able to optimize the access to the slot. If this is omitted, the object type is determined dynamically from *object*.

Values

pointer	A pointer to the slot identified by *slot-name*.

Description The function **foreign-slot-pointer** takes a foreign object, a slot within the object, and optionally the type of the slot, and returns a pointer to the slot.

Example In the following example a structure type called **COMPASS** is defined. An instance of the structure is allocated using **allocate-foreign-object**, pointed to by **point1**. Then

foreign-slot-pointer is used to get a pointer, called **point2**, to the second slot of the foreign object.

```
(fli:define-c-struct COMPASS
  (west :int)
  (east :int))

(setq point1 (fli:allocate-foreign-object :type
                                          'COMPASS))

(setq point2 (fli:foreign-slot-pointer point1 'east
                                       :type :int))
```

The **:type** keyword can be used to return the value stored in the slot as a different type, providing the type is compatible. In the next example, **point3** is set to be a pointer to the same address as **point2**, but it expects the value stored there to be a boolean.

```
(setq point3 (fli:foreign-slot-pointer point1 'east
              :type '(:boolean :int)))
```

Using **dereference** the value can be set as an integer using **point2** and read as a boolean using **point3**.

```
(setf (fli:dereference point2) 0)

(fli:dereference point3)

(setf (fli:dereference point2) 1)

(fli:dereference point3)
```

See also

decf-pointer
incf-pointer
make-pointer
foreign-slot-value
foreign-slot-offset

foreign-slot-type *Function*

Summary Returns the type of a specified slot of a foreign object.

Package **fli**

Signature **foreign-slot-type** *object-or-type slot-name* **=>** *type*

Arguments

object-or-type	A foreign object, a pointer to a foreign object, or a foreign structure or union type.
slot-name	A symbol or a list of symbols identifying the slot whose type is to be returned. The value is interpreted as described for **foreign-slot-value**.

Values

type	The type of *slot-name*.

Description The function **foreign-slot-type** returns the type of a slot of a foreign object.

Example In the following example two new types, **EAST** and **WEST** are defined. Then a new structure, **COMPASS**, is defined, with two slots. An instance of the structure is created, and **foreign-slot-type** is used to get the type of the first slot of the structure.

```
(fli:define-c-typedef EAST (:boolean :int))

(fli:define-c-typedef WEST :long)

(fli:define-c-struct COMPASS
   (x EAST)
   (y WEST))

(fli:foreign-slot-type 'COMPASS 'x)

(setq dir (fli:allocate-foreign-object :type 'COMPASS))

(fli:foreign-slot-type dir 'x)
```

See also **foreign-slot-names**
foreign-slot-value

foreign-slot-value *Function*

Summary Returns the value of a slot in a foreign object.

Package **fli**

Signature **foreign-slot-value** *object slot-name* **&key** *type object-type copy-foreign-object* **=>** *value*

(setf foreign-slot-value) *value object slot-name* **&key** *type object-type copy-foreign-object* **=>** *value*

Arguments

object Either an instance of or a pointer to a FLI structure.

slot-name A symbol or a list of symbols identifying the slot to be accessed.

type The type of *object*. Specifying *type* makes accessing the object faster. If the specified type is different to the actual type, **foreign-slot-value** returns the value of the object in the format of *type* where possible.

object-type The FLI structure type that contains *slot-name*. If this is passed, the compiler might be able to optimize the access to the slot. If this is omitted, the object type is determined dynamically from *object*.

copy-foreign-object

This option is only important when dealing with slots which are aggregate FLI types, and cannot be returned by value. The recognized values are **t**, **nil** and **:error**:

If *copy-foreign-object* is **t**, **foreign-slot-value** makes a copy of the aggregate slot of the object pointed to by *pointer* and returns the copy.

If *copy-foreign-object* is **nil**, **foreign-slot-value** returns the aggregate slot of the object directly.

If *copy-foreign-object* is **:error** then **foreign-slot-value** signals an error. This is the default value for *copy-foreign-object*.

Value

value

The value of the slot *slot-name* in the FLI object *object* is returned.

Description

The function **foreign-slot-value** returns the value of a slot in a specified object. An error is signaled if the slot is an aggregate type and *copy-foreign-object* is not set accordingly. Use **foreign-slot-pointer** to access such aggregate slots.

If *slot-name* is a symbol then it names the slot of *object* to be accessed. If *slot-name* is a list of symbols, then these symbols name slots in nested structures starting with the outermost structure *object*, as in the **inner**/**middle**/**outer** example below.

The function **(setf foreign-slot-value)** can be used to set the value of a slot in a structure, as shown in the example below.

Example

In the following example a foreign structure is defined, an instance of the structure is made with **my-pos** pointing to the instance, and **foreign-slot-value** is used to set the **y** slot of the object to 10.

```
(fli:define-c-struct POS
  (x :int)
  (y :int)
  (z :int))

(setq my-pos (fli:allocate-foreign-object :type 'POS))

(setf (fli:foreign-slot-value my-pos 'y) 10)
```

The next forms both return the value of the **y** slot at **my-pos**, which is 10.

```
(fli:foreign-slot-value my-pos 'y)

(fli:foreign-slot-value my-pos 'y :object-type 'pos)
```

See the *LispWorks User Guide and Reference Manual* section "Optimizing your code" for an example showing how to inline foreign slot access.

This example accesses a slot in nested structures:

```
(fli:define-c-struct inner
  (v1 :int)
  (v2 :int))

(fli:define-c-struct middle
  (i1 (:struct inner))
  (i2 (:struct inner)))

(fli:define-c-struct outer
  (m1 (:struct middle))
  (m2 (:struct middle)))

(fli:with-dynamic-foreign-objects
    ((obj (:struct outer)))
  (setf (fli:foreign-slot-value obj '(m1 i2 v1)) 99))
```

See also

foreign-slot-pointer
foreign-slot-offset
dereference
with-foreign-slots

foreign-type-equal-p *Function*

Summary

Determines whether two foreign types are the same underlying foreign type.

Package

fli

Signature

foreign-type-equal-p *type1 type2* **=>** *result*

Arguments

type1 A foreign type.

type2 A foreign type.

Values *result* A boolean.

Description The function **foreign-type-equal-p** returns true if *type1* and *type2* are the same underlying foreign type, and false otherwise.

Example
```
(fli:define-foreign-type aa () '(:signed :byte))
=>
aa

(fli:define-foreign-type bb () '(:signed :char))
=>
bb

(fli:foreign-type-equal-p 'aa 'bb)
=>
t

(fli:foreign-type-equal-p 'bb :char)
=>
nil
```

See also **define-foreign-type**

foreign-type-error *Condition Class*

Summary The class of errors signaled when an object does not match a foreign type.

Package **fli**

Superclasses **type-error**

Description The condition class **foreign-type-error** is used for errors signaled when an object does not match a foreign type.

foreign-typed-aref *Function*

Summary — Accesses a foreign array and can be compiled to efficient code.

Package — **fli**

Signature — **foreign-typed-aref** *type array index* **=>** *value*

(setf foreign-typed-aref) *value type array index* **=>** *value*

Arguments

type	A type specifier.
array	A foreign pointer.
index	A non-negative **integer**.

Values

value	An element of *array*.

Description — The function **foreign-typed-aref** accesses a foreign array and is compiled to efficient code when compiled at safety 0. It corresponds to **sys:typed-aref** which accesses Lisp vectors.

type must evaluate to a supported element type for foreign arrays. In 32-bit LispWorks these types are **double-float**, **single-float**, **(unsigned-byte 32)**, **(signed-byte 32)**, **(unsigned-byte 16)**, **(signed-byte 16)**, **(unsigned-byte 8)**, **(signed-byte 8)** and **sys:int32**. In 64-bit LispWorks *type* can also be **(unsigned-byte 64)** or **(signed-byte 64)**.

array is a foreign pointer to a FLI array. Memory can be allocated with:

```
(fli:allocate-foreign-object
 :type :double
 :nelems
 (ceiling byte-size
          (fli:size-of :double)))
```

to get sufficient alignment for any call to **foreign-typed-aref**.

In the case the memory is allocated by the operating system the best approach is to reference it from Lisp by a pointer type, to avoid making a **:c-array** foreign type dynamically.

index should be a valid byte index for *array*. If *index* is declared to be of type **fixnum** then the compiler will optimize it slightly better. Some parts of the FLI (for example, **allocate-foreign-object**) assume **fixnum** sizes so it is best to use fixnums only.

Notes — Efficient access to a Lisp vector object is also available. See **sys:typed-aref** in the *LispWorks User Guide and Reference Manual*.

See also — **foreign-aref**

free *Function*

Summary — A synonym for **free-foreign-object**.

Package — **fli**

Signature — **free** *pointer* **=>** *null-pointer*

Description — The function **free** is a synonym for **free-foreign-object**.

See also — **free-foreign-object**

free-foreign-object *Function*

Summary — Deallocates the space in memory pointed to by a pointer.

Package — **fli**

Signature — **free-foreign-object** *pointer* **=>** *null-pointer*

Arguments	*pointer*	A pointer to the object to de-allocate.
Values	*null-pointer*	A pointer with address zero.

Description

The **free-foreign-object** function deallocates the space in memory pointed to by *pointer*, which frees the memory for other uses. The address of *pointer* is the start of a block of memory previously allocated by **allocate-foreign-object**.

If *pointer* is a null pointer then **free-foreign-object** takes no action.

Example

In the following example a boolean type is defined and an instance is created with memory allocated using **allocate-foreign-object**. The function **free-foreign-object** is then used to free up the memory used by the boolean.

```
(fli:define-c-typedef BOOL (:boolean :int))

(setq point (fli:allocate-foreign-object :type 'BOOL))

(fli:free-foreign-object point)
```

See also

allocate-foreign-object

incf-pointer *Function*

Summary

Increases the address held by a pointer.

Package

fli

Signature

incf-pointer *pointer* **&optional** *delta* **=>** *pointer*

Arguments	*pointer*	A FLI pointer.
	delta	An integer. The default value is 1.
Values	*pointer*	The pointer passed.

Description

The function **incf-pointer** increases the address held by the pointer. If *delta* is not given the address is increased by the size of the type pointed to by the pointer. The address can be increased by a multiple of the size of the type by specifying a *delta*.

The function **incf-pointer** is often used to move a pointer through an array of values.

Example

In the following example an array with 10 entries is defined. A copy of the pointer to the array is made, and is incremented and decremented.

```
(setq array-obj
      (fli:allocate-foreign-object :type :int
        :nelems 10
        :initial-contents '(0 1 2 3 4 5 6 7 8 9)))

(setq point1 (fli:copy-pointer array-obj))

(dotimes (x 9)
  (fli:incf-pointer point1)
  (print (fli:dereference point1)))

(dotimes (x 9)
  (fli:decf-pointer point1)
  (print (fli:dereference point1)))
```

See also

decf-pointer

locale-external-formats *Variable*

Summary

Provides a mapping from locale names to encodings

Package

fli

Description

The variable ***locale-external-formats*** contains the mapping from locale names to external formats that **set-locale** uses to set the correct defaults for FLI. The value is an alist with elements of the form:

(*locale multi-byte-ef wide-character-ef*)

The locale names are given as strings. If the first character of the string is #*, then that entry matches any locale having the rest of the string as a suffix. If the last character of the string is #*, then that entry matches any locale having the rest of the string as a prefix. Either external format may be given as **nil**, in which case the corresponding foreign type cannot be used without specifying an external format.

Notes

locale-external-formats is used only on Linux and Unix platforms. On Windows, the external formats are based on the Windows Code Page.

See also

:ef-mb-string
:ef-wc-string
set-locale

make-integer-from-bytes *Function*

Summary

Converts foreign bytes back to a Lisp integer.

Signature

make-integer-from-bytes *pointer length* **=>** *integer*

Arguments

pointer A foreign pointer.

length An integer.

Values

integer An integer.

Description

The function **make-integer-from-bytes** converts *length* bytes starting at *pointer* into the Lisp integer *integer*. The bytes and *length* must have been generated by **with-integer-bytes** or **convert-integer-to-dynamic-foreign-object**.

See also **with-integer-bytes**
convert-integer-to-dynamic-foreign-object

make-pointer *Function*

Summary Creates a pointer to a specified address.

Package **fli**

Signature **make-pointer &key** *address type pointer-type symbol-name functionp module encoding* **=>** *pointer*

Arguments

address	The address pointed to by the pointer to be created.
type	The type of the object pointed to by the pointer to be created.
pointer-type	The type of the pointer to be made.
symbol-name	A string or a symbol.
functionp	If *type* or *pointer-type* are not specified, then *functionp* can be used. If **t**, the pointer made is a pointer to type **:function**. This is the default value. If **nil**, the pointer made is a pointer to type **:void**.
module	A symbol or string naming a module, or **nil**.
encoding	One of **:source**, **:object**, **:lisp** or **:dbcs**.

Values

pointer	A pointer to *address*.

Description The function **make-pointer** creates a pointer of a specified type pointing to a given address, or optionally to a function or foreign callable.

symbol-name is either a string containing the name of a foreign symbol defined in a DLL, or a string or symbol naming a foreign callable defined by **define-foreign-callable**.

encoding controls how *symbol-name* is processed. The values are interpreted like the *encode* argument of **define-foreign-callable**. The default value of *encoding* is **:source** if *symbol-name* is a string and **:lisp** if *symbol-name* is a symbol.

In the case of a pointer to a foreign callable or foreign function, the *module* keyword can be used to ensure that the pointer points to the function in the correct DLL if there are other DLLs containing functions with the same name. *module* is processed as by **define-foreign-function**.

Example

In the following example a module is defined, and the variable **setpoint** is set equal to a pointer to a function in the module.

```
(fli:register-module :user-dll :real-name "user32")

(setq setpoint
      (fli:make-pointer :symbol-name "SetCursorPos"
                        :module :user-dll)
```

See also

copy-pointer
define-foreign-callable
register-module
with-coerced-pointer

malloc *Function*

Summary

A synonym for **allocate-foreign-object**.

Package

fli

Signature **malloc &key** *type pointer-type initial-element initial-contents nelems* **=>** *pointer*

Description The function **malloc** is a synonym for **allocate-foreign-object**.

See also **allocate-foreign-object**

module-unresolved-symbols *Function*

Summary Returns foreign symbol names that cannot be resolved.

Note: This function is not defined in LispWorks for UNIX.

Package **fli**

Signature **module-unresolved-symbols &key** *module* **=>** *list*

Arguments *module* **nil**, **:all**, or a string. The default is **:all**.

Values *list* A list of strings.

Description The function **unresolved-module-symbols** returns a list of foreign symbol names, each of which cannot be resolved in the currently known modules.

If *module* is **nil**, then *list* includes only those names not associated with a module.

If *module* is **:all**, then *list* includes the unresolved names in all modules and those not associated with a module.

If *module* is a string, then it names a module and *list* contains only the unresolved symbols associated with that module.

See also **register-module**

null-pointer *Variable*

Summary A null pointer.

Package **fli**

Description The variable ***null-pointer*** contains a **(:pointer :void)** with address 0.

This provides a simple way to pass a null pointer when needed.

Example
```
(fli:pointer-address fli:*null-pointer*)
=>
0

(fli:null-pointer-p fli:*null-pointer*)
=>
T
```

See also **pointer-address**
null-pointer-p
:pointer

null-pointer-p *Function*

Summary Tests a pointer to see if it is a null pointer.

Package **fli**

Signature **null-pointer-p** *pointer* **=>** *result*

Arguments *pointer* A FLI pointer.

Values *result* A boolean.

Description The function **null-pointer-p** is used to determine if a pointer is a null pointer. A null pointer is a pointer pointing to address 0.

If *pointer* is a null pointer (that is, a pointer pointing to address 0) then *result* is true, otherwise **null-pointer-p** returns false.

Example

In the following example a pointer to an **:int** is defined, and tested with **null-pointer-p**. The pointer is then freed, becoming a null pointer, and is once again tested using **null-pointer-p**.

```
(setq point (fli:allocate-foreign-object :type :int))
(fli:null-pointer-p point)
(fli:free-foreign-object point)
(fli:null-pointer-p point)
```

See also

null-pointer
pointer-address
pointer-eq

pointer-address *Function*

Summary

Returns the address of a pointer.

Package

fli

Signature

pointer-address *pointer* **=>** *address*

Arguments

pointer A FLI pointer.

Values

address The address pointed to by *pointer*.

Description

The function **pointer-address** returns the address of a pointer.

Example

In the following example a pointer is defined, and its address is returned using **pointer-address**.

```
(setq point (fli:allocate-foreign-object :type :int))

(fli:pointer-address point)
```

See also

null-pointer-p
pointer-eq

pointer-element-size *Function*

Summary

Returns the size in bytes of a foreign object or a foreign type.

Package

fli

Signature

pointer-element-size *pointer-or-type* **=>** *size*

Arguments

pointer-or-type A FLI pointer to a foreign object or the name of a FLI pointer type.

Values

size A non-negative integer.

Description

The function **pointer-element-size** returns the size, in bytes, of the object or type specified.

If *pointer-or-type* is an FLI pointer, *size* is the size, in bytes, of the object pointed to by *pointer-or-type*.

If *pointer-or-type* is the name of a FLI pointer type, *size* is the size, in bytes, of the elements of that type.

Example

In the following example a pointer to an integer is created. Then the size in bytes of the integer is returned using **pointer-element-size**.

```
(setq point (fli:allocate-foreign-object :type :int))

(fli:pointer-element-size point)
```

See also

pointer-element-type
size-of

pointer-element-type *Function*

Summary — Returns the type of the foreign object pointed to by a FLI pointer.

Package — **fli**

Signature — **pointer-element-type** *pointer-or-type* **=>** *type*

Arguments

pointer-or-type	A FLI pointer to a foreign object or the name of a FLI pointer type.

Values

type	The name of a FLI pointer type.

Description — The function **pointer-element-type** returns the type of the foreign object specified, or the element type of the foreign type specified.

If *pointer-or-type* is a FLI pointer, *type* is the type of the foreign object pointed to by *pointer-or-type*.

If *pointer-or-type* is the name of a FLI pointer type, *type* is the type of the elements of that FLI pointer type.

Example — In the following example a pointer to an integer is defined, and **pointer-element-type** is used to confirm that the pointer points to an integer.

```
(setq point (fli:allocate-foreign-object :type :int))

(fli:pointer-element-type point)
```

In the next example a new type, **HAPPY**, is defined. The pointer **point** is set to point to an instance of **HAPPY**, and **pointer-element-type** is used to find the type of the object pointed to by **point**.

```
(fli:define-c-typedef HAPPY :long)

(setq point (fli:allocate-foreign-object :type 'HAPPY))

(fli:pointer-element-type point)
```

See also **foreign-slot-type**
pointer-element-size
pointer-element-type-p

pointer-element-type-p *Function*

Summary Tests whether a FLI pointer matches a given element type.

Package **fli**

Signature **pointer-element-type-p** *pointer type* **=>** *result*

Arguments
pointer A FLI pointer to a foreign object.
type A foreign type.

Values
result A boolean.

Description The function **pointer-element-type-p** returns true if the element type of the foreign object pointed to by *pointer* has the same underlying type as *type*.

Example

```
(setq point (fli:allocate-foreign-object :type :int))
=>
=> #<Pointer to type :INT = #x007F3970>

(fli:pointer-element-type-p point :signed)
->
t
```

See also **pointer-element-type**

pointer-eq *Function*

Summary Test whether two pointers point to the same memory address.

Package **fli**

Signature **pointer-eq** *pointer1 pointer2* **=> boolean**

Arguments

pointer1	A FLI pointer.
pointer2	A FLI pointer.

Values

boolean	If *pointer1* points to the same address as *pointer2*, **pointer-eq** returns **t**, otherwise it returns **nil**.

Description The function **pointer-eq** tests whether two pointers point to the same address, and returns **t** if they do, and **nil** if they do not.

Example In the following example a pointer, **point1**, is defined, and **point2** is set equal to it. Both are then tested to see if they are equal to each other using **pointer-eq**. Then **point2** is defined to point to a different object, and the two pointers are tested for equality again.

```
(setq point1 (fli:allocate-foreign-object :type :int))
(setq point2 point1)
(fli:pointer-eq point1 point2)
(setq point2 (fli:allocate-foreign-object :type :int))
(fli:pointer-eq point1 point2)
```

See also **null-pointer-p**
pointerp

pointer-pointer-type *Function*

Summary Returns the pointer type of a FLI pointer.

Package **fli**

Signature **pointer-pointer-type** *pointer* **=>** *pointer-type*

Arguments *pointer* A FLI pointer.

Values *pointer-type* The pointer type of *pointer*.

Description The function **pointer-pointer-type** returns the pointer type of the foreign pointer *pointer*.

Example
```
(setq point (fli:allocate-foreign-object :type :int))
=>
#<Pointer to type :INT = #x007F3DF0>

(fli:pointer-pointer-type point)
=>
(:POINTER :INT)

(fli:free-foreign-object point)
=>
#<Pointer to type :INT = #x00000000>
```

See also **make-pointer**

pointerp *Function*

Summary Tests whether an object is a pointer or not.

Package **fli**

Signature **pointerp** *pointer* **=>** *result*

Arguments *pointer* An object that may be a FLI pointer.

Values *result* A boolean.

Description The function **pointerp** tests whether the argument *pointer* is a pointer.

result is **t** if *pointer* is a pointer, otherwise **nil** is returned.

Example

In the following example a pointer, **point**, is defined, and an object which is not a pointer is defined. Both are tested using **pointerp**.

```
(setq point (fli:allocate-foreign-object :type :int))

(setq not-point 7)

(fli:pointerp point)

(fli:pointerp not-point)
```

See also

null-pointer-p
pointer-address
pointer-eq

print-collected-template-info *Function*

Summary

Prints the FLI Template information in the image.

Package

fli

Signature

print-collected-template-info &key *output-stream* **=> nil**

Arguments

output-stream An output stream designator. The default is **nil**, meaning standard output.

Description

The FLI converters require pieces of compiled code known as FLI templates, and sometimes your delivered application will need extra templates not included in LispWorks as shipped.

The function **print-collected-template-info** prints the information about FLI templates that has been collected. These must be compiled and loaded into your application.

See the *LispWorks Delivery User Guide* for further details.

See also

start-collecting-template-info

print-foreign-modules *Function*

Summary Prints the foreign modules loaded into the image by **register-module**.

Package **fli**

Signature **print-foreign-modules &optional** *stream verbose* **=> nil**

Arguments
- *stream* An output stream.
- *verbose* A generalized boolean.

Description The function **print-foreign-modules** prints a list of the foreign modules loaded via **register-module**, to the stream *stream*.

The default value of *stream* is the value of ***standard-output***.

If *verbose* is true, more information is printed if possible. Currently this only has an effect in LispWorks for Unix. The default value of *verbose* is **nil**.

See also **register-module**

register-module *Function*

Summary Informs LispWorks of the presence of a dynamic library.

Signature **register-module** *name* **&key** *connection-style lifetime real-name dlopen-flags* **=>** *name*

Arguments
- *name* A symbol or string specifying the Lisp name the module will be registered under.

connection-style A keyword determining when the connection to the dynamic library is made. One of **:automatic**, **:manual** or **:immediate**. The default value is **:automatic**.

lifetime A keyword specifying the lifetime of the connection. One of **:indefinite** or **:session**. The default value is **:indefinite.**

real-name Overrides the *name* for identifying the actual dynamic library to connect to.

dlopen-flags Controls use of **dlopen** on Unix-based systems. One of **t**, **nil**, **:local-now**, **:global-now**, **:global-lazy**, **:local-lazy**, or a fixnum. The default value is **nil** on Darwin, and **t** on other platforms.

Values

name The *name* argument.

Description

The function **register-module** explicitly informs LispWorks of the presence of a DLL or shared object file, referred to here as a dynamic library. Functions such as **make-pointer** and **define-foreign-function** have a *module* keyword which can be used to specify which module the function refers to.

The main use of modules is to overcome ambiguities that can arise when two different dynamic libraries have functions with the same name.

If an application is delivered after calling **register-module**, then the application attempts to reload the module on startup but does not report any errors. Therefore it is strongly recommended that you call **register-module** during initialization of your application, rather than at compile time or build time. Loading the module at run time allows you to:

- report loading errors to the user or application error log
- compute the path (as described below), if needed
- make the loading conditional, if needed

You should compute and supply the appropriate full path if possible.

name is used for explicit look up from the **:module** keyword of functions such as **define-foreign-function**. If *name* is a symbol, then *real-name* should also be passed to provide a filename. If *real-name* is not specified then *name* must be a string and specifies the actual name of the dynamic library to connect to.

The naming convention for the module *name* can contain the full pathname for the dynamic library. For example, a pathname such as

```
#p"C:/MYPRODUCT/LIBS/MYLIBRARY.DLL"
```

is specified as

```
"C:\\MYPRODUCT\\LIBS\\MYLIBRARY.DLL"
```

On Windows, if the module is declared without an extension, "**.DLL**" is automatically appended to the name. To declare a name without an extension it must end with the period character ("."). On other platforms, you should provide the extension, since there is more than one library format. Typical would be **.so** on Linux or FreeBSD and **.dylib** on Macintosh.

If a full pathname is not specified for the module, then it is searched for.

On Windows the following directories (in the given order) are searched:

1. The directory of the executable.
2. The current directory. This step can be switched off on Windows XP.
3. The Windows system directory (as specified by **GetSystemDirectory**). For Windows NT/2000/XP the 16-bit system directory (**SYSTEM**) is also searched.
4. The Windows directory (as specified by **GetWindowsDirectory**)

5. Directories specified by the **PATH** variable.

The simplest approach is usually to place the DLL in the same directory as the LispWorks executable or application. However if you really need different directories then be sure to call **register-module** at run time with the appropriate pathname.

On Linux, the search is conducted in this order:

1. Directories on the user's **LD_LIBRARY** path environment variable.
2. The list of libraries specified in **/etc/ld.so.cache**.
3. **/usr/lib**, followed by **/lib**.

If *connection-style* is **:automatic** then the system automatically connects to a dynamic library when it needs to resolve currently undefined foreign symbols.

If *connection-style* is **:manual** then the system only connects to the dynamic library if the symbol to resolve is explicitly marked as coming from this module via the **:module** keyword of functions such as **define-foreign-function**.

Note: on LispWorks for UNIX only (not LispWorks for Linux, FreeBSD, or x86/x64 Solaris) this value **:manual** for *connection-style* is not supported.

If *connection-style* is **:immediate** then the connection to the dynamic library is made immediately. This checks that the library can actually be loaded before its symbols are actually needed: an error is signalled if loading fails.

If *lifetime* is **:session** then the module is disconnected when Lisp starts up. The only supported value of *lifetime* in LispWorks for UNIX is **:indefinite**.

You should load only libraries of the correct architecture into LispWorks. You will need to obtain a 32-bit dynamic library for use with 32-bit LispWorks and similarly you need a 64-bit dynamic library for use with 64-bit LispWorks. (If you build

the dynamic library, pass **-m32** or **-m64** as appropriate to **cc**.) You can conditionalize the argument to **register-module** as in the example below.

Note: On Linux, you may see a spurious "No such file or directory" error message when loading a dynamic library of the wrong architecture. The spurious message might be localized.

Note: In LispWorks for UNIX the loader function **link-load:read-foreign-modules** is now deprecated in favor of **register-module**.

Note: static libraries are not supported except on UNIX. For example, on Linux evaluating this form:

```
(fli:register-module "libc.a"
                     :real-name "/usr/lib/libc.a"
                     :connection-style :immediate)
```

results in an error:

```
Could not register handle for external module "libc"
/usr/lib/libc.a : invalid ELF header
```

The problem is that **libc.a** is a static library. Instead, do:

```
(fli:register-module "libc.so"
                     :real-name "libc.so.6"
                     :connection-style :immediate)
```

Note that **:real-name** is given a relative path in this case, because **libc** is a standard library on Linux and it is best to let the operating system locate it.

dlopen-flags has an effect only on Unix-based systems. It controls the value that is passed to **dlopen** as second argument when the module is connected, and on Darwin it also controls whether **dlopen** is used at all.

The keyword values of *dlopen-flags* correspond to combinations of **RTLD_*** constants (see **/usr/include/dlfcn.h**). The value **t** means the same as **:local-lazy**. The value **nil** means the same as **t** except on Darwin. On Darwin the value

nil means do not use **dlopen**, and use the older interfaces instead.

A fixnum value means pass this value *dlopen-flags* to **dlopen** without checking. It is the responsibility of the caller to get it right in this case.

The default value of *dlopen-flags* is **nil** on Darwin, because it seems **dlopen** does not work properly on this platform.

Notes

1. It is strongly recommended that you call **register-module** during initialization of your application, rather than at compile time or build time.
2. When developing with foreign code in LispWorks, the utilities provided in the Editor are useful - see "Compiling and Loading Foreign Code with the Editor" on page 190

Example

In the following example on Windows, the **user32** DLL is registered, and then a foreign function called **set-cursor-pos** is defined to explicitly reference the **SetCursorPos** function in the **user32** DLL.

```
(fli:register-module :user-dll :real-name "user32")

(fli:define-foreign-function (set-cursor-pos
                              "SetCursorPos")
    ((x :long)
     (y :long))
  :module :user-dll)
```

This example on Linux loads the shared library even though its symbols are not yet needed. An error is signalled if loading fails:

```
(fli:register-module "libX11.so"
                     :connection-style :immediate)
```

This example loads a module from the same directory as the Lisp executable, by executing this code at runtime:

```
(fli:register-module
 modulename
 :file-name
 (merge-pathnames "modulefilename.dylib"
                  (lisp-image-name)))
```

In this last example a program which runs in both 32-bit LispWorks and 64-bit LispWorks loads the correct library for each architecture:

```
(fli:register-module #+:lispworks-32bit "mylib32"
                     #+:lispworks-64bit "mylib64")
```

See also

connected-module-pathname
define-foreign-function
make-pointer
module-unresolved-symbols
print-foreign-modules

replace-foreign-array *Function*

Summary

Copies the contents of one foreign or Lisp array into another.

Package

fli

Signature

replace-foreign-array *to from* **&key** *start1 start2 end1 end2* **=>** *to*

Arguments

to	A foreign array, foreign pointer or a Lisp array.
from	A foreign array, foreign pointer or a Lisp array.
start1	An integer.
start2	An integer.
end1	An integer.
end2	An integer.

Values

to — A foreign array, foreign pointer or a Lisp array.

Description

The function **`replace-foreign-array`** copies the contents of the array specified by *from* into another array specified by *to*. The arrays element types must have the same size and both be either signed or unsigned.

The argument *to* is destructively modified by copying successive elements into it from *from*. Elements of the subsequence of *from* bounded by *start2* and *end2* are copied into the subsequence of *to* bounded by *start1* and *end1*. If these subsequences are not of the same length, then the shorter length determines how many elements are copied; the extra elements near the end of the longer subsequence are not involved in the operation.

Each of *to* and *from* can be one of the following:

A lisp array. The start and end are handled in the same way as Common Lisp sequence functions.

A foreign array. The start and end are handled in the same way as Common Lisp sequence functions.

A pointer to a foreign array

The start and end are handled in the same way as Common Lisp sequence functions.

A pointer to any other foreign object.

In this case, the pointer is assumed to point to an array of such objects. Start and end are used as indices into that array, but without any bounds checking.

Example

This example demonstrates copying from a foreign pointer to a lisp array.

An initial array filled with 42:

```
(setq lisp-array
      (make-array 10
                  :element-type '(unsigned-byte 8)
                  :initial-element 42))
```

A foreign pointer to 10 consecutive unsigned chars:

```
(setq foreign-array
      (fli:allocate-foreign-object
       :type '(:unsigned :char)
       :nelems 10
       :initial-contents '(1 2 3 4 5 6 7 8 9 10)))
```

Copy some of the unsigned char into the lisp array. Without **:start2** and **:end2**, only the first unsigned char would be copied:

```
(fli:replace-foreign-array
 lisp-array foreign-array
 :start1 3
 :start2 5 :end2 8)
=>
#(42 42 42 6 7 8 42 42 42 42)
```

This example demonstrates copying from a foreign array to a lisp array.

A pointer to a foreign array of 10 unsigned chars:

```
(setq foreign-array
      (fli:allocate-foreign-object
       :type
       '(:c-array (:unsigned :char) 10)))

(dotimes (i 10)
  (setf (fli:foreign-aref foreign-array i) (1+ i)))
```

Copy part of the foreign array into the lisp array:

```
(fli:replace-foreign-array
 lisp-array foreign-array :start1 7)
=>
#(42 42 42 6 7 8 42 1 2 3)
```

See also

allocate-foreign-object

copy-pointer

make-pointer
replace-foreign-object

replace-foreign-object *Function*

Summary Copies the contents of one foreign object into another.

Package **fli**

Signature **replace-foreign-object** *to from* **&key** *nelems* **=>** *pointer*

Arguments

to	A foreign object or a pointer to a foreign object.
from	A foreign object or a pointer to a foreign object.
nelems	An integer.

Values

pointer	A pointer to the object specified by *from*.

Description The function **replace-foreign-object** copies the contents of the foreign object specified by *from* into another foreign object specified by *to*. Block copying on an array of elements can also be performed by specifying the number of elements to copy using the **nelems** keyword.

Example In the following object two sets of ten integers are defined. The object **from-obj** contains the integers from 0 to 9. The object **to-obj** contains random values. The **replace-foreign-object** function is then used to copy the contents of **from-obj** into **to-obj**.

```
(setf from-obj
      (fli:allocate-foreign-object
                  :type :int
                  :nelems 10
                  :initial-contents
                  '(0 1 2 3 4 5 6 7 8 9)))
```

```
(setf to-obj
      (fli:allocate-foreign-object
                  :type :int
                  :nelems 10 ))

(fli:replace-foreign-object to-obj from-obj :nelems 10)
```

See also

allocate-foreign-object
fill-foreign-object
copy-pointer
make-pointer
replace-foreign-array

set-locale *Function*

Summary

Sets the C locale and the default for FLI string conversions.

Package

fli

Signature

set-locale &optional *locale* **=>** *c-locale*

Arguments

locale A string, the locale name.

Values

c-locale A string naming the C locale, or **nil**..

Description

This function can be called to set the C locale; if you set the locale in any other way, then Lisp might not do the right thing when passing strings and characters to C. It calls **setlocale** to tell the C library to switch and then calls **set-locale-encodings** to tell the FLI what conversions to do when passing strings and characters to C. The *locale* argument should be a locale name; if not passed, it defaults according to the OS conventions.

If **set-locale** fails to set the C locale, a warning is signaled, **nil** is returned and the FLI conversion defaults are not modified.

Example

On a Windows system:

```
(fli:set-locale "English_UK")
=>
"English_United Kingdom.1252"
```

On a Linux system:

```
(fli:set-locale)
=>
"en_US"
```

See also

convert-from-foreign-string
convert-to-foreign-string
:ef-mb-string
:ef-wc-string
locale-external-formats
set-locale-encodings
with-foreign-string

set-locale-encodings *Function*

Summary

Tells the FLI what default conversions to use when passing strings and characters to C.

Package

fli

Signature

set-locale-encodings *mb wc* **=>** *mb*

Arguments

mb	An external format specification.
wc	An external format specification, or **nil**..

Description

The function **set-locale-encodings** changes the default encodings used by those FLI functions and types which convert strings and characters and accept an **:external-format** argument.

set-locale calls **set-locale-encodings** after successfully setting the C locale.

See also
convert-from-foreign-string
convert-to-foreign-string
:ef-mb-string
:ef-wc-string
set-locale-encodings
with-foreign-string

size-of *Function*

Summary Returns the size in bytes of a foreign type.

Package **fli**

Signature **size-of** *type-name* **=>** *size*

Arguments
type-name A foreign type whose size is to be determined.

Values
size The size of the foreign type *type-name* in bytes.

Description The function **size-of** returns the size in bytes of the foreign language type named by *type-name*.

Example This example returns the size of the C integer type (usually 4 bytes on supported platforms):

```
(fli:size-of :int)
```

This example returns the size of a C array of 10 integers:

```
(fli:size-of '(:c-array :int 10))
```

The function **size-of** can also be used to determine the size of a structure:

```
(fli:define-c-struct POS
  (x :int)
  (y :int)
  (z :int))

(fli:size-of 'POS)
```

See also **allocate-foreign-object**
free-foreign-object

start-collecting-template-info *Function*

Summary Nullifies the FLI Template information in the image.

Package **fli**

Signature **start-collecting-template-info => nil**

Description The FLI converters require pieces of compiled code known as FLI templates, and sometimes your delivered application will need extra templates not included in LispWorks as shipped.

The function **start-collecting-template-info** throws away any information about FLI templates that has been collected. Call it when you want to start collecting to create a definitive set of template information.

See the *LispWorks Delivery User Guide* for further details.

See also **print-collected-template-info**

with-coerced-pointer *Macro*

Summary Makes a temporary copy of a pointer, executes a list of forms which may use and alter the copy of the pointer across the scope of the macro, and then deallocates the memory provided for the copy of the pointer.

Package **fli**

Signature **with-coerced-pointer** (*binding-name* **&key** *type pointer-type*) *pointer* **&body** *body* **=>** *last*

Arguments

binding-name	A temporary name used to access a copy of *pointer*.
type	The type of the object pointed to by the temporary pointer. This keyword can be used to access the data at the pointer as a different type.
pointer-type	The pointer-type of the temporary pointer.
pointer	A FLI pointer of which a copy is made. The lifetime of the copy is across the scope of the **with-coerced-pointer** macro.
body	A list of forms to be executed across the scope of the temporary pointer binding.

Values

last	The value of the last form in *body*.

Description The macro **with-coerced-pointer** makes a temporary copy of a pointer, and executes a list of forms which may use the copy across the scope of the macro. Once the macro has terminated the memory allocated to the copy of the pointer is automatically freed.

Example In the following example an array of ten integers is defined, pointed to by **array-obj**. The macro **with-coerced-pointer** is used to return the values stored in the array, without altering **array-obj**, or permanently tying up memory for a second pointer.

```
(setf array-obj
      (fli:allocate-foreign-object :type :int
                  :nelems 10
                  :initial-contents
                  '(0 1 2 3 4 5 6 7 8 9)))
```

```
(fli:with-coerced-pointer (temp) array-obj
  (dotimes (x 10)
    (print (fli:dereference temp))
    (fli:incf-pointer temp)))
```

See also

allocate-dynamic-foreign-object
free-foreign-object
with-dynamic-foreign-objects

with-dynamic-foreign-objects *Macro*

Summary

Allocates memory for a list of foreign objects, executes a list of forms which may use the objects across the scope of the macro, and then deallocates the foreign objects.

Package

fli

Signature

with-dynamic-foreign-objects *bindings* **&body** *body* **=>** *last*

bindings **::= (***binding****)**

binding **::= (***var foreign-type* **&key** *initial-element initial-contents fill nelems size-slot***)**

body **::=** *form******

Arguments

var	A symbol to be bound to a foreign type.
foreign-type	A foreign type descriptor to be bound to the variable *var*.
form	A form to be executed with *bindings* in effect.

Values

last	The value of the last *form* in *body*.

Description

The macro **with-dynamic-foreign-objects** binds variables according to the list *bindings*, and then executes *body*. Each element of *bindings* is a list which binds a symbol to a pointer which points to a locally allocated instance of a foreign type.

initial-element, *initial-contents*, *fill*, *nelems* and *size-slot* initialize the allocated instance as if by **allocate-foreign-object**.

The lifetime of the bound foreign objects, and hence the allocation of the memory they take up, is within the scope of the **with-dynamic-foreign-objects** function.

Any object created with **allocate-dynamic-foreign-object** within *body* will automatically be deallocated once the scope of the **with-dynamic-foreign-objects** function has been left.

Compatibility note

There is an alternative syntax for *binding* with an optional *initial-element* which is the only way to supply an initial element in LispWorks 5.0 and previous versions. Like this:

binding **::= (***var foreign-type* **&optional** *initial-element***)**

This alternative syntax is deprecated in favor of the keyword syntax for *binding* defined in "Signature" above which is supported in LispWorks 5.1 and later.

Example

This example shows the use of **with-dynamic-foreign-objects** with an implicitly created pointer.

Windows version:

```
typedef struct {
 int one;
 float two;
} foo ;

__declspec(dllexport) void __cdecl init_alloc(foo *ptr,
int a, float b)
{
 ptr->one = a;
 ptr->two = b;
};
```

Unix/Linux/Macintosh version:

```
typedef struct  {
 int one;
 float two;
} foo ;

void init_alloc(foo * ptr, int a, float b)
{
 ptr->one = a;
 ptr->two = b;
};
```

Here are the FLI definitions interfacing to the above C code:

```
(fli:define-c-typedef (foo (:foreign-name "foo"))
  (:struct (one :int) (two :float)))

(fli:define-foreign-function (init-alloc "init_alloc")
    ((ptr (:pointer foo))
     (a :int)
     (b :float))
  :result-type :void
  :calling-convention :cdecl)
```

Try this test function which uses **`with-dynamic-foreign-objects`** to create a transient **`foo`** object and pointer:

```
(defun test-alloc (int-value float-value &optional
(level 0))
  (fli:with-dynamic-foreign-objects ((object foo))
    (init-alloc object int-value float-value)
    (format t "~%Level - ~D~&   object : ~S~&   slot one
: ~S~&   slot two : ~S~&"
            level object
            (fli:foreign-slot-value object 'one)
            (fli:foreign-slot-value object 'two))
    (when (> int-value 0)
      (test-alloc (1- int-value)
                  (1- float-value) (1+ level)))
    (when (> float-value 0)
      (test-alloc (1- int-value)
                  (1- float-value) (1+ level)))))
```

```
(test-alloc 1 2.0)
=>
Level - 0
   object : #<Pointer to type FOO = #x007E6338>
   slot one : 1
   slot two : 2.0

Level - 1
   object : #<Pointer to type FOO = #x007E6340>
   slot one : 0
   slot two : 1.0

Level - 2
   object : #<Pointer to type FOO = #x007E6348>
   slot one : -1
   slot two : 0.0

Level - 1
   object : #<Pointer to type FOO = #x007E6340>
   slot one : 0
   slot two : 1.0

Level - 2
   object : #<Pointer to type FOO = #x007E6348>
   slot one : -1
   slot two : 0.0
```

A further example using **with-dynamic-foreign-objects** and a pointer created explicitly by **allocate-dynamic-foreign-object** is given in "An example of dynamic memory allocation" on page 7.

See also **allocate-dynamic-foreign-object**
free-foreign-object
with-coerced-pointer

with-dynamic-lisp-array-pointer *Macro*

Summary Creates a dynamic-extent foreign pointer which points to the data in a given Lisp array while the forms are executed.

Package **fli**

Signature **`with-dynamic-lisp-array-pointer (`***`pointer-var lisp-array`* **`&key`** *`start type`*`)` **`&body`** *`body`* **`=>`** *`last`*

Arguments

pointer-var	A variable to be bound to the foreign pointer.
lisp-array	A Lisp array.
start	An index into the Lisp array. The default is **`0`**.
type	A foreign type. The default is **`:void`**.
body	A list of forms.

Values

last	The value of the last form in *body*.

Description

The macro **`with-dynamic-lisp-array-pointer`** enables the data in a Lisp array (a string or a byte array) to be shared directly with foreign code, without making a copy. A dynamic-extent pointer to the array's data can be used within *body* wherever the **`:pointer`** foreign type allows.

`with-dynamic-lisp-array-pointer` creates a dynamic extent foreign pointer, with element type *type*, which is initialized to point to the element of *lisp-array* at index *index*.

This foreign pointer is bound to *pointer-var*, the forms of *body* are executed and the value of the last form returned.

Pointers created with this macro must be used with care. There are three restrictions:

1. *lisp-array* must be static, for example allocated as shown below.
2. The pointer has dynamic extent and *lisp-array* is guaranteed to be preserved only during the execution of *body*. If you keep the value of the pointer, you must also preserve *lisp-array*, that is you must ensure it is not garbage-collected.

3. Lisp strings and arrays are not null-terminated, therefore foreign code must only access the data of *lisp-array* up to its known length.

Example

```
(let ((vector
       (make-array 3 :element-type '(unsigned-byte 8)
                   :initial-contents '(65 77 23)
                   :allocation :static)))
  (fli:with-dynamic-lisp-array-pointer
      (ptr vector :start 1 :type :unsigned-byte)
    (fli:dereference ptr)))
=>
77
```

See also

:lisp-array

:lisp-simple-1d-array

with-foreign-slots *Macro*

Summary

Allows convenient access to the slots of a foreign structure.

Package

fli

Signature

with-foreign-slots *slots-and-options form* **&body** *body*

slots-and-options **:=** (*slots* **&key** *object-type*) | *slots*

slots **:=** (*slot-spec**)

slot-spec **:=** *slot-name* | (*variable-name slot-name* **&key** *copy-foreign-object*)

Arguments

variable-name	A symbol
slot-name	A symbol
object-type	A FLI structure type
form	A form evaluating to an instance of (or a pointer to) a FLI structure
body	Forms to be executed

Description

The macro **with-foreign-slots** is analogous to the Common Lisp macro **with-slots**. Within *body,* each *slot-name* (or *variable-name*) evaluates to the result of calling **foreign-slot-value** on *form* with that slot. **setf** can be used to set the foreign slot value.

If the first syntax of *slots-and-options* is used, then *object-type* is passed as the value of the **:object-type** keyword argument in all the generated calls to **foreign-slot-value**. If the second syntax of *slots-and-options* is used, no *object-type* is passed.

Each *slot-spec* can either be a symbol *slot-name* naming a slot in the object, which will be also be used in *body,* or a list of *variable-name*, a symbol naming a slot, and a plist of options. In this case the *copy-foreign-object* option is passed as the value of the **:copy-foreign-object** keyword argument in the generated call to **foreign-slot-value**. The default value of *copy-foreign-object* is **:error**.

The **with-foreign-slots** form returns the value of the last form in *body.*

Example

```
(fli:define-c-struct abc
  (a :int)
  (b :int)
  (c :int))
=>
(:STRUCT ABC)

(setf abc (fli:allocate-foreign-object :type 'abc))
=>
#<Pointer to type (:STRUCT ABC) = #x007F3BE0>

(fli:with-foreign-slots (a b c) abc
  (setf a 6 b 7 c (* a b)))
=>
42

(fli:foreign-slot-value abc 'c)
=>
42
```

See also **foreign-slot-value**

with-foreign-string *Macro*

Summary Converts a Lisp string to a foreign string, binds variables to a pointer to the foreign string, the number of elements in the string, and the number of bytes taken up by the string, then executes a list of forms, and finally de-allocates the foreign string and pointer.

Package **fli**

Signature **with-foreign-string (***pointer element-count byte-count* **&key** *external-format null-terminated-p allow-null***)** *string* **&body** *body* **=>** *last*

body*::= *form*

Arguments

pointer	A symbol bound to a pointer to the foreign string.
element-count	A symbol bound to the number of elements in the foreign string.
byte-count	A symbol bound to the number of bytes occupied by the foreign string. If the element size of the string is equal to one byte, then *byte-count* will be the same as *element-count*.
external-format	An external format specification.
null-terminated-p	If **t**, the foreign string is terminated by a null character. The null character is included in the *element-count* of the string.
allow-null	A boolean. The default is **nil**.
string	The Lisp string to convert.
body	A list of forms to be executed.
form	A form to be executed.

Values

last The value of the last *form* in *body*.

Description

The macro **with-foreign-string** is used to dynamically convert a Lisp string to a foreign string and execute a list of forms using the foreign string. The macro first converts *string*, a Lisp string, into a foreign string. The symbol *pointer* is bound to a pointer to the start of the string, the symbol *element-count* is set equal to the number of elements in the string, and the symbol *byte-count* is set equal to the number of bytes the string occupies. Then the list of forms specified by *body* is executed. Finally, the memory allocated for the foreign string and pointer is de-allocated.

The *external-format* argument is used to specify the encoding of the foreign string. It defaults to a format appropriate for C string of type **char***. For Unicode encoded strings, specify **:unicode**. If you want to pass a string to the Win32 API, known as **STR** in the Win32 API terminology, specify ***multi-byte-code-page-ef***, which is a variable holding the external format corresponding to the current Windows multi-byte code page. To change the default, call **set-locale** or **set-locale-encodings**.

The *null-terminated-p* keyword specifies whether the foreign string is terminated with a null character. It defaults to **t**. If the string terminates in a null character, it is included in the *element-count*.

If *allow-null* is non-nil, then if *string* is **nil** a null pointer is passed.

Example

See "Passing a string to a Windows function" on page 27 and "Modifying a string in a C function" on page 29 for examples of the use of **with-foreign-string**.

See also

convert-to-foreign-string
set-locale
set-locale-encodings
with-dynamic-foreign-objects

with-integer-bytes *Macro*

Summary Converts a Lisp integer to foreign bytes while executing a body of code.

Signature **`with-integer-bytes (`***pointer length***`)`** *integer* **`&body`** *body* **`=>`** *last*

Arguments

pointer	A variable to be bound to the foreign pointer.
length	A variable to be bound to the length in bytes.
integer	An integer.
body	Forms to be executed.

Values

last	The value of the last form in *body*.

Description The macro **`with-integer-bytes`** evaluates the forms in *body* with *pointer* bound to a dynamic foreign object containing the bytes of *integer* and *length* bound to the number of bytes in that object. The layout of the bytes is unspecified, but the bytes and the length are sufficient to reconstruct *integer* by calling **`make-integer-from-bytes`**.

See also **`convert-integer-to-dynamic-foreign-object`**
`make-integer-from-bytes`

6

Type Reference

:boolean *FLI type descriptor*

Summary Converts between a Lisp boolean value and a C representation of a boolean value.

Syntax `:boolean &optional` *encapsulates*

Arguments *encapsulates* An integral type.

Description The FLI `:boolean` type converts between a Lisp boolean value and a C representation of a boolean value. The *encapsulates* option is used to specify the size of the value from which the boolean value is obtained. For example, if a `byte` is used in C to represent a boolean, the size to map across for the FLI will be one byte, but if an `int` is used, then the size will be four bytes.

A value of `0` in C represents a `nil` boolean value in Lisp, and a non-zero value in C represents a `t` boolean value in Lisp.

Example In the following three examples, the size of a `:boolean`, a `(:boolean :int)` and a `(:boolean :byte)` are returned.

```
(fli:size-of :boolean)
(fli:size-of '(:boolean :int))
(fli:size-of '(:boolean :byte))
```

See also **size-of**

:byte *FLI type descriptor*

Summary Converts between a Lisp integer with a C **signed char**.

Syntax **:byte**

Arguments None.

Description The FLI **:byte** type converts between a Lisp integer type and a C **signed char** type.

See also **:char**
:short

:c-array *FLI type descriptor*

Summary Converts between a FLI array and a C array type.

Syntax **:c-array** *type* **&rest** *dimensions*

Arguments

type	The type of the elements of the array.
dimensions	A sequence of the dimensions of the new array.

Description The FLI **:c-array** type converts between FLI arrays and the C array type. In C, pointers are used to access the elements of an array. The implementation of the **:c-array** type takes this into account, by automatically dereferencing any pointers

returned when accessing an array using **foreign-aref**, unlike **:foreign-array**.

When using the **:c-array** type in the specification of an argument to **define-foreign-function**, a pointer to the array is passed to the foreign function, as specified by the C language. You are allowed to call the foreign function with a FLI pointer pointing to an object of type *type* instead of a FLI array.

Note that **:c-array** uses the C convention that the first index value of an array is **0**.

Example

The following code defines a 3 by 3 array of integers.

```
(setq array1 (fli:allocate-foreign-object
              :type '(:c-array :int 3 3)))
```

The next example defines an array of arrays of bytes.

```
(setq array2 (fli:allocate-foreign-object
              :type '(:c-array (:c-array :byte 3) 2)))
```

See **foreign-aref** and **foreign-array-pointer** for more examples on the use of arrays.

See also

foreign-aref
:foreign-array
foreign-array-pointer

:char

FLI type descriptor

Summary

Converts between a Lisp **character** type and a C **char** type.

Syntax

:char

Arguments

None.

Description

The FLI **:char** type converts between a Lisp **character** and a C **char** type.

Notes — If you want an integer on the Lisp side, rather than a **character**, then you should use **(:signed :char)** or **(:unsigned :char)**.

See also — **:byte**, **:signed**, **:unsigned**

:const — *FLI type descriptor*

Summary — Corresponds to the C **const** type.

Syntax — **:const &optional** *type*

Arguments — *type* The type of the constant. The default is **:int**.

Description — The FLI **:const** type corresponds to the C **const** type qualifier. The behavior of a **:const** is exactly the same as the behavior of its *type*, and it is only included to ease the readability of FLI code and for naming conventions.

Example — In the following example a constant is allocated and set equal to 3.141.

```
(setq pi1 (fli:allocate-foreign-object
           :type '(:const :float)))

(setf (fli:dereference pi1) 3.141))
```

See also — **:volatile**

:double — *FLI type descriptor*

Summary — Converts a Lisp double float to a C **double**.

Syntax — **:double**

Arguments None.

Description The FLI **`:double`** type converts between a Lisp double float and the C **`double`** type.

Compatibility Note In LispWorks 4.4 and previous on Windows and Linux platforms, all Lisp floats are doubles. In LispWorks 6.0, there are three disjoint Lisp float types, on all platforms.

See also **`:float`**

:ef-mb-string *FLI type descriptor*

Summary Converts between a Lisp string and a C multi-byte string .

Syntax **`:ef-mb-string &key`** ***limit external-format null-terminated-p***

Arguments

limit The maximum number of bytes of the C multi-byte string.

external-format An external format specification.

null-terminated-p A boolean controlling the null termination byte.

Description The FLI **`:ef-mb-string`** type converts between a Lisp string and a C multi-byte string. The C string may have a maximum length of *limit* bytes. The *limit* can be omitted in cases where a new foreign string is being allocated.

The *external-format* is used to specify the encoding of the foreign string. It defaults to an encoding appropriate for C string of type **`char*`**. If you want to pass a string to the Windows API, known as **`STR`** in the Windows API terminology, specify **`win32:*multibyte-code-page-ef*`**, which is a variable holding the external format corresponding to the current Win-

dows multi-byte code page. To change the default, call **set-locale** or **set-locale-encodings**.

If *null-terminated-p* is non-nil, a NULL byte is added to the end of the string.

Notes

If you want to pass a string argument by reference but also allow conversion from Lisp **nil** to a null pointer, specify the **:reference** type **:allow-null** argument, for example:

```
(:reference-pass :ef-mb-string :allow-null t)
```

See also

:ef-wc-string
:reference
set-locale
set-locale-encodings

:ef-wc-string *FLI type descriptor*

Summary

Converts between a Lisp string and a C wide-character string.

Syntax

:ef-wc-string &key ***limit external-format null-terminated-p***

Arguments

limit The maximum number of characters of the C wide-character string.

external-format An external format specification.

null-terminated-p A boolean controlling the null termination byte.

Description

The FLI **:ef-wc-string** type converts between a Lisp string and a C wide-character string. The C string may have a maximum length of *limit* characters. The *limit* can be omitted in cases where a new foreign string is being allocated.

The *external-format* is used to specify the encoding of the foreign string. It defaults to an encoding appropriate for C string of type **wchar_t***. For Unicode encoded strings, specify **:unicode**. If you want to pass a string to the Windows API, known as **WSTR** in the Windows API terminology, also specify **:unicode**. To change the default, call **set-locale** or **set-locale-encodings**.

If *null-terminated-p* is non-nil, a NULL word is added to the end of the string.

See also

:ef-mb-string
set-locale
set-locale-encodings

:enum

FLI type descriptor

Summary

Converts between a Lisp symbol and a C **enum**.

Syntax

:enum &rest *enum-constants*

enum-constants **::= {***symbol* **|** **(***symbol value***)}***

Arguments

enum-constants	A sequence of one or more symbols naming the elements of the enumeration.
symbol	A symbol naming an element of the enumeration.
value	An integer specifying the value of *symbol*.

Description

The FLI **:enum** type converts between a Lisp symbol and the C **enum** type. Each entry in the *enum-constants* can either consist of a symbol, in which case the first entry has a value 0, or of a list of a symbol and its corresponding integer value.

Example

See **define-c-enum**, page 64, for an example using the **:enum** type.

See also **define-c-enum**

:enumeration *FLI type descriptor*

Summary A synonym for **:enum**

Syntax **:enumeration &rest** *enum-constants*

Description The FLI **:enumeration** type is the same as the FLI **:enum** type.

See also **:enum**

:fixnum *FLI type descriptor*

Summary Converts between a Lisp fixnum and a 32 bit raw integer.

Syntax **:fixnum**

Arguments None.

Description The FLI **:fixnum** type converts between a Lisp fixnum and a 32 bit integer in C.

:float *FLI type descriptor*

Summary Converts a Lisp single float to a C **float**.

Syntax **:float**

Arguments None.

Description The FLI **:float** type converts between a Lisp single float and the C **float** type.

Compatibility note

In LispWorks 4.4 and previous on Windows and Linux platforms, all Lisp floats are doubles. In LispWorks 6.0, there are three disjoint Lisp float types, on all platforms.

See also

:double

:foreign-array *FLI type descriptor*

Summary

Converts between a FLI array and a foreign array type.

Syntax

:foreign-array *type dimensions*

Arguments

type The type of the elements of the array.

dimensions A list containing the dimensions of the array.

Description

The FLI **:foreign-array** converts between FLI arrays and the foreign array type. It creates an array with the dimensions specified in *dimensions*, of elements of the type specified by *type*.

Example

The following code defines a 3 by 4 foreign array with elements of type **:byte**.

```
(setq farray (fli:allocate-foreign-object
              :type '(:foreign-array :byte (3 4)))
```

See also

:c-array
foreign-aref
foreign-array-pointer

:function *FLI type descriptor*

Summary

Converts between Lisp and the C **function** type.

Syntax **`:function &optional`** ***args-spec return-spec*** **`&key`** ***calling-convention***

Arguments

args-spec A list of function argument types.

return-spec A list of function return types.

calling-convention

One of **`:stdcall`** or **`:cdecl`**.

Description The FLI **`:function`** type allows for conversion from the C **`function`** type. It is typically used in conjunction with the **`:pointer`** type to reference an existing foreign function.

The default value of *calling-convention* is as described for **`define-foreign-function`**.

Example The following code lines present a definition of a pointer to a function type, and a corresponding C definition of the type. The function type is defined for a function which takes as its arguments an integer and a pointer to a void, and returns an integer value.

```
(:pointer (:function (:int (:pointer :void)) :int))

int (*)( int, void * )
```

See also **`:pointer`**

:int *FLI type descriptor*

Summary Converts between a Lisp integer and a C **`int`** type.

Syntax **`:int`**

Arguments None.

Description The **:int** type converts between an Lisp integer and a C **int** type. It is equivalent to the **:signed** and **(:signed :int)** types.

See also **:signed**

:int8
:int16
:int32
:int64
:intmax
:intptr

FLI type descriptors

Summary The signed sized integer types.

Description FLI types are defined for integers of particular sizes. These are equivalent to the types defined by ISO C99. For example, Lisp **:int8** is ISO C99 int8_t.

The types have these meanings:

:int8	8-bit signed integer
:int16	16-bit signed integer
:int32	32-bit signed integer
:int64	64-bit signed integer
:intmax	The largest type of signed integer available
:intptr	A signed integer the same size as a pointer

See also **:uint8**

:lisp-array *FLI type descriptor*

Summary A foreign type which passes the address of a Lisp array direct to C.

Syntax **`:lisp-array &optional`** *type*

Arguments

type	A list. The default is **`nil`**.

Description **`:lisp-array`** is a foreign type which accepts a Lisp array and passes a pointer to the first element of that array. The Lisp array may be non-simple.

It is vital that the garbage collector does not move the Lisp array, hence **`:lisp-array`** checks that the array is statically allocated.

Note also that the Lisp garbage collector does not know about the array in the C code. Therefore, if the C function retains a pointer to the array, then you must ensure the Lisp object is not collected, for example by retaining a pointer to it in Lisp.

The argument *type*, if non-nil, is a list **`(`***element-type* **`&rest`** ***dimensions*`)`** and is used to check the element type and dimensions of the Lisp array passed.

Example This C function fills an array of doubles from an array of single floats.

Windows version:

```
__declspec(dllexport) void __cdecl ProcessFloats(int
count, float * fvec, double * dvec)
{
 for(--count ; count >= 0 ; count--) {
   dvec[count] = fvec[count] * fvec[count];
  }
}
```

Linux/Unix/Macintosh version:

```
void ProcessFloats(int count, float * fvec, double *
dvec)
{
 for(--count ; count >= 0 ; count--) {
   dvec[count] = fvec[count] * fvec[count];
  }
}
```

The following Lisp code demonstrates the use of `:lisp-array` in a call to `ProcessFloats`:

```
(fli:define-foreign-function (process-floats
                              "ProcessFloats")
    ((count :int)
     (fvec :lisp-array)
     (dvec :lisp-array)))

(defun test-process-floats (length)
  (let ((f-vector
         (make-array length
                     :element-type 'single-float
                     :initial-contents
                     (loop for x below
                           length
                           collect
                           (coerce x 'single-float))
                     :allocation :static))
        (d-vector
         (make-array length
                     :element-type 'double-float
                     :initial-element 0.0D0
                     :allocation :static)))
    (process-floats length f-vector d-vector)
    (dotimes (x length)
      (format t "f-vector[~D] = ~A; d-vector[~D] = ~A~%"
              x (aref f-vector x)
              x (aref d-vector x)))))
```

Now

```
(test-process-floats 3)
```

prints

```
single-array[0] = 0.0; double-array[0] = 0.0
single-array[1] = 1.0; double-array[1] = 1.0
single-array[2] = 2.0; double-array[2] = 4.0
```

See also **:lisp-simple-1d-array**
with-dynamic-lisp-array-pointer

:lisp-double-float *FLI type descriptor*

Summary A synonym for **:double**.

Syntax **:lisp-double-float**

Description The FLI **:lisp-double-float** type is the same as the FLI **:double** type.

See also **:double**

:lisp-float *FLI type descriptor*

Summary Converts between any Lisp float and the C **double** type or the C **float** type.

Syntax **:lisp-float &optional** *float-type*

float-type **::= :single | :double**

Arguments *float-type* Determines the C type to convert to. The default is **:single**.

Description The FLI **:lisp-float** type converts between any Lisp float and either the C **float** or the C **double** type. The default is to convert to the C **float** type, but by specifying **:double** for *float-type*, conversion occurs between any Lisp float and the C **double** type.

See also **:double**
:float

:lisp-simple-1d-array *FLI type descriptor*

Summary A foreign type which passes the address of a Lisp simple vector direct to C.

Syntax **`:lisp-simple-1d-array &optional`** *type*

Arguments *type* A list. The default is **`nil`**.

Description **`:lisp-simple-1d-array`** is a foreign type which accepts a Lisp simple vector and passes a pointer to the first element of that vector.

The Lisp vector must be simple. That is, it does not have a fill pointer, is not adjustable, and it is not a displaced array.

The Lisp vector as subject to the same memory management restrictions as the array passed with **`:lisp-array`**. It must be statically allocated, and may need to be retained explicitly in Lisp.

The argument *type*, if non-nil, is a list **`(`***element-type* **`&rest`** ***dimensions*`)`** and is used to check the element type and dimensions of the Lisp array passed.

See also **`:lisp-array`**
`with-dynamic-lisp-array-pointer`

:lisp-single-float *FLI type descriptor*

Summary A synonym for **`:float`**.

Syntax **`:lisp-single-float`**

Description The FLI **`:lisp-single-float`** type is the same as the FLI **`:float`** type.

See also **`:float`**

:long *FLI type descriptor*

Summary Converts between a Lisp **integer** and a C **long**.

Syntax

:long &optional *integer-type*

integer-type **::= :int | :double | :long**

Arguments

integer-type One of **:int**, **:double**, or **:long**.

Description The FLI **:long** type converts between the Lisp **integer** type and the C **long** type. See Table 6.1 for comparisons between Lisp and C long types.

Table 6.1 A comparison between Lisp and C long types

Lisp type	FLI type	C type
integer	**:long**	**long**
integer	**:long :int**	**long**
integer	**:long :double**	**long double**
integer	**:long :long** **:long-long**	**long long**

See also

:int
:long-long
:short

:long-long *FLI type descriptor*

Summary Converts between a Lisp **integer** and a signed C **long long**.

Syntax

:long-long

Arguments

None.

Description The FLI **:long-long** type converts between the Lisp **integer** type and the C **long long** type.

Notes This is supported only on platforms where the C **long long** type is the same size as the C **long** type.

See also **:long**

:one-of *FLI type descriptor*

Summary Converts between Lisp and C types of the same underlying type.

Syntax **:one-of &rest** *types*

Arguments

types	A list of types sharing the same underlying type.

Description The FLI **:one-of** type is used to allocate an object which can be one of a number of types. The types must have the same underlying structure, which means they must have the same size and must be referenced in the same manner. The FLI **:one-of** type is useful when a foreign function returns a value whose underlying type is known, but whose exact type is not.

Example In the following example, a **:one-of** type is allocated.

```
(setq thing (fli:allocate-foreign-object
             :type '(:one-of :ptr :int :unsigned)))
```

If **thing** is set to be 100 using **dereference**, it is taken to be an object of type **:int**, as this is the first element in the sequence of types defined by **:one-of** which matches the type of the number 100.

```
(setf (fli:dereference thing) 100)
```

However, if **thing** is now dereferenced, it is returned as a pointer to the address 100 (Or hex address 64), as there is no

method for determining the type of **thing**, and therefore the first element in the list of **:one-of** is used.

```
(fli:dereference thing)
```

See also **:union**

:pointer *FLI type descriptor*

Summary Defines a C-style FLI pointer to an object of a specified type.

Syntax **:pointer** *type*

Arguments

type	The type of FLI object pointed to by the pointer.

Description The FLI **:pointer** type is part of the FLI implementation of pointers. It defines a C-style pointer to an object of *type*. Passing **nil** instead of a pointer is treated the same as passing a null pointer (that is, a pointer to address **0**)

For more details on pointers, including examples on pointer coercion, dereferencing, making, and copying see Chapter 3, "FLI Pointers".

See also **copy-pointer**
dereference
make-pointer
null-pointer

:ptr *FLI type descriptor*

Summary A synonym for **:pointer**.

Syntax **:ptr** *type*

Description The FLI **:ptr** type is the same as the FLI **:pointer** type.

See also **:pointer**

:ptrdiff-t *FLI type descriptor*

Summary Converts between a Lisp integer and an ISO C ptrdiff_t.

Syntax **:ptrdiff-t**

Arguments None.

Description The FLI **:ptrdiff-t** type converts between a Lisp integer and an ISO C ptrdiff_t type, which is an signed integer representing the difference in bytes between two pointers.

:reference *FLI type descriptor*

Summary Passes a foreign object of a specified type by reference, and automatically dereferences the object.

Syntax **:reference** *type* **&key** *allow-null lisp-to-foreign-p foreign-to-lisp-p*

Arguments

type	The type of the object to pass by reference.
allow-null	If non-nil, if the input argument is **nil** a null pointer is passed instead of a reference to an object containing **nil**.
lisp-to-foreign-p	If non-nil, allow conversion from Lisp to the foreign language. The default value is **t**.
foreign-to-lisp-p	If non-nil, allow conversion from the foreign language to Lisp. The default value is **t**

Description

The FLI **:reference** type is essentially the same as a **:pointer** type, except that **:reference** is automatically dereferenced when it is processed.

The **:reference** type is useful as a foreign function argument. When a function is called with an argument of the type **(:reference** *type***)**, an object of *type* is dynamically allocated across the scope of the foreign function, and is automatically de-allocated once the foreign function terminates. The value of the argument is not copied into the temporary instance of the object if *lisp-to-foreign-p* is **nil**, and similarly, the return value is not copied back into a Lisp object if *foreign-to-lisp-p* is **nil**.

Notes

If the argument is of an aggregate type and *foreign-to-lisp-p* is true, then a malloc'd copy is made which you should later free explicitly. It is usually better to use **:pointer**, make the temporary foreign object using **with-dynamic-foreign-objects** and then copy whatever slots you need into a normal Lisp object on return.

Example

In the following example an **:int** is allocated, and a pointer to the integer is bound to the Lisp variable **number**. Then a pointer to **number**, called **point1**, is defined. The pointer **point1** is set to point to **number**, itself a pointer, but to an **:int**.

```
(setq number (fli:allocate-foreign-object :type :int))

(setf (fli:dereference number) 42)

(setq point1 (fli:allocate-foreign-object
              :type '(:pointer :int)))

(setf (fli:dereference point1) number)
```

If **point1** is dereferenced, it returns a pointer to an **:int**. To get at the value stored in the integer, we need to dereference twice:

```
(fli:dereference (fli:dereference point1))
```

However, if we dereference **point1** as a **:reference**, we only have to dereference it once to get the value:

```
(fli:dereference point1 :type '(:reference :int))
```

See also **:reference-pass**
:reference-return

:reference-pass *FLI type descriptor*

Summary Passes an object from Lisp to the foreign language by reference.

Syntax **:reference-pass** *type* **&key** *allow-null*

Arguments

type	The type of the object to pass by reference.
allow-null	If non-nil, if the input argument is **nil** a null pointer is passed instead of a reference to an object containing **nil**.

Description The FLI type **:reference-pass** is equivalent to:

```
(:reference :lisp-to-foreign-p t
            :foreign-to-lisp-p nil)
```

See **:reference** for the details.

See also **:reference**
:reference-return

:reference-return *FLI type descriptor*

Summary Passes an object from the foreign language to Lisp by reference.

Syntax **:reference-return** *type* **&key** *allow-null*

Arguments

type	The type of the object to return by reference.
allow-null	If non-nil, if the input argument is **nil** a null pointer is passed instead of a reference to an object containing **nil**.

Description

The FLI type **:reference-return** is equivalent to:

```
(:reference :lisp-to-foreign-p nil
            :foreign-to-lisp-p t)
```

See **:reference** for the details.

See also

:reference
:reference-pass

:short *FLI type descriptor*

Summary

Converts between a Lisp **fixnum** type and a C **short** type.

Syntax

:short &optional *integer-type*

interger-type **::= :int**

Arguments

integer-type	If specified, must be **:int**, which associates a Lisp **fixnum** with a C **int**.

Description

The FLI **:short** type associates a Lisp **fixnum** with a C **short**.

The FLI types **:short**, **(:short :int)**, **(:signed :short)**, and **(:signed :short :int)** are equivalent.

See also

:int
:signed

:signed *FLI type descriptor*

Summary

Converts between a Lisp integer and a foreign signed integer.

Syntax **:signed &optional** *integer-type*

integer-type **::= :byte | :char | :short | :int | :long | :long :int | :short :int**

Arguments *integer-type* The type of the signed integer.

Description The **:signed** type converts between a Lisp integer and a foreign signed integer. The optional *integer-type* argument specifies other kinds of signed integer types. See Table 6.2 for a comparison between Lisp and C signed types.

Table 6.2 A comparison of Lisp and C signed types

Lisp type	FLI type	C type
integer	**:signed**	**signed int**
fixnum	**:signed :byte**	**signed char**
fixnum	**:signed :char**	**signed char**
fixnum	**:signed :short**	**signed short**
integer	**:signed :int**	**signed int**
integer	**:signed :long**	**signed long**
fixnum	**:signed :short :int**	**signed short**
integer	**:signed :long :int**	**signed long**

See also **cast-integer**
:unsigned

:size-t *FLI type descriptor*

Summary Converts between a Lisp integer and an ISO C size_t.

Syntax **:size-t**

Arguments None.

Description The FLI **:size-t** type converts between a Lisp integer and an ISO C size_t type, which is an unsigned integer representing the size of an object in bytes.

See also **:ssize-t**

:ssize-t *FLI type descriptor*

Summary Converts between a Lisp integer and the platform-specific ssize_t type.

Syntax **:ssize-t**

Arguments None.

Description The FLI **:ssize-t** type converts between a Lisp integer and a platform-specific ssize_t type, which is a signed integer representing the size of an object in bytes.

See also **:size-t**

:struct *FLI type descriptor*

Summary Converts between a FLI structure and a C **struct**.

Syntax **:struct &rest** *slots*

slots **::= {**_symbol_ **|** **(**_symbol slot-type_**)}***

slot-type **::=** *type* **|** **(:bit-field** *integer-type size***)**

Arguments

slots	A sequence of one or more slots making up the structure.
symbol	A symbol naming the slot.

type	The slot type. If no type is given it defaults to an **:int**.
integer-type	An integer type. Only **:int**, **(:unsigned :int)** and **(:signed :int)** are guaranteed to work on all platforms.
size	An integer specifying a number of bits for the field.

Description

The FLI **:struct** type is an aggregate type, and converts between a FLI structure and a C **struct** type. The FLI structure consists of a collection of one or more slots. Each slot has a name and a type. A structure can also contain bit fields, which are integers with a specified number of bits.

The **foreign-slot-names**, **foreign-slot-type**, and **foreign-slot-value** functions can be used to access and change the slots of the structure. The convenience FLI function **define-c-struct** is provided to simplify the definition of structures.

Example

In the following example a structure for passing coordinates to Windows functions is defined.

```
(fli:define-c-struct tagPOINT (x :long) (y :long))
```

An instance of the structure is allocated and bound to the Lisp variable **place**.

```
(setq place
      (fli:allocate-foreign-object :type 'tagPOINT))
```

Finally, the **x** slot of **place** is set to be **4** using **fli:foreign-slot-value**.

```
(seft (fli:foreign-slot-value place 'x) 4)
```

See also

define-c-struct
foreign-slot-names
foreign-slot-offset
foreign-slot-pointer

foreign-slot-type
foreign-slot-value

:time-t *FLI type descriptor*

Summary — Converts between a Lisp integer and the platform-specific time_t type.

Syntax — **:time-t**

Arguments — None.

Description — The FLI **:time-t** type converts between a Lisp integer and an ISO C time_t type, which is an integer type used for storing system time values.

:uint8
:uint16
:uint32
:uint64
:uintmax
:uintptr *FLI type descriptors*

Summary — The unsigned sized integer types.

Description — FLI types are defined for integers of particular sizes. These are equivalent to the types defined by ISO C99. For example, Lisp **:uint8** is ISO C99 uint8_t.

The types have these meanings:

:uint8	8-bit unsigned integer
:uint16	16-bit unsigned integer
:uint32	32-bit unsigned integer

:uint64	64-bit unsigned integer
:uintmax	The largest type of unsigned integer available
:uintptr	An unsigned integer the same size as a pointer

See also **:int8**

:union *FLI type descriptor*

Summary Converts between a FLI union and a C **union** type.

Syntax

:union &rest *slots*

slots* ::= {*symbol* | (*symbol type*)}

Arguments

slots	A sequence of one or more slots making up the union.
symbol	A symbol naming the slot.
type	The slot type. If no type is given, it defaults to an **:int**.

Description The FLI **:union** type is an aggregate type, and converts between a FLI union and a C **union** type. The FLI union consists of a collection of one or more slots, only one of which can be active at any one time. The size of the whole union structure is therefore equal to the size of the largest slot. Each slot has a name and a type.

The **foreign-slot-names**, **foreign-slot-type**, and **foreign-slot-value** functions can be used to access and change the slots of the union. The convenience FLI function **define-c-union** is provided to simplify the definition of unions.

Example In the following example a union type with two slots is defined.

```
(fli:define-c-union my-number
                    (small :byte) (large :int))
```

An instance of the union is allocated and bound to the Lisp variable **length**.

```
(setq length
      (fli:allocate-foreign-object :type 'my-number))
```

Finally, the **small** slot of the union is set equal to **24**.

```
(setf (fli:foreign-slot-value length 'small))
```

See also

define-c-union
foreign-slot-names
foreign-slot-offset
foreign-slot-pointer
foreign-slot-type
foreign-slot-value

:unsigned *FLI type descriptor*

Summary

Converts between a Lisp integer and a foreign unsigned integer.

Syntax

:unsigned &optional *integer-type*

integer-type **::= :byte | :char | :short | :int | :long | :long :int | :short :int**

Arguments

integer-type The type of the unsigned integer.

Description

The **:unsigned** type converts between a Lisp integer and a foreign unsigned integer. The optional *integer-type* argument specifies other kinds of unsigned integer types. See Table 6.3 for a comparison between Lisp and C unsigned types.

Table 6.3 A comparison of Lisp and C unsigned types

Lisp type	FLI type	C type
integer	**:unsigned**	**unsigned int**

Table 6.3 A comparison of Lisp and C unsigned types

Lisp type	FLI type	C type
fixnum	**:unsigned :byte**	**unsigned char**
fixnum	**:unsigned :char**	**unsigned char**
fixnum	**:unsigned :short**	**unsigned short**
integer	**:unsigned :int**	**unsigned int**
integer	**:unsigned :long**	**unsigned long**
fixnum	**:unsigned :short :int**	**unsigned short**
integer	**:unsigned :long :int**	**unsigned long**

See also **cast-integer**
:signed

:void *FLI type descriptor*

Summary Represents the C **void** type.

Syntax **:void**

Arguments None.

Description The FLI **:void** type represents the C void type. It can only be used in a few limited circumstances, as the:

- *result-type* of a **define-foreign-function**, **define-foreign-funcallable** or **define-foreign-callable** form. In this case, it means that no values are generated.
- element type of a **:pointer** type, that is **(:pointer :void)**. Any FLI pointer can be converted to this type, for example when used like this as the argument type in **define-foreign-function**.
- element type of a FLI pointer when memory is not being allocated, for example in a call to **make-pointer**. It is an

error to dereference a FLI pointer with element type **:void** (but **with-coerced-pointer** can be used).

- expansion of a **define-c-typedef** or **define-foreign-type** form. The type defined in this way can only be used in situations where **:void** is allowed.

See also **:pointer**

:volatile *FLI type descriptor*

Summary Corresponds to the C **volatile** type.

Syntax **:volatile &optional** *type*

Arguments *type* The type of the volatile. The default is **:int**.

Description The FLI **:volatile** type corresponds to the C++ **volatile** type. The behavior of a **:volatile** is exactly the same as the behavior of its *type*, and it is only included to ease the readability of FLI code and for naming conventions.

See also **:const**

:wchar-t *FLI type descriptor*

Summary Converts between a Lisp character and a C **wchar_t**.

Syntax **:wchar-t**

Arguments None.

Description The FLI **:wchar-t** type converts between a Lisp character and a C **wchar_t** type.

:wrapper *FLI type descriptor*

Summary — Allows the specification of automatic conversion functions between Lisp and an instance of a FLI type.

Syntax — **:wrapper** *foreign-type* **&key** *lisp-to-foreign foreign-to-lisp*

Arguments

foreign-type	The underlying type to wrap.
lisp-to-foreign	Code specifying how to convert between Lisp and the FLI.
foreign-to-lisp	Code specifying how to convert between the FLI and Lisp.

Description — The FLI **:wrapper** type allows for an extra level of conversion between Lisp and a foreign language through the FLI. With the **:wrapper** type you can specify conversion functions from and to an instance of another type. Whenever data is passed to the object, or received from the object it is passed through the conversion function. See below for an example of a use of **:wrapper** to pass values to an **:int** as strings, and to receive them back as strings when the pointer to the **:int** is dereferenced.

Example — In the following example an **:int** is allocated with a wrapper to allow the **:int** to be accessed as a string.

```
(setq wrap (fli:allocate-foreign-object
            :type '(:wrapper :int
                    :lisp-to-foreign read-from-string
                    :foreign-to-lisp prin1-to-string)))
```

The object pointed to by **wrap**, although consisting of an underlying **:int**, is set with **dereference** by passing a string, which is automatically converted using the Lisp function **read-from-string**. Similarly, when **wrap** is dereferenced, the value stored as an **:int** is converted using **prin1-to-string** to a Lisp string, which is the returned. The following two commands demonstrate this.

```
(setf (fli:dereference wrap) "#x100")

(fli:dereference wrap)
```

The first command sets the value stored at **wrap** to be 256 (100 in hex), by passing a string to it. The second command dereferences the value at **wrap**, but returns it as a string. The pointer **wrap** can be coerced to return the value as an actual **:int** as follows:

```
(fli:dereference wrap :type :int)
```

7

The Foreign Parser

7.1 Introduction

The Foreign Parser automates the generation of Foreign Language Interface defining forms, given files containing C declarations.

The result does often need some editing, due to ambiguities in C.

7.1.1 Requirements

The Foreign Parser requires a C preprocessor, so you must have a suitable preprocessor installed on your machine.

By default LispWorks invokes **`cl.exe`** (VC++) on Windows and **`cc`** on other platforms. If you have this installed, then make sure it is on your PATH.

On Windows, if you don't have **`cl.exe`**, download the VC++ toolkit from Microsoft

Preprocessors known to work with LispWorks are:

- Microsoft Visual Studio's **`cl.exe`**.
- **`cc`**
- **`gcc`**

To use a preprocessor other than the default, set the variable **foreign-parser:*preprocessor***, for example:

```
(setf foreign-parser:*preprocessor* "gcc")
```

7.2 Loading the Foreign Parser

The Foreign Parser is in a loadable module **foreign-parser**.

Load it by:

```
(require "foreign-parser")
```

7.3 Using the Foreign Parser

The interface is the function **foreign-parser:process-foreign-file.**

Suppose we wish to generate the FLI definitions which interface to the C example from "Modifying a string in a C function" on page 29. The header file **test.h** needs to be slightly different depending on the platform.

Windows version:

```
__declspec(dllexport) void __cdecl modify(char *string)
```

Linux/Unix/Macintosh version:

```
void modify(char *string)
```

1. Load the Foreign Parser:

   ```
   (require "foreign-parser")
   ```

2. Now generate prototype FLI definitions:

```
(foreign-parser:process-foreign-file
 "test.h"
 :case-sensitive nil)
=>
;;;    Output dff file #P"test-dff.lisp"
;;;    Parsing source file "test.h"

;;; Process-foreign-file : Preprocessing file

;;; Process-foreign-file : Level 1 parsing

;;; Process-foreign-file : Selecting foreign forms
NIL
```

3. You should now have a Lisp file **`test-dff.lisp`** containing a form like this:

```
(fli:define-foreign-function
    (modify "modify" :source)
    ((string (:pointer :char)))
  :result-type
  :void
  :language
  :c
  :calling-convention
  :cdecl)
```

4. This edited version passes a string using **`:ef-mb-string`**:

```
(fli:define-foreign-function
    (modify "modify" :source)
    ((string (:reference (:ef-mb-string :limit 256))))
  :result-type
  :void
  :language
  :c
  :calling-convention
  :cdecl)
=>
MODIFY
```

5. Create a DLL containing the C function.

6. Load the foreign code by

```
(fli:register-module "test.dll")
```

or

```
(fli:register-module "/tmp/test.so")
```

7. Call the C function from LISP:

```
(modify "Hello, I am in LISP")
=>
NIL
"'Hello, I am in LISP' modified in a C function"
```

7.4 Using the LispWorks Editor

The LispWorks Editor's C Mode offers a convenient alternative to using **foreign-parser:process-foreign-file** directly as above. It also allows you to generate and load a C object file.

To use this, you should be familiar with the LispWorks Editor as described in the *LispWorks IDE User Guide* and the *LispWorks Editor User Guide*.

7.4.1 Processing Foreign Code with the Editor

1. Open the file **test.h** in the LispWorks Editor. Note that the buffer is in C Mode, indicated by "(C)" in the mode line.
2. Use the menu command **Buffer > Evaluate**, or equivalently run **Meta+X Evaluate Buffer**.
3. A new buffer named **test.h (C->LISP)** is created. It contains the prototype FLI definition forms generated by **foreign-parser:process-foreign-file**.
4. You can now edit the Lisp forms if necessary (note that your new buffer is in Lisp mode) and save them to file. Follow the previous example from Step 4.

7.4.2 Compiling and Loading Foreign Code with the Editor

1. Open the file **test.c** in the LispWorks Editor. Note that the buffer is in C Mode, indicated by "(C)" in the mode line.
2. Use the menu command **Buffer > Compile**, or equivalently run **Meta+X Compile Buffer**.

3. Your C file is compiled with the same options as **lw:compile-system** would use, and the object file is loaded. The object file name is printed in the Output tab. It is written in your temporary directory (usually that given by the value of the environment variable **TEMP**) and deleted after **register-module** is called on it.

7.5 Foreign Parser Reference

preprocessor *Variable*

Package **foreign-parser**

Initial Value **"cc"** on Unix, Linux and Mac OS X.

"cl" on Windows

Description The variable ***preprocessor*** provides the default value for the *preprocessor* used by **process-foreign-file**.

See also ***preprocessor-options***
process-foreign-file

preprocessor-format-string *Variable*

Package **foreign-parser**

Initial Value On Windows:

```
""~A" /nologo /E ~A ~{/D~A ~}~{/I"~A" ~}/Tc "~A""
```

On Unix, Linux and and Mac OS X:

```
"~A -E ~A ~{-D~A~ ~}~{-I~A ~}~A"
```

Description The variable ***preprocessor-format-string*** provides the default value for the *preprocessor-format-string* used by **process-foreign-file**.

See also **process-foreign-file**

preprocessor-include-path *Variable*

Package **foreign-parser**

Initial Value **nil**

Description The variable ***preprocessor-include-path*** provides the default value for the *preprocessor-include-path* used by **process-foreign-file**.

See also **process-foreign-file**

preprocessor-options *Variable*

Package **foreign-parser**

Initial Value **nil**

Description The variable ***preprocessor-options*** provides the default *preprocessor-options* passed to the *preprocessor* used by **process-foreign-file**.

See also ***preprocessor***
process-foreign-file

process-foreign-code *Macro*

Summary Compiles and loads C code, or allows it to be included in a Lisp fasl file, in 32-bit LispWorks on Solaris and HP-UX.

Package **foreign-parser**

Syntax

process-foreign-code *c-string* **&key** *language control* **=>**

Arguments

c-string	A string.
language	One of **:c** or **:ansi-c**.
control	One of **:fasl**, **:object** or **:source**.

Description

c-string is a string containing C source code.

language is **:c** by default.

If *control* is **:fasl**, the C code is compiled at Lisp **compile-file** time into a temporary **.o** file. The resulting object module is stored in the fasl file. If the value is **:object**, the C code is compiled at **compile-file** time into a **.o** file with the same name as the Lisp source file, and loaded when the fasl file is loaded. If the value is **:source**, compilation and loading of the C code is done when the macro function is evaluated. The default value of *control* is **:fasl**.

Notes

1. **process-foreign-code** is implemented only in 32-bit LispWorks on Solaris and HP-UX.
2. The Foreign Parser is loaded by:

```
(require "foreign-parser")
```

Example

When this statement is evaluated the C code is compiled and also loaded into the image:

```
(foreign-parser:process-foreign-code
         "int sum (int a, int b)
           { return a+b; } "
        :control :source)
```

The C function can be called from Lisp in the usual way:

```
(fli:define-foreign-function sum
    ((a :int)
     (b :int))
  :result-type :int)

(sum 2 3) => 5
```

See also **define-foreign-function**
link-load:read-foreign-modules in the *LispWorks User Guide and Reference Manual*.

process-foreign-file *Function*

Package **foreign-parser**

Syntax **process-foreign-file** *source* **&key** *dff language preprocess preprocessor preprocessor-format-string preprocessor-options preprocessor-include-path case-sensitive package* **=>**

Arguments

source	One or more filenames.
dff	A filename.
language	A keyword.
preprocess	A boolean.
preprocessor-format-string	A string.
preprocessor	A string.
preprocessor-options	A string.
include-path	A list.
case-sensitive	See description.
package	A package designator or **nil**.

Description The **process-foreign-file** function takes a file or files of foreign declarations — usually header files — and parses them, producing 'dff' files of Lisp definitions using **define-foreign-function**, **define-foreign-variable**, **define-foreign-type**, and so on, providing a Lisp interface to the foreign code.

source gives the name of the header files or file to be processed. The name of a file consists of *source-file-name* and *source-file-type* (typically **.h**).

dff is an output file which will contain the Lisp foreign function definitions. The default value is **nil**, in which case the dff file will be *source-file-name*-**dff.lisp**. (See *source*, above.)

language specifies the language the header files are written in. Currently the supported languages are **:c** (standard K&R C header files) and **:ansi-c**. The default value is **:ansi-c**.

preprocess, when non-nil, runs the preprocessor on the input files. The default value is **t**.

preprocessor-format-string should be a format string which is used to make a preprocessor command line. The format arguments are a pathname or string giving the preprocessor executable, a list of strings giving the preprocessor options, a list of strings giving macro names to define, a list of pathnames or strings contain the include path, and a source pathname. On Windows, the default contains options needed for VC++. The default is the value of ***preprocessor-format-string***.

preprocessor is a string containing the pathname of the preprocessor program. By default this is the value of ***preprocessor***.

preprocessor-options is a string containing command line options to be passed to the preprocessor if it is called. By default this is the value of ***preprocessor-options***.

include-path should be a list of pathnames or strings that will be added as the include path for the preprocessor. The default is the value of ***preprocessor-include-path***.

case-sensitive specifies whether to maintain case sensitivity in symbol names as in the source files. Values can be:

- **t** — the names of all Lisp functions and classes created are of the form |*name*|. This is the default value.

- **nil** — all foreign names are converted to uppercase and an error is signalled if any name clashes occur as a result of this conversion. For example, **OneTwoTHREE** becomes **ONETWOTHREE**.
- **:split-name** — attempts to split the name up into something sensible. For example, **OneTwoTHREE** becomes **ONE-TWO-THREE**.
- **:prefix** — changes lowercase to uppercase and concatenates the string with the string held in **sys:*prefix-name-string***. For example, **OneTwoTHREE** becomes **FOREIGN-ONETWOTHREE**.
- **(list :user-routine** *function-name***)** — enables you to pass your own function for name formatting. Your function must take a string argument and return a string result. It is not advised to use destructive functions (for example, **nreverse**) as this may cause unusual side effects.

If *case-sensitive* takes any other value, names are not changed.

package is used to generate an **in-package** form at the start of the output (dff) file. The name of the package designated by *package* is used in this form. The default value of *package* is the value of ***package***.

Note that in some cases the derived Lisp FLI definitions will not be quite correct, due to an ambiguity in C. **char*** can mean a pointer to a character, or a string, and in many cases you will want to pass a string. Therefore, **process-foreign-file** is useful for generating prototype FLI definitions, especially when there are many, but you do need to check the results when **char*** is used.

See also

process-foreign-code
register-module
preprocessor
preprocessor-options

Glossary

aggregate type

Any FLI type which is made up of other FLI types. This can be either an array of instances of a given FLI type, or a structured object.

Arrays, string, structure, and unions are all aggregate types. Pointers are not aggregates.

callable function

A Lisp function, defined with the FLI macro **`define-foreign-callable`**, which can be called from a foreign language.

coerced pointer

A coerced pointer is a pointer that is dereferenced with the **`:type`** key in order to return the value pointed to as a different type than specified by the pointer type. For example, a pointer to a byte can be coerced to return a boolean on dereferencing.

FLI

The Foreign Language Interface, which consists of the macros, functions, types and variables defined in the **`fli`** package.

FLI code

Code written in Lisp using the functions, macros and types in the **`fli`** package.

FLI function

A function in the **fli** package used to interface Lisp with a foreign language.

FLI type

A data type specifier in the **fli** package used to define data objects that interface between Lisp and the foreign language. For example, a C **long** might be passed to LispWorks through an instance of the FLI type **:long**, from which it is transferred to a Lisp **integer**.

foreign callable function

See **callable function**.

foreign function

A Lisp function, defined using the FLI macro **define-foreign-function**, which calls a function written in a foreign language. A foreign function contains no body, consisting only of a name and a list of arguments. The function in the foreign language provides the body of the foreign function.

foreign language

A language to which Lisp can be interfaced using the FLI. Currently the FLI interfaces to C, and therefore also the Win32 API functions.

immediate type

See scalar type.

pointer

A FLI type consisting of an address and a type specification. A pointer normally points to the memory location of an instance of the type specified, although there might not actually be an allocated instance of the type at the pointer location.

A pointer is a boxed foreign object because it contains type information about the type it is pointing to (so that we can dereference it). In 'C' a pointer can be represented by a single register.

scalar type

A FLI type that is not an aggregate type. The FLI type maps directly to a single foreign type such as integer, floating point, enumeration and pointer.

wrapper

A description of the **`:wrapper`** FLI type which "wraps" around an object, allowing data to be passed to or obtained from the object as though it was of a different type. A wrapper can be viewed as a set of conversion functions defined on the object which are automatically invoked when the wrapped object is accessed.

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