Foreign Language Interface User Guide and Reference Manual

Version 8.0

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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 chapters explaining the FLI implementation of pointers and some of the more advanced topics. Finally, **6 Self-contained examples** enumerates relevant example Lisp source files which are available in the LispWorks library.

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.

Viewing example files

This manual refers to example files in the LispWorks library via a Lisp form like this:

```
(example-edit-file "fli/foreign-callable-example")
```

These examples are Lisp source files in your LispWorks installation under **`lib/8-0-0-0/examples/`**. You can simply evaluate the given form to view the example source file.

Example files contain instructions about how to use them at the start of the file.

The examples files are in a read-only directory and therefore you should compile them inside the IDE (by the Editor command **Compile Buffer** or the toolbar button or by choosing **Buffer > Compile** from the context menu), so it does not try to write a fasl file.

If you want to manipulate an example file or compile it on the disk rather than in the IDE, then you need first to copy the file elsewhere (most easily by using the Editor command **Write File** or by choosing **File > Save As** from the context menu).

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 Microsoft 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.

To interface to a C++ program from LispWorks, define C stubs which call your C++ entry points, as described in **5.5.2 Using C++ DLLs**. Use the FLI to interface to these C stubs.

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 **`define-foreign-function`** that **`FahrenheitToCelsius`** 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 interfacing 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, LispWorks for x86/x64 Solaris 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).

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

On all platforms the function **`register-module`** is the main 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 macOS:

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

Note: It is also possible to embed a DLL in the Lisp image. See **5.6 Incorporating a foreign module into a LispWorks image**.

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 **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 in order to access 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. Also, there is **`foreign-typed-aref`** for efficient access in compiled code.
- Documentation for types — foreign type definitions can 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.
- Querying and testing functions — to get the byte size of a foreign type, use **`size-of`**. To test for equivalence of foreign types, use **`foreign-type-equal-p`**.

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 immediate 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`**, **`:double-complex`**, **`:enum`**, **`:float`**, **`:float-complex`**, **`: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 association 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 Complex number types

The FLI provides two immediate types for the representation of complex numbers, named **:float-complex** and **:double-complex**, which correspond to the C types **float complex** and **double complex** respectively.

2.1.4 Character types

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

2.1.5 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**. **(:boolean :standard)** would associate a Lisp boolean with a C99 _Bool.

2.1.6 Pointer types

Pointers are discussed in detail in **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 **8 Type Reference**.

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`**, and the macro **`with-foreign-slots`**. 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.

2.2.4 Vector types

Vector types are types that correspond to C vector types. These are handled by the C compiler in a special way, and therefore when you pass or return them to/from foreign code by value you must declare them correctly.

2.2.4.1 Vector type names

The names of the FLI types are designed to best match the types that are defined by Clang, which is used on macOS, iOS and FreeBSD and is optionally available on other operating systems. For every C/Objective-C type of the form **vector_<type><count>**, there is an FLI type of the form **fli:vector-<scalar fli type><count>**. For example, the C/Objective-C type **vector_double8** is matched by the FLI type **fli:vector-double8**.

The scalar fli types and their matching Common Lisp types are:

char	**(signed-byte 8)**
uchar	**(unsigned-byte 8)**
short	**(signed-byte 16)**
ushort	**(unsigned-byte 16)**
int	**(signed-byte 32)**
uint	**(unsigned-byte 32)**
long	**(signed-byte 64)**
ulong	**(unsigned-byte 64)**
float	**single-float**
double	**double-float**

The count can be 2, 3, 4, 8, 16 (for elements of 32 bits or less) or 32 (for elements of 16 bits or less). The restrictions mean that the maximum size of a vector is 64 bytes and the maximum count is 32.

Note that **long** and **ulong** are always 64 bits in this context, even on 32-bit where the C type **long** is 32 bits.

The full list of types:

vector-char2	**vector-char3**	**vector-char4**	**vector-char8**	**vector-char16**	**vector-char32**
vector-uchar2	**vector-uchar3**	**vector-uchar4**	**vector-uchar8**	**vector-uchar16**	**vector-uchar32**
vector-short2	**vector-short3**	**vector-short4**	**vector-short8**	**vector-short16**	**vector-short32**
vector-ushort2	**vector-ushort3**	**vector-ushort4**	**vector-ushort8**	**vector-ushort16**	**vector-ushort32**
vector-int2	**vector-int3**	**vector-int4**	**vector-int8**	**vector-int16**	

vector-uint2	**vector-uint3**	**vector-uint4**	**vector-uint8**	**vector-uint16**
vector-long2	**vector-long3**	**vector-long4**	**vector-long8**	
vector-ulong2	**vector-ulong3**	**vector-ulong4**	**vector-ulong8**	
vector-float2	**vector-float3**	**vector-float4**	**vector-float8**	**vector-float16**
vector-double2	**vector-double3**	**vector-double4**	**vector-double8**	

In addition, **vector-long1** and **vector-ulong1** are defined as immediate 64-bit signed and unsigned integers, because Clang defines them like that.

2.2.4.2 Vector type values

When passing an argument that is declared as any of the FLI vector types, the value needs to be a Lisp vector of the correct length or a foreign pointer to the FLI vector type.

- For **vector-double<count>** and **vector-float<count>**, the Lisp vector must either have element type **double-float** or **single-float**, or have element type **t** and contain elements of type **float**.
- For the integer vector types, the Lisp vector must either have an element type that is subtype of the element type of the FLI vector type, or have element type **t** and contain elements that fit into the FLI vector.
- If a foreign pointer is passed for an argument that is declared as a FLI vector type, it must point to an object of the FLI vector type, which must be an exact match, including being correctly signed. The vector is passed by value, not as a pointer.

When a FLI vector type is passed into Lisp, either because it is a returned value from a foreign function or an argument to a foreign callable, it is automatically converted to a Lisp vector of the correct length and element type. This also occurs when accessing a value using **foreign-slot-value**, **foreign-aref** and **dereference**.

2.2.4.3 Using a foreign pointer to a vector type

When you have a foreign pointer to a vector type, you can access individual elements using **foreign-aref**, or convert the vector into a Lisp vector using **dereference**. The reverse operations can be performed using the **setf** form or **foreign-aref** and **dereference**. For example:

```
(let ((d4-poi (fli:allocate-foreign-object
               :type 'fli:vector-double4)))
  (setf (fli:dereference d4-poi) #(0d0 1d0 2d0 3d0))
  (format t "Collected values: ~s~%"
             (loop for x below 4
               collect (fli:foreign-aref d4-poi x)))
  (setf (fli:foreign-aref d4-poi 3) -3d0)
  (format t "Dereference after setf: ~s~%"
           (fli:dereference d4-poi)))
=>
Collected values: (0.0D0 1.0D0 2.0D0 3.0D0)
Dereference after setf: #(0.0D0 1.0D0 2.0D0 -3.0D0)
```

Normally there is no reason to allocate a foreign object for a vector type as in the example above. You would, however, encounter such a pointer if you have foreign code that calls into Lisp passing it an argument that is a pointer to a vector type, and your Lisp code needs to set the values in it. In this case, you will need to declare the argument type as **(:pointer vector-double4)** and then set it like this:

```
(fli:define-foreign-callable my-callable
   ((d4-poi (:pointer fli:vector-double4)))
  (let ((lisp-v4 (my-compute-d4-values)))
     (setf (fli:dereference d4-poi) lisp-v4)))
```

```
(defun my-compute-d4-values ()
   (vector 3.5d0 7d0 9d23 0.1d0)))
```

Note that if you call a function that takes a pointer to a vector type, you can use the FLI types **:reference**, **:reference-pass** and **:reference-return** to pass and return values without having to explicitly allocate a foreign pointer. For example, if the C function **my_function** takes a pointer to **vector_double2** and fills it like this:

```
void my_function (vector_double2* d2_poi) {
   (*d2_poi)[0] = 3.0;
   (*d2_poi)[1] = 4.0;
}
```

then in Lisp you can call it by:

```
(fli:define-foreign-function my-function
   ((d2-po1 (:reference-return fli:vector-double2))))

(my-function)  ; returns #(3D0 4D0)
```

2.2.4.4 Notes on foreign vector types

C compilers other than Clang can also define vector types in various ways:

- In GCC, they can be defined using the **vector_size** attribute, for example, **vector_double4** would be defined by:

  ```
  typedef double vector_double4 __attribute__ ((vector_size (32)));
  ```

  Note that the size is in bytes, rather than an element count.

- The compiler supplied by ARM has "vector data types", so for example the type **float32x4_t** matches **vector-float4**.
- In Clang, it is possible to define vector types using the GCC syntax, OpenCL syntax, AltiVec syntax and Neon syntax.

On 32-bit x86, vector types can be passed either with or without using SSE2. The Lisp FLI definitions must pass/receive arguments in the same way as the C compiler that was used to compile the foreign code. On macOS, this is always with SSE2, so this is not an issue, but on other platforms (Linux, FreeBSD, Solaris) the situation is not clear. What the Lisp definitions do is controlled by ***use-sse2-for-ext-vector-type***.

When using **vector-char2** and **vector-uchar2** on x86_64 platforms and the C compiler is Clang or a derivative, you need to check that you have the latest version of the C compiler, because earlier versions of Clang compiled these types differently from later versions. This affects macOS too because the Xcode C compiler is based on Clang. You can check the version of the C compiler by executing **cc -v** in a shell. On macOS, you need to check that you have LLVM 8.0 or later. If you have Clang, you need to check that you have version 3.9 or later.

On macOS x86_64, the treatment of **vector_char2** and **vector_uchar2** changed between LLVM 6.0 and 8.0. LispWorks is compatible with LLVM 8.0. You can check which version of LLVM you have by executing **cc -v** in a shell.

When a structure is passed by value and it contains one of more fields whose types are vector types, it is also important to declare the type correctly in Lisp, otherwise the wrong data may be passed. That is because the machine registers that are used to pass such structures may be different from the registers that are used to pass seemingly equivalent structures that are defined without vector types. Such structures are commonly used to represent matrices.

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**.

The **:wrapper** foreign type allows the specification of automatic conversion functions between Lisp and an instance of a FLI type. Its signature is:

: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)**.

For an example of interfacing to a **void ****, see **3.5.2 Allocating a pointer to a pointer to a 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**.

A pointer which holds the address of a foreign symbol, either one which is defined in foreign code or one that is defined in

Lisp using **define-foreign-callable**, can be created either by **make-pointer** with **:symbol-name** or **foreign-function-pointer**.

3.1.2 Copying pointers

Suppose the Lisp variable **point3** is bound to a FLI pointer as in **3.1.1 Creating pointers**. 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 unpredictable 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 **2 FLI Types**, and the use of the **dereference** function with aggregate types is discussed further in **5 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 **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, however, 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.

The function **pointer-pointer-type** returns the pointer type of a foreign pointer.

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.

3.5.1 Allocating an integer

To allocate an integer in C:

```
(int *)malloc(sizeof(int))
```

You can allocate the integer from LispWorks using the **`:type`** argument:

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

Alternatively you can allocate the integer from LispWorks using the **`:pointer-type`** argument:

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

3.5.2 Allocating a pointer to a pointer to a void

Suppose you need to call a C function that takes a **`void **`** argument, defined as follows:

```
struct arg_struct
{
int val;
};

void func_handle_init(void **h)
{
  struct arg_struct *handle = NULL;
  handle = (struct arg_struct *)malloc(sizeof(struct arg_struct));
  memset(handle, 0, sizeof(struct arg_struct));
  handle->val = 12;
  *h = handle;
}
```

With this foreign function definition:

```
(fli:define-foreign-function
    (func-handle-init "func_handle_init"
                      :source)
    ((handle (:pointer (:pointer :void))))
  :result-type :void
  :language :ansi-c)
```

you could simply do:

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

(func-handle-init handle)
```

but do not forget to also free the pointer:

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

Another approach is to allocate the pointer on the stack. In this case you do not need to free it explicitly:

```
(fli:with-dynamic-foreign-objects ((handle :pointer))
  (func-handle-init handle))
```

Yet another approach is to define the foreign function like this:

```
(fli:define-foreign-function
    (func-handle-init "func_handle_init"
                      :source)
    ((:ignore (:reference-return (:pointer :void))))
  :result-type :void
  :language :ansi-c)
```

Then call the function like this:

```
(func-handle-init)
```

and it will return the handle. This works because the **`:reference-return`** type allocates the temporary **`void **`** within the function and returns its contents.

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 Defining foreign functions and callables

This chapter discusses how to define foreign functions and callables.

4.1 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 **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)
```

A FLI foreign function calling some C code. is an illustration of **`set-cursor-position`**, represented by a square, calling the C code which constitutes **`SetCursorPos`**.

A FLI foreign function calling some C code.

The next diagram, **C calling a callable function in Lisp.**, 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.

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**.

A FLI foreign function calling a callable function. 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".

A FLI foreign function calling a callable function.

For more information on calling foreign code see **define-foreign-function**.

For more information on defining foreign callable functions see **4.1.1 Strings and foreign callables** and **define-foreign-callable**.

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

For some complete examples of building a LispWorks DLL, then loading and calling it from foreign code, see "Delivering a dynamic library" in the *Delivery User Guide*.

4.1.1 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.

4.2 Specifying a calling convention.

The FLI macros such as **`define-foreign-function`** and **`define-foreign-callable`** take a keyword **`:calling-convention`**. Apart from on 32-bit Windows and on the ARM architectures, there is only one calling convention and in most cases you do not need to specify it.

The common case when you need to specify the calling convention is on 32-bit Windows where the default LispWorks calling convention is **`__stdcall`**. This matches the Win32 API functions, but compilers typically produce **`__cdecl`** by default (which is the same as the non-Windows x86 systems).

ARM (both 32-bit and 64-bit) also has more than one calling convention, but it should be rare (in 32-bit) or extremely rare (in 64-bit) that you need to specify the convention. Note however that, on ARM, failing to specify that a function is variadic (by the keyword **`:variadic-num-of-fixed`**) is more likely to cause crashes than on the other architectures.

4.2.1 Windows 32-bit calling conventions

The Win32 API functions in 32-bit Windows applications are compiled using the **`__stdcall`** calling convention, but compilers normally use **`__cdecl`** by default. Thus if you call functions that are not part of the Win32 API from 32-bit LispWorks then you need to check the calling convention and in most cases you need to specify it as **`__cdecl`** by passing **`:calling-convention :cdecl`**. To specify **`__stdcall`**, pass **`:calling-convention :stdcall`**, which is the default so is not really needed.

Note that all the other LispWorks architectures, including 64-bit Windows, interpret both **`:cdecl`** and **`:stdcall`** to mean the default.

Since whole libraries are normally compiled with the same calling convention, it is usually convenient to define your own defining macro that expands to the FLI defining macro and passes it the calling convention. For example, LispWorks itself uses the following defining macro to define foreign calls to the MySQL library:

```
(defmacro def-mysql-function (&body x)
  `(dspec:def (def-mysql-function ,(car x))
     (define-foreign-function ,@x
       :module 'mysql-library
       :calling-convention :cdecl)))
```

4.2.2 ARM 32-bit calling conventions

32-bit ARM systems have two calling conventions: hard float and soft float. These calling conventions are binary incompatible, and operating systems generally support only one or the other. Currently, Android and iOS are both soft float but Android is now starting to support hard float code, while ARM Linux distributions are now almost always hard float, but used to be soft float. Moreover, iOS has a calling convention which is soft, and somewhat different from the Android/old-Linux soft float, so these are also binary incompatible.

Thus LispWorks supports 3 calling conventions:

Soft float conventions:

iOS	The calling convention that is used by iOS.
soft Linux	The calling convention that is used by Android, and was used by old Linux systems.

Hard float convention:

hard float	The calling convention used by newer Linux systems.

When LispWorks compiles a foreign call or callable function, it (by default) generates "tri-compatible" code that can interface with either hard float, soft Linux or iOS foreign code. At run time, the code checks an internal flag and uses the appropriate calling convention. The internal flag is set to the correct value on start-up. The tri-compatible code is needed only for functions where the calling conventions differ, and when 2 or more of the conventions need the same code LispWorks avoids duplicating code, while remaining compatible with all 3 conventions.

Because of the tri-compatible code, LispWorks binaries (fasl files) are compatible with all the conventions. The compiled Lisp code is also compatible with all conventions. However, LispWorks executables (including LispWorks as a shared library) have a small C program that starts Lisp (the "xstarter"), and this is either hard float, soft Linux or iOS. Therefore, a LispWorks executable can run only on one calling convention, but the code that LispWorks compiles can run on all of them.

In particular, that means that it is possible to compile and build runtimes for Android and iOS on either soft float or hard float systems, because the runtime is created using the appropriate xstarter for the target OS.

It is possible to tell LispWorks to compile a foreign call or callable function for only one calling convention, by supplying the keyword **`:calling-convention`** with one of these values:

:ios iOS.

:hard-float hard float.

:soft-linux soft Linux.

:android Android. Currently that is an alias to :soft-linux.

:soft-float Code that selects between **:soft-linux** and **:ios** .

All other values generate tri-compatible code.

You are only required to pass **:calling-convention** when you use a library with a calling convention that does not match the calling convention of the OS. That should be rare.

Passing **:calling-convention** also makes the code smaller and slightly faster, but the difference is unlikely to be significant.

Note that variadic functions (for example **printf** and **sscanf**) are always soft float, which means that when compiling calls to such functions it is essential to specify that they are variadic (by passing **:variadic-num-of-fixed**) to ensure that LispWorks does not try to pass the arguments as hard float.

Compatibility note: in LispWorks 7.0, you had to pass **:calling-convention :soft-float** for variadic functions. This still works, but passing **:variadic-num-of-fixed** is more correct and will make it work properly on other architectures, (in particular 64-bit ARM).

4.2.3 ARM 64-bit calling conventions

There is a standard calling convention for 64-bit ARM (documented by ARM), but iOS uses a slightly different one. Therefore, there are effectively two calling conventions: the standard one and iOS.

By default, LispWorks compiles code that selects which convention to use at run time. However, the difference between the conventions is quite minor and affects only a small number of functions, so the code is the same for most functions. Thus the overhead is quite small and you will not normally have a reason to pass **:calling-convention** for 64-bit ARM.

You can use the following values with **:calling-convention** to tell LispWorks to compile for a specific convention:

:ios Compile only the iOS convention.

:standard Compile only the standard convention.

Other values are treated as the default.

Note that all the keywords used for 32-bit ARM (see **4.2.2 ARM 32-bit calling conventions**), with the exception of **:ios**, are treated as the default on 64-bit ARM.

4.2.4 Fastcall on 32-bit x86 platforms

On 32-bit x86 platforms, the C compilers have a fastcall calling convention. In Visual C and the GNU C compiler, this it is specified by the **__fastcall** qualifier. If you call a foreign function that is compiled as a fastcall, you must specify the calling convention **:fastcall**.

On other architectures, the calling convention **:fastcall** is quietly ignored, and the code produced is the same as would be produced without it.

The calling convention **:fastcall** cannot be used in foreign callables (calls from foreign code into LispWorks).

5 Advanced Uses of the FLI

Note: Some of the examples in this chapter only work for LispWorks for 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.

5.1 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 or a later system based on it (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**, for more details on the use of foreign strings.

5.2 Passing and returning strings

5.2.1 Use of Reference Arguments

Lisp and C cannot in general share memory so the FLI needs to make a copied of strings, either temporarily when passing them to C or as new Lisp objects when returning them.

5.2.2 Passing a 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;
}
```

Non-Windows 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
```

5.2.3 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;
}
```

Non-Windows 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 does not have to pass a dummy argument for the returned string, and **:result-type nil** corresponding 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"
```

5.2.4 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);
}
```

Non-Windows 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))))
```

5.2.5 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))))
```

Here is a similar example converting Lisp strings to **`**char`** or **`*char[]`** which by default allocates using **`malloc`** (the value **`:static`** for the *allocation* argument):

```
(defun convert-strings-to-foreign-array (strings &key
                                                 (allocation :static))
  (let* ((count (length strings))
         (array (fli:allocate-foreign-object
                 :type '(:pointer (:unsigned :char))
                 :nelems (1+ count)
                 :initial-element nil
                 :allocation allocation)))
    (loop for index from 0
          for string in strings
          do (setf (fli:dereference array :index index)
                   (fli:convert-to-foreign-string
                    string
                    :external-format :utf-8
                    :allocation allocation)))
    array))
```

If you call it frequently, then you will probably want to free the array (and the strings inside it). Alternatively, you can give the array and its strings dynamic scope if the foreign side does not keep a pointer to the data, like this:

```
(fli:with-dynamic-foreign-objects ()
  (let ((array (convert-strings-to-foreign-array
                strings :allocation :dynamic)))
    (%foo array)))
```

5.2.6 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.

Consider 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;
}
```

Non-Windows 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 Non-Windows 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.

5.2.7 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 Non-Windows systems, 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
```

5.2.8 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. Supported versions of Microsoft Windows support both flavors. 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 three ways to handle this:

- Use the **A** function explicitly, for example:

  ```
  (define-foreign-function (create-file "CreateFileA")
      ((lpFileName win32:lpcstr) ...))
  ```

  This will prevent the use of Unicode strings but this is typically only a problem if you are handling mixed language data. Be sure to use the correct FLI types **win32:str**, **win32:lpcstr** and so on when explicitly interfacing to an ANSI Win32 function.

- Use the **W** function explicitly, for example:

  ```
  (define-foreign-function (create-file "CreateFileW")
      ((lpFileName win32:lpcwstr) ...))
  ```

  This will allow use of Unicode strings. Be sure to use the correct FLI types **win32:wstr**, **win32:lpcwstr** and so on when explicitly interfacing to a Unicode Win32 function.

- Use *encoding* **:dbcs** in **define-foreign-function** and omit the single letter suffix, for example:

  ```
  (fli:define-foreign-function (create-file "CreateFile" :dbcs)
      ((lpFileName win32:lpctstr) ...))
  ```

This will cause it to use the Unicode **W** function implicitly in supported versions of Windows. (In some older operating systems such as Windows ME, this mechanism would implicitly use the ANSI **A** function.)

In all cases, as well as calling the correct function, you must encode/decode any string arguments and results correctly, to match the **A** or **W** in the function name. The foreign types **win32:tstr**, **win32:lpctstr** and **win32:lptstr** automatically switch between ANSI and Unicode strings and 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*.

5.2.9 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) void __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]);
     }
  }
}
```

Non-Windows version:

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

void 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]);
     }
  }
}
```

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
```

5.3 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.

5.4 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 **2 FLI Types**. 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`**.

5.5 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.

5.5.1 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 2 follows. Let us assume you have the following C code in a file called **`example.c`**.

```
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 **`cl.exe`**.

```
cl /LD example.c /link /export:multiply
```

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 (the default for **cl.exe**).

5.5.1.1 Testing whether a function is defined

Having loaded your DLLs (with **register-module**) you may wish to test whether certain functions are now available.

To detect when a C function *name* is defined, call:

```
(not (fli:null-pointer-p
      (fli:make-pointer :symbol-name name
                        :errorp nil)))
```

You can also return a list of unresolved foreign symbol names by calling **module-unresolved-symbols**.

5.5.2 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 **5.5.1 Using C DLLs**.

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

5.6 Incorporating a foreign module into a LispWorks image

Embedded dynamic modules are dynamically loaded foreign modules which are embedded (that is, the data is stored inside the LispWorks image). They can then be used at run time.

The formats supported include DLL on Windows, dylib on macOS, and shared object or shared library on other platforms. See **1.1.2 Loading foreign code** for details of the types of modules supported.

You use an embedded dynamic module when you want to integrate foreign code, and that foreign code is not expected to be available on the end-user's computer. In principle this could also be achieved by supplying the foreign module as a separate file together with the Lisp image, locating it at run time and loading it with **register-module**. The embedded dynamic modules mechanism simplifies this.

The main interface is **get-embedded-module**, which is called at load time to "intern" the module, and **install-embedded-module** which needs to be called at run time to make the foreign code available. It is possible to incorporate in a fasl file by using **get-embedded-module-data** and **setup-embedded-module** instead of **get-embedded-module**.

Another way to "intern" the module is to define a **`lw:defsystem`** system containing a C source file member with the **`:embedded-module`** keyword. When the system is loaded, the value associated with **`:embedded-module`** is used to create the embedded module. You would then call **`install-embedded-module`** at run time to make the foreign code available.

5.7 Block objects in C (foreign blocks)

This section applies to LispWorks for Macintosh, only.

Foreign blocks are objects that correspond to the opaque "Block" object in C and derived languages that are introduced in CLANG and used by Apple Computer, Inc.

A "Block" in C is similar to a closure in Lisp. It encapsulates a piece of code, and potentially some variables (which may be local), and allows invocation of this code.

LispWorks foreign blocks allows your Lisp program to call into and get called by code that uses blocks.

A foreign block is represented in LispWorks by a foreign pointer with pointer type **`foreign-block-pointer`**. Even though these are foreign pointers, these objects should be regarded as opaque, and should not be manipulated or used except as described below.

You use a foreign block by passing it to a foreign function that is defined to take a block as an argument, or by invoking a block that is received from a foreign function. The argument type needs to be specified as **`foreign-block-pointer`**.

When a foreign function invokes a block which was created in Lisp (or a copy of it), this invocation calls a Lisp function which the programmer supplied to the creating function or macro. When Lisp invokes a block that came from foreign code, it invokes some (unknown) foreign code.

Blocks can be used to run code via the Grand Central Dispatch mechanism (GCD) in macOS (see Apple documentation). There is a simple example in:

```
(example-edit-file "fli/grand-central-dispatch")
```

5.7.1 Calling foreign code that receives a block as argument

To call foreign code that needs a block as an argument, the Lisp program needs to create the blocks. You do this in two steps:

1. At load time, define a "type" by using the macro **`define-foreign-block-callable-type`**. This "type" corresponds to the "signature" in C.

2. At run time, generate the block, for example by calling **`allocate-foreign-block`** with the "type". Alternatively use one of the macros **`with-foreign-block`** and **`with-local-foreign-block`**. When generating the block, you also pass an arbitrary Lisp function that gets called when the block (or a copy of it) is invoked.

Foreign blocks created by **`allocate-foreign-block`** are released when appropriate by **`free-foreign-block`**.

Foreign block pointers created by **`allocate-foreign-block`** are of type **`foreign-block-pointer`** and print with **`"lisp-foreign-block-pointer"`**.

For examples see:

```
(example-edit-file "fli/foreign-blocks")
```

and:

```
(example-edit-file "fli/grand-central-dispatch")
```

5.7.2 Operations on foreign blocks

You might obtain a foreign pointer of type **foreign-block-pointer** that was passed as an argument to another foreign block, to a callable defined by **define-foreign-callable** or returned by a foreign function.

The foreign block can be invoked by defining an invoker (at load time) using **define-foreign-block-invoker**, and calling the invoker. If you need to keep the block after returning to the caller, you normally need to copy it by **foreign-block-copy**. If you copy a block, once you are finished with it, you should release it by **foreign-block-release**.

For examples of this see:

```
(example-edit-file "fli/invoke-foreign-block")
```

5.7.3 Scope of invocation

In principle, in the general case each of these is not defined:

- The time at which the code that the block encapsulates is invoked. In particular, even after a block is released (freed), the same code may be invoked by a copy of the block.
- In which thread the code is invoked.
- How many invocations can occur in parallel. In other words, whether it is invoked serially or concurrently.

The implementation of foreign blocks copes with all of these, that is it can work concurrently on any thread and after the block was released/freed, as long as there are live copies of it (except with blocks created by **with-local-foreign-block**). However, whether the code inside the block can cope with it is dependent on the code. This needs to be considered when creating blocks.

Specific foreign functions that take blocks as argument should be documented to state the scope of invocation. Apple's documentation commonly states whether the code is invoked concurrently or serially. In some functions the caller can decide when it calls the function whether the code can be executed concurrently or not. If you pass the block to a function that is documented to execute it serially, or you can tell it to do it, then you can assume that function that you made the block with is not going to be called concurrently from the block. Otherwise it must be able to cope with concurrent calls from the blocks.

Whether the code may be invoked on another thread or after the function that took the block returned is not normally documented. In many cases it can be deduced with confidence: when you dispatch a block to a queue (for example **dispatch_after** and similar functions, see the Apple documentation) it clearly can be invoked from another threads after the function returns. In the case of **qsort_b** (see Apple documentation and the example in **(example-edit-file "fli/foreign-blocks")**) we can be sure that the code will not be invoked after **qsort_b** returned, because the arguments to the block are based on the data (first argument to **qsort_b**), and **qsort_b** and its callees cannot be guaranteed that the data is still valid once **qsort_b** returned. On the other hand, we cannot be sure that the block is not invoked on another thread(s) before **qsort_b** returns. Currently it is probably always called in the same thread where **qsort_b** was called, but the interface does not guarantee it.

Thus when you create a foreign block in Lisp, the following considerations apply to the Lisp function *function* that you supply:

- In most cases, *function* needs to cope with being called in any thread, and hence cannot rely on the dynamic environment. Normally it is impossible to deduce that function will not be called on another thread, so it can be guaranteed only when the function to which the block is passed is documented to guarantee it.

  Note: that is the only situation in which it is really valid to use **with-local-foreign-block**.

- *function* may need to be able to cope with being called at any time, unless it is documented or deducible from the interface that it can be called only within the scope of the caller. It may be possible to deduce the time limit on a call from the way the block is used.
- The function needs to be able to cope with being called concurrently, unless the documentation of the user of the blocks says that it does not, or you can tell that it is going to be called only on one thread.

5.8 Interfacing to graphics functions

This section applies to LispWorks for Windows, only.

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

This condition does not apply on non-Windows platforms.

5.9 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, including code using blocks.

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.

6 Self-contained examples

This chapter enumerates the set of examples in the LispWorks library relevant to the content of this manual. Each example file contains complete, self-contained code and detailed comments, which include one or more entry points near the start of the file which you can run to start the program.

To run the example code:

1. Open the file in the Editor tool in the LispWorks IDE. Evaluating the call to **`example-edit-file`** shown below will achieve this.
2. Compile the example code, by **`Ctrl+Shift+B`**.
3. Place the cursor at the end of the entry point form and press **`Ctrl+X Ctrl+E`** to run it.
4. Read the comment at the top of the file, which may contain further instructions on how to interact with the example.

6.1 Foreign block examples

This section lists the examples illustrating the use of foreign blocks, which is described in **5.7 Block objects in C (foreign blocks)**.

These examples apply to LispWorks for Macintosh only:

```
(example-edit-file "fli/foreign-blocks")
```

```
(example-edit-file "fli/grand-central-dispatch")
```

```
(example-edit-file "fli/invoke-foreign-block")
```

6.2 Miscellaneous examples

```
(example-edit-file "fli/foreign-callable-example")
```

7 Function, Macro and Variable 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*.

Examples

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

allocate-dynamic-foreign-object
alloca

Functions

Summary

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

Package

fli

Signatures

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

alloca &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⇓	The initial value of the newly allocated objects.
initial-contents⇓	A list of values to initialize the contents of the newly allocated objects.
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**.

initial-element, *initial-contents*, *fill*, *nelems* and *size-slot* initialize the allocated instance 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.

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

Examples

A full example using **with-dynamic-foreign-objects** and **allocate-dynamic-foreign-object** is given in **1.4 An example of dynamic memory allocation**.

See also

allocate-foreign-object
with-dynamic-foreign-objects
1.4 An example of dynamic memory allocation
3.5 More examples of allocation and pointer allocation
5.2.4 Modifying a string in a C function

allocate-foreign-block *Function*

Summary

Allocates a foreign block, in LispWorks for Macintosh.

Package

fli

Signature

allocate-foreign-block *type* *function* **&rest** *extra-arguments* **=>** *foreign-block*

Arguments

type⇓	A symbol.
function⇓	A Lisp function.
extra-arguments⇓	Arguments.

Values

foreign-block	A Lisp-allocated **foreign-block-pointer**.

Description

The function **allocate-foreign-block** allocates a foreign block of type *type* such that when the foreign block is is invoked it calls the function *function* with the arguments given to the block followed by *extra-arguments* (if any).

type is a symbol which must have been defined as a type using **define-foreign-block-callable-type**.

function is any Lisp function, but see the **5.7.3 Scope of invocation** for potential limitations.

The resulting foreign block lives indefinitely, until it is freed by **free-foreign-block**, and can be used repeatedly and concurrently. It cannot be garbage collected, so if your program repeatedly allocates foreign blocks, you need to free them by calls to **free-foreign-block**. The macro **with-foreign-block** does this for you.

extra-arguments allows you to (roughly speaking) "close over" some values to the function, but they are read-only. If the function needs to set values, you can either pass some objects and set slots inside them, or make the function a real Lisp closure.

Notes

The result of **`allocate-foreign-block`** prints with **`"lisp-foreign-block-pointer"`**.

`allocate-foreign-block` is implemented in LispWorks for Macintosh only.

See also

`define-foreign-block-callable-type`
`free-foreign-block`
`with-foreign-block`
5.7 Block objects in C (foreign blocks)

allocate-foreign-object
malloc *Functions*

Summary

Allocates memory for an instance of a foreign object.

Package

`fli`

Signatures

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

`malloc &key` *type pointer-type initial-element initial-contents fill nelems size-slot allocation* **`=>`** *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⇓	The initial value of the newly allocated objects.
initial-contents⇓	A list of values to initialize the contents of the newly allocated objects.
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.
allocation⇓	A keyword, either **`:dynamic`** or **`:static`**.

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*.

If *allocation* is **`:static`** then memory is allocated in the C heap and must be explicitly freed using **`free-foreign-object`** once the object is no longer needed.

If *allocation* is **`:dynamic`**, then **`allocate-foreign-object`** allocates memory for the object and pointer within the scope of the body of **`with-dynamic-foreign-objects`**. This is equivalent to using **`allocate-dynamic-foreign-object`**.

The default value of *allocation* is **`:static`**.

An integer value of *fill* 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.

If *initial-contents* is supplied and its length is less than *nelems*, then the remaining elements are not initialized.

If *initial-contents* is supplied and its length is greater than *nelems*, then the length of *initial-contents* overrides *nelems*. This is a common case where *initial-contents* is supplied and *nelems* is omitted (and hence defaults to 1).

size-slot can be used to initialize a slot in a struct or union type to the size of the object in bytes. If *size-slot* is supplied then it must be the name of a slot in that type. The slot named by *size-slot* is set to the size of the object in bytes. This occurs after *fill*, *initial-element* and *initial-contents* are processed. If *nelems* is greater than 1, then the slot named by *size-slot* is initialized in each element. If *size-slot* is not supplied, then no such setting occurs.

The function **`malloc`** is a synonym for **`allocate-foreign-object`**.

Notes

When *allocation* is **`:static`**, memory allocated by **`allocate-foreign-object`** is in the C heap. Therefore *pointer* (and any copy) cannot be used after **`save-image`** or **`deliver`**.

Examples

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
3 FLI Pointers

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.

Examples

```
(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`**.

Examples

```
(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*.

external-format is interpreted as by **`with-foreign-string`**. The names of available external formats are listed in section 26.6 External Formats to translate Lisp characters from/to external encodings in the LispWorks® User Guide and Reference Manual.

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 and *pointer* is a null pointer then **`nil`** is returned. Otherwise, an error is signalled if *pointer* is a null pointer.

See also

`convert-to-foreign-string`
`set-locale`
`set-locale-encodings`
`with-foreign-string`
26.6 External Formats to translate Lisp characters from/to external encodings in the LispWorks® User Guide and Reference Manual

5.2.4 Modifying a string in a C function
5.2.9 Mapping `nil` to a Null Pointer

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

Summary

Converts a Lisp integer to foreign bytes.

Package

`fli`

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

5.3 Lisp integers
`with-integer-bytes`
`make-integer-from-bytes`

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.

external-format is interpreted as by **`with-foreign-string`**. The names of available external formats are listed in section 26.6 External Formats to translate Lisp characters from/to external encodings in the LispWorks® User Guide and Reference Manual.

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

If *allow-null* is non-nil and *string* is **`nil`** then a null pointer *pointer* is returned. Otherwise, an error is signalled if *string* is **`nil`**.

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`
26.6 External Formats to translate Lisp characters from/to external encodings in the LispWorks® User Guide and Reference Manual
5.2.5 Calling a C function that takes an array of strings

convert-to-foreign-string *Function*

Summary

Converts a Lisp string to a foreign string.

Package

fli

Signature

convert-to-foreign-string *string* **&key** *external-format null-terminated-p allow-null into limit allocation* **=>** *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**.
into⇓	A foreign array, a foreign pointer 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.

external-format is interpreted as by **with-foreign-string**. The names of available external formats are listed in section 26.6 External Formats to translate Lisp characters from/to external encodings in the LispWorks® User Guide and Reference Manual.

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

If *allow-null* is non-nil and *string* is **nil** then a null pointer *pointer* is returned. Otherwise, an error is signalled if *string* is **nil**.

If *into* is **nil**, then a new foreign string is allocated according to *allocation*, and *limit* is ignored.

If *into* is a FLI pointer to a integer type, then *limit* must be a fixnum and up to *limit* elements are filled with elements converted from the characters of *string*. The size of the integer type must equal the foreign size of *external-format*.

If *into* is a FLI array of integers or a pointer to a FLI array of integers, up to *limit* elements are filled with elements converted from the characters of *string*. If *limit* is **nil**, then the dimensions of the array are used. The size of the array element type must equal the foreign size of *external-format*.

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 and *length* and *byte-count* are not returned.

See also

convert-from-foreign-string
set-locale
set-locale-encodings
with-foreign-string
26.6 External Formats to translate Lisp characters from/to external encodings in the LispWorks® User Guide and Reference Manual
5.2.5 Calling a C function that takes an array of strings

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⇓	A FLI type descriptor.
pointer-type⇓	A FLI pointer type descriptor.

Values

copy⇓	A copy of *pointer*.

Description

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

If *type* is supplied, then it is used as the FLI type that *copy* points to. Alternatively, if *pointer-type* is supplied, then it must be a FLI pointer type and it is used as the pointer type of *copy*. If neither *type* nor *pointer-type* are supplied then the type of *copy* is the same as *pointer*. An error is signalled if both *type* and *pointer-type* are supplied.

Examples

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 pointer object, a pointer to a **char**, whereas **point3** contains a copy of the foreign pointer object.

See also

make-pointer
with-coerced-pointer
3.1.2 Copying pointers

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 *pointer*. If *delta* is not given the address is decreased by the size of the type pointed to by *pointer*. The address can be decreased by a multiple of the size of the type by specifying a value for *delta*. If the size of the type is 0 then an error is signalled.

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

Examples

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)
  (print (fli:dereference point1))
  (fli:incf-pointer point1))

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

See also

incf-pointer
3.4 An example of dynamic pointer allocation

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** *foreign-name***)** **|** **(:forward-reference-p** *forward-reference-p***)**

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

Arguments

enumerator-list⇓	Symbols, possibly with integer values, constituting the enumerator type.
name⇓	A symbol naming the new enumeration type specifier.
foreign-name⇓	A string specifying the foreign name of the type.

forward-reference-p⇓ A boolean.

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**.

The FLI type specifier is named by *name*, with optional foreign name *foreign-name*.

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

When *forward-reference-p* is true, the new type specifier is defined as a forward reference type and descriptions can be empty. See **define-foreign-forward-reference-type**.

Examples

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
2 FLI Types

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`** *foreign-name***`)`** **`|`** **`(:forward-reference-p`** *forward-reference-p***`)`**

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

slot-description **`::=`** **`(`***slot-name slot-type***`)`**

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

aligned **`::=`** **`(:aligned`** *nbytes***`)`**

Arguments

name⇓	A symbol naming the new structure type specifier.
foreign-name⇓	A string specifying the foreign name of the structure.
forward-reference-p⇓	A boolean.
byte-packing⇓	A list specifying byte packing for the subsequent slots.
slot-name⇓	A symbol naming the slot.
slot-type⇓	The foreign type of the slot.
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 **`foreign-slot-type`** and **`foreign-slot-value`** functions.

The FLI type specifier is named by *name*, with optional foreign name *foreign-name*.

Each *slot-description* is a list of a symbol *slot-name* and a corresponding FLI type descriptor *slot-type* which is the type of the slot named by *slot-name*.

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.

An *aligned* form specifies that the next slot must be aligned on *nbytes* bytes. Note that this affects only the alignment of the next slot. It does not affect the length of the slot, or the alignment of other slots. You will need this when the slot is made to be aligned, for example in **gcc** a slot defined like this:

```
int slot_name __attribute__ ((aligned (16))) ;
```

needs to be aligned on 16 bytes, even though the native alignment of the type **int** is 4.

When *forward-reference-p* is true, the new type specifier is defined as a forward reference type and descriptions can be empty. See **define-foreign-forward-reference-type**.

Notes

foreign-name, specifying the foreign name, is supported only for documentation purposes.

Examples

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 *byte-packing*, 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
2 FLI Types

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** *foreign-name***)**

Arguments

type-description⇓ An FLI type descriptor.

name⇓ A symbol naming the new FLI type.

foreign-name⇓ A string specifying the foreign name of the type.

Values

name The name of the new FLI type.

Description

The macro **`define-c-typedef`** 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`**.

The FLI type specifier is named by *name*, with optional foreign name *foreign-name*.

type-description is not evaluated and the FLI type *name* will have no parameters.

Notes

foreign-name, specifying the foreign name, is supported only for documentation purposes.

Examples

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`
2 FLI Types

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** *foreign-name***) | (:forward-reference-p** *forward-reference-p***)**

slot-descriptions **::= {***slot-description***}***

slot-description **::= (***slot-name slot-type***)**

Arguments

name⇓	A symbol naming the new union type descriptor.
foreign-name⇓	A string specifying the foreign name of the type.
forward-reference-p⇓	A boolean.
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.

The FLI type specifier is named by *name*, with optional foreign name *foreign-name*.

Each *slot-description* is a list of a symbol *slot-name* and a corresponding FLI type descriptor *slot-type* which is the type of the slot named by *slot-name*.

When *forward-reference-p* is true, the new type specifier is defined as a forward reference type and descriptions can be empty. See **define-foreign-forward-reference-type**.

Notes

foreign-name, specifying the foreign name, is supported only for documentation purposes.

Examples

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
2 FLI Types

define-foreign-block-callable-type *Macro*

Summary

Defines a type for foreign blocks, in LispWorks for Macintosh.

Package

fli

Signature

define-foreign-block-callable-type *name result-type arg-types* **=>** *name*

Arguments

name⇓ A symbol.

result-type⇓ A foreign type specifier.

arg-types⇓ A list of foreign type specifiers.

Values

name Symbol.

Description

The macro **define-foreign-block-callable-type** defines a type for foreign blocks.

name specifies the name of the type. It must not be the same as the name of a **define-foreign-callable**.

result-type specifies the type of the result of the foreign block.

arg-types specifies the types of the arguments that a block of type *name* takes. These must correspond to the arguments types with which the block is called from the foreign call.

Note that *arg-types* specifies the types for a call from foreign code into Lisp, which affects the way **:reference-return** and **:reference-pass** are used. If the block is called from the foreign code with a pointer and you want to treat it as pass-by-reference, you need to use **:reference-return** (like **define-foreign-callable** does). See the qsort_b example in:

```
(example-edit-file "fli/foreign-blocks")
```

define-foreign-block-callable-type returns *name*.

Notes

define-foreign-block-callable-type is implemented in LispWorks for Macintosh only.

See also

allocate-foreign-block
with-foreign-block
with-local-foreign-block
5.7 Block objects in C (foreign blocks)

define-foreign-block-invoker *Macro*

Summary

Defines an invoker of a foreign block, in LispWorks for Macintosh.

Package

fli

Signature

define-foreign-block-invoker *the-name args* **&key** *lambda-list documentation result-type language no-check calling-convention*

Arguments

the-name⇓	A symbol.
args⇓	A lambda list.
lambda-list⇓	The lambda list to be used for the defined Lisp function.
documentation⇓	A string.
result-type⇓	A foreign type.
language⇓	The language in which the foreign source code is written. The default is **:ansi-c**.
no-check⇓	A boolean.
calling-convention⇓	Specifies the calling convention used.

Description

The macro **define-foreign-block-invoker** defines an invoker of a foreign block.

It defines *the-name* to be a function that can be used to invoke foreign blocks which takes arguments that match *args*. The block is then invoked by simply calling the function *the-name* with the block and arguments:

(*the-name block arg1 arg2* **...)**

The *block* argument is of type **foreign-block-pointer**.

define-foreign-block-invoker is very similar to **define-foreign-funcallable** and **define-foreign-function**, which specify how *documentation*, *result-type*, *language*, *no-check* and *calling-convention* are used.

Notes

The lambda list of the invoker is **(***block* **.** *args***)**. When *lambda-list* is supplied, **define-foreign-block-invoker** inserts in front of the supplied *lambda-list* an additional argument for the block. Therefore a supplied *lambda-list* must not include an argument for the block. Similarly a supplied *lambda-list* in **define-foreign-funcallable** should not include an argument for the function.

define-foreign-block-invoker returns *the-name*.

define-foreign-block-invoker is implemented in LispWorks for Macintosh only.

Examples

```
(example-edit-file "fli/foreign-blocks")
```

```
(example-edit-file "fli/invoke-foreign-block")
```

See also

define-foreign-funcallable
define-foreign-function
foreign-block-pointer
5.7 Block objects in C (foreign blocks)

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***)** **({***arg***}*) &body** *body* **=>** *lisp-name*

arg **::=** *arg-name* **|** **(***arg-name arg-type***)**

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

Arguments

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

encode⇓ One of **:source**, **:object**, **:lisp** or **dbcs**.

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⇓ A boolean.

calling-convention⇓ Specifies the calling convention used on Windows and ARM.

arg 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.

arg-name⇓ A Lisp symbol.

arg-type⇓ A FLI type.

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 C 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.

If *no-check* is **nil**, the result of the foreign callable function, produced by *body*, is checked to see if matches *result-type*, and an error is raised if they do not match. If *no-check* is **t** then this check is not done and the effect will be undefined if the types do not match.

calling-convention is ignored on platforms other than Windows and ARM, where there is no calling convention issue. On 32-bit 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"**. See **4.2.1 Windows 32-bit calling conventions** for details.

On ARM platforms, there is also more than one calling convention, but normally you do not need to specify it. See **4.2.2 ARM 32-bit calling conventions** and **4.2.3 ARM 64-bit calling conventions** for details.

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 *result-pointer* 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")
```

By default, LispWorks performs automatic name encoding to translate *foreign-name*. If you want to explicitly specify an encoding, *encode* can be one of the following:

:source *foreign-name* is the name of the function in the foreign source code. This is the default value of *encode* 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 *encode* 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.

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 *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**.

Compatibility note

64-bit integer types such as **(:long :long)**, **:int64** and **:uint64** are now supported for *arg-type* in **define-foreign-callable** in 32-bit LispWorks. In 32-bit LispWorks 6.1 and earlier versions, these types could only be used by **define-foreign-function**.

Examples

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
4 Defining foreign functions and callables
5.7.2 Operations on foreign blocks

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*

object-names **::=** *object-name* **|** **(***lisp-object-name foreign-object-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 macro expansion form that evaluates to a FLI type descriptor.

foreign-to-lisp⇓ A macro expansion form to convert between Lisp and the FLI.

lisp-to-foreign⇓ A macro expansion form to convert between the FLI and Lisp.

predicate⇓ A macro expansion form to check whether a Lisp object is of this type.

tested-value⇓ A macro expansion form to give an error if a Lisp object is not of this type.

error-form⇓ A macro expansion form to give an error if *predicate* returns false.

documentation⇓ A string.

object-name⇓, *lisp-object-name*⇓, *foreign-object-name*⇓
Lisp symbols.

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 *foreign-type*, *foreign-to-lisp*, *lisp-to-foreign*, *predicate* and *tested-value*.

If *object-names* is a symbol *object-name*, then it provides the name of a variable for use in all of the macro expansion 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 *lisp-to-foreign*, *predicate* and *tested-value* forms and *foreign-object-name* provides the name of a variable for use in *foreign-to-lisp*.

When the new FLI type is used, *foreign-type* 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`**), *foreign-to-lisp* is evaluated to determine how the conversion should be made. It works like a macro expansion 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 macro expansion 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 macro expansion 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 macro expansion 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 macro expansion 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
2.3 Parameterized types

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

type-name⇓	A symbol naming the new FLI 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

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.

lambda-list and *forms* are used as in **`define-foreign-type`**.

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 variadic-num-of-fixed* **`=>`** *the-name*

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

Arguments

the-name⇓ A symbol naming the Lisp function.

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.

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

no-check⇓ A boolean.

calling-convention⇓ Specifies the calling convention used.

variadic-num-of-fixed⇓

`nil` or a non-negative integer.

arg⇓ Argument specifier as in **`define-foreign-function`**.

Values

the-name A symbol naming the Lisp function.

Description

The macro **`define-foreign-funcallable`** 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.

See **`define-foreign-function`** for how *the-name*, *lambda-list*, *documentation*, *result-type*, *language*, *no-check*, *calling-convention*, *variadic-num-of-fixed* and *arg* are used.

Examples

Define a caller for this shape:

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

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 result-pointer language no-check calling-convention module variadic-num-of-fixed* **`=>`** *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`**

Arguments

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

documentation⇓ A string.

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 *result-type* is an aggregate type.

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

no-check⇓ A boolean.

calling-convention⇓ Specifies the calling convention used.

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

variadic-num-of-fixed⇓

`nil` or a non-negative integer.

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.

default⇓ A Lisp object.

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 *lisp-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 *arg* is a symbol *arg-name*, 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.

If *documentation* is supplied then it is set as the **`function`** documentation for *lisp-name*.

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*.

If *no-check* is **`nil`**, then the types of the arguments provided when *lisp-name* is called are compared with the expected types and an error is raised if they do not match. If *no-check* is **`t`** then this check is not done and the effect will be undefined if the types do not match. If the compilation safety level is set to 0 then *no-check* defaults to **`t`**, otherwise it defaults to **`nil`**.

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.

If *arg-type* is a struct then the value *arg-name* can be either a foreign struct object or a pointer to a foreign struct object.

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 *result-pointer* 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 some platforms, where there is no calling convention issue. On 32-bit 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"`**. See **4.2.1 Windows 32-bit calling conventions** for details.

On ARM platforms, there is also more than one calling convention, but normally you do not need to specify it. See **4.2.2 ARM 32-bit calling conventions** and **4.2.3 ARM 64-bit calling conventions** for details.

On 32-bit x86 platforms (including 32-bit Windows), the **`:fastcall`** calling convention can be use (see **4.2.4 Fastcall on 32 -bit x86 platforms** for details).

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.

When *variadic-num-of-fixed* a non-negative integer, it specifies that the foreign function that it is calling is variadic (like **`printf`**). The integer must be the number of fixed arguments that the foreign function takes. For **`printf`**, for example, you need to pass **`:variadic-num-of-fixed 1`**, and for **`sprintf`** you need **`:variadic-num-of-fixed 2`**. When *variadic-num-of-fixed* is **`nil`** (the default), then the function is specified to be not variadic. Calls to variadic function without using *variadic-num-of-fixed* work on some platforms, but not all. Thus you should always use it when calling variadic functions.

Compatibility notes

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`**.

The **`:fastcall`** *calling-convention* was added in LispWorks 7.1.

variadic-num-of-fixed was added in LispWorks 7.1.

Examples

A simple example of the use of **`define-foreign-function`** is given in **1.2.2 Defining a FLI function**. More detailed examples are given in **5 Advanced Uses of the FLI**.

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

Non-Windows 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
4 Defining foreign functions and callables

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

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

Values

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

Description

The macro **define-foreign-pointer** defines two things:

- An FLI pointer type *type-name*, which is a pointer to *points-to-type*.
- A Lisp type specifier *type-name* that is a foreign 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 values for *option-name* are the **defstruct** options **:conc-name**, **:constructor**, **:predicate**, **:print-object**, **:print-function**. In each case the symbol supplied as *option-value* provides the corresponding option for *type-name*.

slots is a list of **defstruct** slot-descriptions which become slots in *type-name*.

When LispWorks makes a foreign pointer of type *type-name*, then an object of Lisp type *type-name* is made instead of a foreign pointer object. This is useful if you want to associate extra Lisp data with the foreign pointer object, using *slots*.

See also

3.1.1 Creating pointers

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** *foreign-name***)**

Arguments

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.
name⇓	A symbol naming the new FLI type.
foreign-name⇓	A string specifying the foreign name of the type.

Values

name	The name of the new FLI type.

Description

The macro **define-foreign-type** defines a new FLI type called *name*, with optional foreign name *foreign-name*.

When *name* is used as a foreign type, *forms* are evaluated as an implicit **progn** with the variables in *lambda-list* bound to the arguments of the foreign type. The value returned by *forms* is used as the definition of the foreign type. This is similar to how **deftype** works for Lisp type specifiers.

Notes

foreign-name, specifying the foreign name, is supported only for documentation purposes.

Examples

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
2 FLI Types
5.4 Defining new types

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.
type⇓	The FLI type corresponding to the type of the foreign variable to which Lisp is interfacing. The default is **`:int`**.
language⇓	The language in which the foreign source code for the variable is written. The default is **`:ansi-c`**.
no-check⇓	A boolean.
module⇓	A string or symbol naming the module in which the foreign variable is defined.
lisp-name⇓	A symbol naming the Lisp accessor.
foreign-name⇓	A string or a symbol specifying the foreign name of the variable.

Values

lisp-name	A symbol naming the Lisp accessor.

Description

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

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

`:value` — The value of the foreign variable is returned directly and is the default when *type* is a non-aggregate type. If *type* is an aggregate type, 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.

`:address-of` — Returns an FLI pointer pointing to the foreign variable.

`:read-only` — Ensures that no **`setf`** expander 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.

If the foreign variable has a type corresponding to an FLI aggregate type, then *accessor* must be supplied (there is no default).

encoding controls how the Lisp variable name is translated to match the foreign variable name in the foreign DLL. *encoding* 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`**.

If *no-check* is **`nil`**, then the type of the value is provided to the **`setf`** expander for *lisp-name* is compared with *type* and an error is raised if it does not match. If *no-check* is **`t`** then this check is not done and the effect will be undefined if the type does not match. If the compilation safety level is set to 0 then *no-check* defaults to **`t`**, otherwise it defaults to **`nil`**.

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 processed as for **define-foreign-function**.

Examples

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 named *pointer-type* and foreign structure type with a name based on *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.

Examples

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 *Accessor*

Summary

Accesses and returns the value of a foreign object.

Package

fli

Signature

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

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

Arguments

pointer⇓	An instance of a FLI pointer.
index⇓	An integer.
type⇓	A foreign type.
copy-foreign-object⇓	One of **t**, **nil** or **:error**.
value	The value of the dereferenced object at *pointer*.

Values

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

Description

The accessor **dereference** accesses and returns the value of the FLI object pointed to by *pointer*.

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

If *type* is supplied, then **dereference** assumes that *pointer* points to an object of that type, overriding the type in *pointer* itself.

copy-foreign-object is only used when the type of *pointer* (or *type* if supplied) is an aggregate type, because objects of these types cannot be converted to a Lisp value. If *copy-foreign-object* is **`t`**, **`dereference`** makes a copy of the aggregate object pointed to by *pointer* and returns the copy. If *copy-foreign-object* is **`nil`**, **`dereference`** returns the aggregate object directly. If *copy-foreign-object* is **`:error`** (the default) then **`dereference`** signals an error.

The value of an object at *pointer* can be changed using the **`setf`** form of **`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.

Compatibility note

64-bit integer types such as **`(:long :long)`**, **`:int64`** and **`:uint64`** are now supported for *type* in **`dereference`** in 32-bit LispWorks. In 32-bit LispWorks 6.1 and earlier versions, these types could only be used by **`define-foreign-function`**.

Examples

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 the **`setf`** form of **`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`
2 FLI Types
3.3 Pointer dereferencing and coercing
5.2.5 Calling a C function that takes an array of strings

disconnect-module *Function*

Summary

Disconnects the DLL associated with a registered module.

Package

fli

Signature

disconnect-module *name* **&key** *verbose* *remove* **=>** *result*

Arguments

name⇓	A symbol or string.
verbose⇓	**nil**, **t** or an output stream.
remove⇓	A boolean.

Values

result	**nil**, **t** or **:removed**.

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 a stream, then **disconnect-module** will send disconnection information to that stream. If *verbose* is **t**, this is interpreted as standard output. The default value of *verbose* is **nil**.

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 non-nil 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. The default value of *remove* is **nil**.

disconnect-module returns **t** if it actually disconnected the module, which means it unloaded the foreign module, but has not removed the module. It returns **:removed** when it also removed the module. Note that when **disconnect-module** is supplied with a non-nil *remove*, it may still decline to remove the module if there are symbols which are explicitly associated withe the module (for example by by passing **:module** to **define-foreign-function**). **nil** is returned if it fails to find the module, or it was not already connected before the call and was not removed by the call.

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`

Signatures

`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 *enum-type*, where a pair is a cons of symbol and value.

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

Examples

```
(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.

Examples

```
(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 *Accessor*

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 *array* **&rest** *subscripts***)** *value* **=>** *value*

Arguments

array⇓ A FLI array or a pointer to a FLI array.

subscripts⇓ A list of valid array indices for *array*.

value An element of *array*.

Values

value An element of *array*.

Description

The accessor **`foreign-aref`** accesses an element in *array* specified by *subscripts* 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 get access to such embedded aggregate data.

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

Examples

In the first example, a 3 by 3 integer array is created, and the **`setf`** form of **`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

2 FLI Types
`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`** returns a list containing the dimensions of *array-or-type*.

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** returns the type of the elements of *array-or-type*.

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 an element in *array* specified by *subscripts*. You can then use **dereference** or **foreign-slot-value** to access the value.

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** form of **dereference** 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-block-copy *Function*

Summary

Makes a copy of a foreign block, in LispWorks for Macintosh.

Package

fli

Signature

foreign-block-copy *foreign-block* **=>** *new-foreign-block*

Arguments

foreign-block⇓ A foreign block pointer.

Values

new-foreign-block⇓ A foreign block pointer.

Description

The function **`foreign-block-copy`** makes and returns a copy of the foreign block *foreign-block*. It corresponds to the C function **`_Block_copy`**.

foreign-block can be any foreign block.

The result of the copy is another foreign block with an indefinite scope, which has the same attributes as *foreign-block*. In other words, invoking the copy invokes the same function.

The new foreign block cannot be garbage collected. It should be freed when you are finished with it by **`foreign-block-release`**.

`foreign-block-copy` is not expected to be commonly useful. You need it when you get passed a block and you want to use it outside the scope of the call in which it was passed, unless it is documented that the block is global.

Notes

1. If you use *new-foreign-block* with a function that is documented to release the block, you must not call **`foreign-block-release`** on it. However, we do not expect this situation to happen, because a proper interface will only free blocks that it allocates.

2. **`foreign-block-copy`** is implemented in LispWorks for Macintosh only.

See also

`foreign-block-release`
5.7 Block objects in C (foreign blocks)

foreign-block-release *Function*

Summary

Releases a foreign block, like **`_Block_release`**, in LispWorks for Macintosh.

Package

`fli`

Signature

`foreign-block-release` *foreign-block*

Arguments

foreign-block⇓ A foreign block pointer.

Description

The function **`foreign-block-release`** releases a foreign block. It corresponds to the C function **`_Block_release`**.

foreign-block must be the result of **`foreign-block-copy`**. In particular, it is an error to call **`foreign-block-release`** on the result of **`allocate-foreign-block`**.

Notes

1. In principle, you can also use **`foreign-block-release`** on foreign blocks that you received from foreign code, if the interface says that you need to release them. However, we do not expect this to happen, because proper interface will always free blocks that it allocates or copies.
2. After the call to **`foreign-block-release`**, *foreign-block* is of type **`released-foreign-block-pointer`**.
3. **`foreign-block-release`** has no useful return value.
4. **`foreign-block-release`** is implemented in LispWorks for Macintosh only.
5. To free a foreign block that was allocated by Lisp, use **`free-foreign-block`**.

See also

`foreign-block-copy`
`free-foreign-block`
`released-foreign-block-pointer`
5.7 Block objects in C (foreign blocks)

foreign-function-pointer *Function*

Summary

Returns a FLI pointer with its address set to the address of a foreign symbol.

Package

`fli`

Signature

`foreign-function-pointer` *symbol-name* **`=>`** *pointer*

Arguments

symbol-name⇓ A string or a symbol.

Values

pointer A FLI pointer.

Description

The function **`foreign-function-pointer`** returns a FLI pointer with its address set to the address of a foreign symbol, which can be either a symbol defined in a foreign library or a foreign callable.

symbol-name needs to be a name of a foreign symbol specifying a foreign function, either a string naming a symbol defined in a foreign library, or a symbol naming a foreign callable (defined by **`define-foreign-callable`**).

`foreign-function-pointer` returns a FLI pointer with its address set to the address of the symbol. If the symbol is not defined yet an error is signaled.

The pointer that is returned is associated with the symbol and is returned in further calls to **foreign-function-pointer** with the same argument. The pointer must not be modified by functions like **incf-pointer**.

When a saved image is restarted all the pointers that have been returned by **foreign-function-pointer** are updated to reflect the current address of their symbol (which may be different in the new invocation).

Notes

1. The pointer is not updated if the module containing the symbol is disconnected and registered again.
2. Only the pointer itself is updated, but not any copies of it. **foreign-function-pointer** is very similar to calling **make-pointer** with *symbol-name*, with the following differences:
   - The result of **foreign-function-pointer** is updated on image restart.
   - **foreign-function-pointer** returns the same pointer for the same *symbol-name* each time, so modifying the pointer will break it.
   - **foreign-function-pointer** allocates only in the first call for each symbol. In contrast, **make-pointer** allocates a pointer in each call.
   - **foreign-function-pointer** keeps the pointer, so if you want to use it only once, **make-pointer** is better.
3. **foreign-function-pointer** is especially useful for creating pointers for passing the address of foreign callables to foreign code in situations where the same address is used repeatedly.

See also

define-foreign-callable
make-pointer
3.1.1 Creating pointers

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 function **`foreign-slot-names`** returns a list containing the slot names of *object*, whose foreign type was defined by **`define-c-struct`**. If *object* is not a structure, an error is signaled.

Examples

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

2.2.3 Structures and unions
`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 the slot *slot-name* in *object-or-type*. 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.

Examples

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⇓	A foreign type.
object-type⇓	The FLI structure type that contains *slot-name*.

Values

pointer	A pointer to the slot identified by *slot-name*.

Description

The function **`foreign-slot-pointer`** returns a foreign pointer to the slot *slot-name* in *object*.

If *type* is supplied, then **`foreign-slot-pointer`** assumes that the slot contains an object of that type, overriding the type in the structure definition.

If *object-type* is supplied then **`foreign-slot-pointer`** assumes that *object* is of the that type and the compiler might be able to optimize the access to the slot. If *object-type* is not supplied, then the object type is determined dynamically from *object*.

Examples

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

2.2.3 Structures and unions
`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 the slot *slot-name* in *object-or-type*.

Examples

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

2.2.3 Structures and unions
foreign-slot-names
foreign-slot-value

foreign-slot-value *Accessor*

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 *object slot-name* **&key** *type object-type copy-foreign-object***)** *value* **=>** *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⇓	A foreign type.
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⇓	One of **t**, **nil** or **:error**.
value	The value of the slot *slot-name* in the FLI object *object* is returned.

Values

value	The value of the slot *slot-name* in the FLI object *object* is returned.

Description

The accessor **foreign-slot-value** accesses and 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 supplied as **t** or **nil**. 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.

If *type* is supplied, then **foreign-slot-value** assumes that the slot contains an object of that type, overriding the type in the structure definition.

copy-foreign-object is only used when the type of the slot (or *type* if supplied) is an aggregate type, because objects of these types cannot be converted to a Lisp value. If *copy-foreign-object* is **t**, **foreign-slot-value** makes a copy of the aggregate object in the slot and returns the copy. If *copy-foreign-object* is **nil**, **foreign-slot-value** returns the aggregate object directly. If *copy-foreign-object* is **:error** (the default) then **foreign-slot-value** signals an error.

If *object-type* is supplied then **foreign-slot-value** assumes that *object* is of the that type and the compiler might be able to optimize the access to the slot. If *object-type* is not supplied, then the object type is determined dynamically from *object*.

The **setf** form of **foreign-slot-value** can be used to set the value of a slot in a structure, as shown in the example below.

Compatibility note

64-bit integer types such as **(:long :long)**, **:int64** and **:uint64** are now supported for *type* in **foreign-slot-value** in 32-bit LispWorks. In 32-bit LispWorks 6.1 and earlier versions, these types could only be used by **define-foreign-function**.

Examples

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 section 9.7 Optimizing your code in the LispWorks® User Guide and Reference Manual in 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

2.2.3 Structures and unions
foreign-slot-pointer
foreign-slot-offset
dereference

with-foreign-slots

foreign-typed-aref *Accessor*

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 *type array index***)** *value* **=>** *value*

Arguments

type⇓	A type specifier.
array⇓	A foreign pointer.
index⇓	A non-negative **integer**.
value	An element of *array*.

Values

value	An element of *array*.

Description

The accessor **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)**, **(signed-byte 64)** and **sys:int64**.

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

2 FLI Types
foreign-aref

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.

Examples

```
(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

2 FLI Types
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.

free-foreign-block *Function*

Summary

Frees a foreign block that was allocated by Lisp, in LispWorks for Macintosh.

Package

fli

Signature

free-foreign-block *foreign-block*

Arguments

foreign-block⇓	A Lisp-allocated **foreign-block-pointer**.

Description

The function **free-foreign-block** frees a foreign block that was allocated by Lisp.

foreign-block must be a result of a call to **allocate-foreign-block**. It is an error to call **free-foreign-block** on the result of **foreign-block-copy** or on a foreign block coming from foreign code.

Note that the function that was passed to **allocate-foreign-block** may still be invoked after **free-foreign-block**, because the block may have been copied. See the discussion in **5.7.3 Scope of invocation**.

It is an error to call **free-foreign-block** more than once on the same *foreign-block*.

free-foreign-block has no useful return value.

Notes

1. To free a foreign block that was allocated by foreign code, use **foreign-block-release**.
2. **free-foreign-block** is implemented in LispWorks for Macintosh only.

See also

allocate-foreign-block
with-foreign-block
5.7 Block objects in C (foreign blocks)

free-foreign-object
free

Functions

Summary

Deallocates the space in memory pointed to by a pointer.

Package

fli

Signatures

free-foreign-object *pointer* **=>** *null-pointer*

free *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.

The function **free** is a synonym for **free-foreign-object**.

Examples

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
1.4 An example of dynamic memory allocation
3.1.3 Allocation of FLI memory

get-embedded-module *Function*

Summary

Gets a foreign module from a file and sets up an embedded dynamic module.

Package

fli

Signature

get-embedded-module *name filename*

Arguments

name⇓ A symbol.

filename⇓ A pathname specifier for a file containing a dynamic foreign module.

Description

The function **get-embedded-module** gets the foreign module in *filename* and sets up an embedded dynamic module named *name*.

Notes

1. **get-embedded-module** is called at load time and has no effect except to set up the embedded module. To actually use the code in the module, you need to call **install-embedded-module** at run time.
2. The effect of **get-embedded-module** persists after **save-image** and **deliver**.
3. The module should not have dependencies on other non-standard modules, otherwise **install-embedded-module** may fail to install it.

4. To incorporate an embedded module into a fasl file (that is, to load it at compile time) you need to use both **get-embedded-module-data** (at compile time) and **setup-embedded-module** (at load time), instead of **get-embedded-module**.

5. **get-embedded-module** does not return a useful value.

See also

install-embedded-module
get-embedded-module-data
setup-embedded-module
5.6 Incorporating a foreign module into a LispWorks image

get-embedded-module-data *Function*

Summary

Returns a foreign module as a Lisp object suitable for use at run time, possibly via a fasl file.

Package

fli

Signature

get-embedded-module-data *filename* **=>** *data*

Arguments

filename⇓ A pathname specifier for a file containing a dynamic foreign module.

Values

data A Lisp object containing the data of the foreign module.

Description

The function **get-embedded-module-data** returns the foreign module in *filename* as a Lisp object suitable as argument to **setup-embedded-module**, but also externalizable, that is the compiler can put it in a fasl file.

Notes

1. **get-embedded-module-data** is useful when you need to incorporate a foreign dynamic module in a fasl file, which is itself useful when the fasl is loaded on the run time computer. In the usual situation when the fasl is loaded on the same computer where it is compiled, **get-embedded-module** is more convenient, and replaces both **get-embedded-module-data** and **setup-embedded-module**.

2. To incorporate the module in a fasl file, **get-embedded-module-data** must be called at compile time, which is typically done either by doing it at read time with **#.** or using a macro. The result is then used as argument to **setup-embedded-module** at load time. Examples of both approaches are shown below.

3. To actually use the code in the module, **install-embedded-module** must be called at run time with the name of the module (**my-embedded-module-name** in the examples below).

4. The module should not have dependencies on other non-standard modules, otherwise **install-embedded-module** may fail to install it.

Examples

Calling **get-embedded-module-data** at read time with **#.** :

```
(setup-embedded-module 'my-embedded-module-name
  #.(get-embedded-module-data
      (my-locate-the-foreign-module)))
```

Calling **get-embedded-module-data** via a macro. Note that there is no backquote or quote, so the code is executed by by the compiler:

```
(defmacro my-get-embedded-module-data ()
    (let ((pathname (my-locate-the-foreign-module)))
      (get-embedded-module-data pathname))

(setup-embedded-module 'my-embedded-module-name
  (my-get-embedded-module-data))
```

See also

install-embedded-module
get-embedded-module
setup-embedded-module
5.6 Incorporating a foreign module into a LispWorks image

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 *pointer*. If *delta* is not given the address is increased by the size of the type pointed to by *pointer*. The address can be increased by a multiple of the size of the type by specifying a *delta*. If the size of the type is 0 then an error is signalled.

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

Examples

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)
  (print (fli:dereference point1))
  (fli:incf-pointer point1))

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

See also

`decf-pointer`
3.4 An example of dynamic pointer allocation

install-embedded-module *Function*

Summary

Installs an embedded dynamic module.

Package

`fli`

Signature

`install-embedded-module` *name* **`&key`** *delay-delete*

Arguments

name⇓ A symbol.

delay-delete⇓ A boolean.

Description

The function **install-embedded-module** installs the embedded dynamic module name.

name must be a name of an embedded dynamic module that was set up either by **get-embedded-module** or **setup-embedded-module**.

install-embedded-module installs the module, which means making its code available to be used in Lisp, as if **register-module** was called with the original module.

The module is written to a temporary file that is deleted by LispWorks.

Note: You should consult LispWorks Support before using *delay-delete*.

delay-delete controls the time of deletion of the temporary file that is created by **install-embedded-module**. It defaults to the value of ***install-embedded-module-delay-delete***, which defaults to **nil**. If *delay-delete* is **nil**, the temporary file is deleted during the call to **install-embedded-module**. If *delay-delete* is non-nil, the file is deleted only when LispWorks exists. On Windows it always behave as if *delay-delete* is non-nil.

Deleting the file immediately is better in most cases, because it means that the file is not left in the filesystem if LispWorks does not exit cleanly (for example if POSIX **kill** is used). However, some debugging code may try to find the temporary file, in which case you can delay the deletion.

Notes

1. **install-embedded-module** must be called at run time, normally during the initialization of the application.
2. The effect of **install-embedded-module** does not persist after **save-image** or **deliver**.
3. **install-embedded-module** can be called repeatedly with the same name. The subsequent calls in the same invocation of the application do not have any effect.
4. **install-embedded-module** does not return a useful value.

See also

get-embedded-module
get-embedded-module-data
setup-embedded-module
install-embedded-module-delay-delete
5.6 Incorporating a foreign module into a LispWorks image

install-embedded-module-delay-delete *Variable*

Summary

Default for the keyword *delay-delete* in **install-embedded-module**.

Package

fli

Initial Value

nil

Description

The variable **`*install-embedded-module-delay-delete*`** is used as the default value for the keyword *delay-delete* in **`install-embedded-module`**. See **`install-embedded-module`** for more details.

See also

`install-embedded-module`

locale-external-formats *Variable*

Summary

Provides a mapping from locale names to encodings.

Package

`fli`

Initial Value

Not specified.

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 non-Windows 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.

Package

`fli`

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

5.3 Lisp integers
`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⇓	A boolean.
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 *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**.

Either *address* or *symbol-name* must be supplied, otherwise **make-pointer** signals an error.

Note that in many cases, especially when **:symbol-name** is used with a symbol defined by **define-foreign-callable**, **foreign-function-pointer** would be better than using **make-pointer** with **:symbol-name**.

If *type* is supplied, then it is used as the FLI type that *pointer* points to. Alternatively, if *pointer-type* is supplied, then it must be a FLI pointer type and it is used as the pointer type of *pointer*. An error is signalled if both *type* and *pointer-type* are supplied.

If *type* or *pointer-type* are not supplied, then *functionp* can be used. If *functionp* is **t**, then *pointer* is a pointer to type **:function**. This is the default value. If *functionp* is **nil**, then *pointer* is a pointer to type **:void**.

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, *module* can be supplied 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**.

Examples

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

3 FLI Pointers
4.1 Foreign callables and foreign functions
`copy-pointer`
`define-foreign-callable`
`foreign-function-pointer`
`register-module`
`with-coerced-pointer`

module-unresolved-symbols *Function*

Summary

Returns foreign symbol names that cannot be resolved.

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 **`module-unresolved-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

5.5.1.1 Testing whether a function is defined
`register-module`

null-pointer *Variable*

Summary

A null pointer.

Package

`fli`

Initial Value

The result of calling **`(make-pointer :address 0 :type :void)`**.

Description

The variable **`*null-pointer*`** contains a **`(:pointer :void)`** with address 0.

This provides a simple way to pass a null pointer when needed.

Examples

```
(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.

Examples

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

3.2 Pointer testing functions
5.5.1.1 Testing whether a function is defined
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 A non-negative integer.

Description

The function **`pointer-address`** returns the address of *pointer* as an integer.

Examples

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

3.2 Pointer testing functions
`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.

Examples

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

3.2 Pointer testing functions
`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.

Examples

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

3.2 Pointer testing functions
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*.

Examples

```
(setq point (fli:allocate-foreign-object :type :int))
=>
=> #<Pointer to type :INT = #x007F3970>

(fli:pointer-element-type-p point :signed)
->
t
```

See also

3.2 Pointer testing functions
`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	A boolean.

Description

The function **`pointer-eq`** tests whether *pointer1* points to the same address as *pointer2* and returns **`t`** if they do, and **`nil`** if they do not.

Examples

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

3.2 Pointer testing functions
`null-pointer-p`
`pointerp`

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.

Examples

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

3.2 Pointer testing functions
`null-pointer-p`
`pointer-address`
`pointer-eq`

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*.

Examples

```
(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

3.3 Pointer dereferencing and coercing
`make-pointer`

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. The output is printed to *output-stream*.

See the *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***.

verbose is ignored.

See also

register-module

register-module *Function*

Summary

Informs LispWorks of the presence of a dynamic library.

Package

fli

Signature

register-module *name* **&key** *connection-style* *lifetime* *real-name* *file-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⇓ Deprecated. Use *file-name* instead.

file-name⇓ A pathname designator or **nil**.

dlopen-flags⇓ Controls use of **dlopen** on non-Windows platforms. One of **t** (the default), **nil**, **:local-now**, **:global-now**, **:global-lazy**, **:local-lazy**, or a fixnum.

Values

name A symbol or string specifying the Lisp name the module will be registered under.

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 *file-name* should also be supplied to provide a filename. *file-name* defaults to the deprecated argument *real-name*, which defauls to **nil**. If *file-name* is **nil** then *name* must be a string that 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, x86/x64 Solaris or FreeBSD and **.dylib** on macOS.

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 Windows system directory (as specified by **GetSystemDirectory**).
3. The 16-bit system directory.
4. The Windows directory (as specified by **GetWindowsDirectory**).
5. The current directory. This step can be made to happen earlier, though this is considered less safe as described in the Microsoft documentation.
6. Directories specified by the **PATH** environment 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, FreeBSD and Solaris the search is conducted in this order:

1. Directories on the user's **LD_LIBRARY_PATH** environment variable.
2. The list of libraries known to the operating system (for example, in **/etc/ld.so.cache** on Linux).
3. **/usr/lib**, followed by **/lib**.

On macOS, the search is conducted in this order:

1. Directories on the user's **`LD_LIBRARY_PATH`** environment variable.
2. Directories on the user's **`DYLD_LIBRARY_PATH`** environment variable.
3. **`~/lib`**
4. **`/usr/local/lib`**
5. **`/usr/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`**.

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.

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: static libraries are not supported. For example, on Linux evaluating this form:

```
(fli:register-module "libc.a"
                     :real-name "/usr/lib/libc.a"
                     :connection-style :immediate)
```

would result in an error like this:

```
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 non-Windows platforms. It controls the value that is passed to **`dlopen`** as second argument when the module is connected.

The keyword values of *dlopen-flags* correspond to combinations of **`RTLD_*`** constants (see **`/usr/include/dlfcn.h`**). The values **`t`** and **`nil`** mean the same as **`:local-lazy`**.

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.

Compatibility note:

In LispWorks 7.1 and earlier versions, *dlopen-flags* defaults to **`nil`** on macOS, which caused it to use the older interfaces instead of **`dlopen`**. Since LispWorks 8.0, this is no longer supported.

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 **9.4.2 Compiling and Loading Foreign Code with the Editor**.

Examples

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 run time:

```
(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

5.6 Incorporating a foreign module into a LispWorks image
`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 allow-sign-mismatch* **`=>`** *to*

Arguments

to⇓ A foreign array, foreign pointer or a Lisp array.

from⇓ A foreign array, foreign pointer or a Lisp array.

start1⇓, *start2*⇓, *end1*⇓, *end2*⇓
Integers.

allow-sign-mismatch⇓ A boolean, default value **`nil`**.

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. When *allow-sign-mismatch* is **`nil`** (the default), the array element types must also match for sign, that is they must be either both signed or both unsigned. When *allow-sign-mismatch* is non-nil, the array element types do not need to match.

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. The array must be "raw", which means either an integer array of length 8, 16, 32 or 64 bits, or an array of one of **`cl:base-char`**, **`lw:bmp-char`**, **`cl:single-float`** and **`cl:double-float`**. For matching with the other argument, the latter are considered as "unsigned", with size 8, 16, 32 and 64 bits respectively. Note that arrays with element type **`cl:character`** are not allowed.

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.

Compatibility note:

In LispWorks 6.1 and earlier versions you can use an array of **`lw:simple-char`**, that is **`lw:text-string`**, because **`lw:simple-char`** was limited to the range that is now **`lw:bmp-char`** and had width of 16.

In LispWorks 7.0 and later versions **`lw:simple-char`** is a synonym for **`cl:character`**, and thus arrays of **`lw:simple-char`** (that is, **`lw:text-string`**) cannot be used in **`replace-foreign-array`**.

Examples

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 supplying the number of elements to copy using *nelems*.

Examples

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

5.2.4 Modifying a string in a C function
`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

The function **`set-locale`** 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. *locale* 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.

Examples

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**.

Values

mb An external format specification.

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.

mb is set as the external format for multi-byte encodings.

If *wc* is non-nil, then it is set as the external format for wide-character encodings, such as **:ef-wc-string**.

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
with-foreign-string

setup-embedded-module *Function*

Summary

Sets up an embedded dynamic module.

Package

fli

Signature

setup-embedded-module *name data*

Arguments

name⇓	A symbol.
data⇓	A Lisp object containing the data of the foreign module.

Description

The function **setup-embedded-module** sets up an embedded dynamic module named *name* using *data*.

data must be a result of a call to **get-embedded-module-data**.

Notes

1. **setup-embedded-module** is called at load time and has no effect except to set up the embedded module. To actually use the code in the module, you need to call **install-embedded-module** at run time.
2. The effect of **setup-embedded-module** persists after **save-image** and **deliver**.
3. See **get-embedded-module-data** for more discussion and examples.
4. **setup-embedded-module** does not return a useful value.

See also

install-embedded-module
get-embedded-module-data
get-embedded-module
5.6 Incorporating a foreign module into a LispWorks image

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*.

Examples

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

2 FLI Types
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 *Delivery User Guide* for further details.

See also

`print-collected-template-info`

use-sse2-for-ext-vector-type *Variable*

Summary

32-bit x86 specific: control whether to pass/receive vector type arguments/results using SSE2.

Package

`fli`

Initial Value

`t` on macOS, **`nil`** on other platforms.

Description

On 32-bit x86 platforms, the variable **`*use-sse2-for-ext-vector-type*`** controls whether the code that is generated by foreign interface definitions that pass or receive vector type arguments or results (see **2.2.4 Vector types**) uses SSE2 to pass or receive these arguments or results.

SSE2 is a feature of the x86 CPU, which was introduced by Intel in 2001, and is supported by all new x86 CPUs. However, the C compiler can still pass arguments without using SSE2 for backwards compatibility. The Lisp definitions must pass/receive arguments in the same way that as the C compiler that compiled the foreign code they call/are called from.

On macOS, code always uses SSE2, so **`*use-sse2-for-ext-vector-type*`** is set to **`t`** initially and you should not change it. On other platforms (Linux, FreeBSD, Solaris) the situation is less clear.

`*use-sse2-for-ext-vector-type*` affects the code at macro expansion time, so if you use **`compile-file`** and later load the compiled file, the value of **`*use-sse2-for-ext-vector-type*`** at the time of **`compile-file`** determine what the code does. When evaluating the definition, the value at the time of evaluating the definition determines what the code does.

Notes

On FreeBSD, the default C compiler is Clang, which currently (Dec 2016 in FreeBSD 10.3) does not use SSE2 by default, and therefore matches what LispWorks does by default.

On other platforms, or using other compilers or newer versions of Clang, if you use vector types then you will need to check what the C compiler does. If you have any doubt, contact LispWorks support.

See also

2.2.4 Vector types

valid-foreign-type-p *Function*

Summary

Checks if the argument is a valid foreign type.

Package

`fli`

Signature

`valid-foreign-type-p` *type* **`=>`** *boolean*

Arguments

type⇓	A Lisp object.

Values

boolean	A boolean.

Description

The function **`valid-foreign-type-p`** returns true if *type* is a valid foreign type and returns false otherwise.

An object is a valid foreign type if it matches any of the types which are described in chapter **2 FLI Types**.

See also

2 FLI Types

with-coerced-pointer *Macro*

Summary

Executes forms with a variable bound to a dynamic-extent copy of an FLI pointer, possibly with a different type.

Package

fli

Signature

with-coerced-pointer (*coerced-pointer* **&key** *type pointer-type***)** *pointer* **&body** *body* **=>** *last*

Arguments

coerced-pointer⇓	A variable bound to 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.
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.

The macro **with-coerced-pointer** evaluates *body* with *coerced-pointer* bound to a dynamic-extent copy of the FLI pointer *pointer*.

coerced-pointer points to the same foreign object as *pointer*.

If *type* is specified, then it must be a FLI type specifying the type that *coerced-pointer* points to. Alternatively, if *pointer-type* is specified, then it must be a FLI pointer type specifying the pointer type of *coerced-pointer*. If neither *type* nor *pointer-type* are specified then the type is the same as *pointer*.

You can use **with-coerced-pointer** in a similar way to casting a pointer type in C. You can also use it make a temporary FLI pointer that can be changed using **incf-pointer** or **decf-pointer**, without affecting *pointer*.

Note that *coerced-pointer* has dynamic-extent, so you should not use it after returning from *body*.

Examples

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

3.4 An example of dynamic pointer allocation
`allocate-dynamic-foreign-object`
`free-foreign-object`
`with-dynamic-foreign-objects`

with-dynamic-foreign-objects *Macro*

Summary

Does the equivalent of **`dynamic-extent`** for 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***`)`**

Arguments

body⇓	Forms to be executed with *bindings* in effect.
var⇓	A symbol to be bound to a pointer to a foreign object.
foreign-type⇓	A foreign type descriptor.
initial-element⇓	The initial value of the newly allocated objects.
initial-contents⇓	A list of values to initialize the contents of the newly allocated objects.
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

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 evaluaed the forms in *body* as an implicit **`progn`**. Each element of *bindings* is a list which caused *var* to be bound to a pointer to a locally allocated instance of *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 above, which is supported in LispWorks 5.1 and later.

Examples

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;
};
```

Non-Windows 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 **1.4 An example of dynamic memory allocation**.

See also

5.2.4 Modifying a string in a C function
`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 static or pinned Lisp array (a string or a byte/single-float/double-float array).
start⇓	An index into the Lisp array.
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 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 *start*. The default value of *start* is 0.

This foreign pointer is bound to *pointer-var*, the forms of *body* are executed and the value of the last form is returned.

Pointers created with this macro must be used with care. There are three restrictions:

1. *lisp-array* must be static or pinned, 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.

Examples

An example of using a static array:

```
(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
```

An example of using a pinned array:

```
(let ((vector
       (make-array 3 :element-type '(unsigned-byte 8)
                   :initial-contents '(65 77 23)
                   :allocation :pinnable)))
  (with-pinned-objects (vector)
    (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-pinned-objects

with-foreign-block *Macro*

Summary

Allocates a foreign block, executes code and frees the block, in LispWorks for Macintosh.

Package

fli

Signature

with-foreign-block (*foreign-block-var type function* **&rest** *extra-args***) &body** *body* **=>** *results*

Arguments

foreign-block-var⇓	A symbol.
type⇓	A symbol naming a foreign block type defined using **define-foreign-block-callable-type**.
function⇓	A Lisp function.
extra-args⇓	Arguments for *function*.
body⇓	Lisp forms.

Values

results	The results of *body*.

Description

The macro **`with-foreign-block`** allocates a foreign block using *type*, *function* and *extra-args* in the same way as **`allocate-foreign-block`**. It then binds *foreign-block-var* to the foreign block, execute the code of *body* and frees the foreign block using **`free-foreign-block`**, using **`unwind-protect`**.

`with-foreign-block` is a convenient way to ensure that you do not forget to free the foreign block.

Notes

If the foreign block is copied in the code of *body*, the copy may be invoked, and hence the function called, after exiting this macro. See the discussion in **5.7.3 Scope of invocation**.

`with-foreign-block` returns the results of *body*.

`with-foreign-block` is implemented in LispWorks for Macintosh only.

See also

`allocate-foreign-block`
`free-foreign-block`
`with-local-foreign-block`
5.7 Block objects in C (foreign blocks)

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

form⇓	A form evaluating to an instance of (or a pointer to) a FLI structure.
body⇓	Forms to be executed.
object-type⇓	A FLI structure type.

slot-name⇓ A symbol.

variable-name⇓ A symbol.

copy-foreign-object⇓ **`t`**, **`nil`** or **`:error`**.

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 *copy-foreign-object* 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*.

Examples

```
(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

2.2.3 Structures and unions
`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*

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 value of *element-count*.
allow-null⇓	A boolean. The default is **nil**.
string⇓	The Lisp string to convert.
body⇓	A list of forms 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.

external-format 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 ***multibyte-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 names of available external formats are listed in section 26.6 External Formats to translate Lisp characters from/to external encodings in the LispWorks® User Guide and Reference Manual.

null-terminated-p 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 value of *element-count*.

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

See also

5.2.4 Modifying a string in a C function
5.1 Passing a string to a Windows function
26.6 External Formats to translate Lisp characters from/to external encodings in the LispWorks® User Guide and Reference Manual

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.

Package

fli

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

5.3 Lisp integers
convert-integer-to-dynamic-foreign-object
make-integer-from-bytes

with-local-foreign-block *Macro*

Summary

Allocates a foreign block, executes code and frees the block, in LispWorks for Macintosh.

Package

`fli`

Signature

`with-local-foreign-block (`*foreign-block-var type function* **`&rest`** *extra-args***`) &body`** *body* **`=>`** *results*

Arguments

foreign-block-var⇓	A symbol.
type⇓	A symbol naming a foreign block type defined using **`define-foreign-block-callable-type`**.
function⇓	A Lisp function.
extra-args⇓	Arguments for *function*
body⇓	Lisp forms.

Values

results	The results of *body*.

Description

The macro **`with-local-foreign-block`** allocates a foreign block using *type*, *function* and *extra-args* in the same way as **`allocate-foreign-block`**, but with dynamic extent. It then binds *foreign-block-var* to the foreign block and executes the code of *body*.

`with-local-foreign-block` can be used only if the code in *body* can be guaranteed not to invoke the block or a copy of it either outside the scope of **`with-local-foreign-block`** or in another thread. Unless you can be sure of that, you need to use **`with-foreign-block`**.

`with-local-foreign-block` returns the results of *body*.

`with-local-foreign-block` can be a little faster than **`with-foreign-block`**.

Notes

`with-local-foreign-block` is implemented in LispWorks for Macintosh only.

See also

`allocate-foreign-block`
`free-foreign-block`
`with-foreign-block`
5.7 Block objects in C (foreign blocks)

8 Type Reference

:boolean *FLI Type Descriptor*

Summary

Converts between a Lisp boolean value and a C representation of a boolean value.

Package

`keyword`

Syntax

`:boolean &optional` *encapsulates*

Arguments

encapsulates⇓	An integral type or **`:standard`**.

Description

The FLI type **`:boolean`** converts between a Lisp boolean value and a C representation of a boolean value. *encapsulates* specifies the size of the value from which the boolean value is obtained, which defaults to **`:int`**. 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. If *encapsulates* is **`:standard`**, then the type maps to the **`_Bool`** type in the C99 language definition.

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.

Examples

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`
2.1.5 Boolean types

:byte

FLI Type Descriptor

Summary

Converts between a Lisp integer with a C **`signed char`**.

Package

`keyword`

Syntax

`:byte`

Description

The FLI type **`:byte`** converts between a Lisp integer type and a C **`signed char`** type.

See also

`:char`
`:short`
2.1.1 Integral types

:c-array

FLI Type Descriptor

Summary

Converts between a FLI array and a C array type.

Package

`keyword`

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 type **`:c-array`** 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`**.

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.

When using the **`:c-array`** type in other situations, it acts as an aggregate type like **`:foreign-array`**. In particular, **`:c-array`** with more than one dimension is an array containing embedded arrays, not an array of pointers.

dimensions is the dimensions of the array.

Notes

1. **`:c-array`** uses the C convention that the first index value of an array is **`0`**.
2. Only use the **`:c-array`** type when the corresponding C code uses an array with a constant declared size. If you need a dynamically sized array, then use a pointer type, allocate the array using the *nelems* argument to **`allocate-foreign-object`** or **`with-dynamic-foreign-objects`** and use **`dereference`** to access the elements. The pointer type is more efficient than making **`:c-array`** types dynamically with different dimensions because the FLI caches information about every different FLI type descriptor that is used.

Examples

The following code defines a 3 by 3 array of integers:

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

The type of this is equivalent to the C declaration:

```
int aaa[3][3];
```

The next example defines an array of arrays of bytes:

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

The type of this is equivalent to the C declaration:

```
int bbb[2][3];
```

Note the reversal of the 3 and 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`
2.2.1 Arrays

:char

FLI Type Descriptor

Summary

Converts between a Lisp **character** type and a C **char** type.

Package

keyword

Syntax

:char

Description

The FLI type **:char** 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
2.1.4 Character types

:const

FLI Type Descriptor

Summary

Corresponds to the C **const** type.

Package

keyword

Syntax

:const &optional *type*

Arguments

type⇓	The type of the constant. The default is **:int**.

Description

The FLI type **`:const`** 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.

Examples

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`
2.1 Immediate types

:double *FLI Type Descriptor*

Summary

Converts a Lisp double float to a C **`double`**.

Package

`keyword`

Syntax

`:double`

Description

The FLI type **`:double`** 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 later versions, there are three disjoint Lisp float types in 32-bit LispWorks and two in 64-bit LispWorks, on all platforms.

See also

`:float`
2.1.2 Floating point types

:double-complex *FLI Type Descriptor*

Summary

Converts a Lisp double float complex number to a C **`double complex`**.

Package

`keyword`

Syntax

`:double-complex`

Description

The FLI type **`:double-complex`** converts between a Lisp **`(complex double-float)`** and the C **`double complex`** type.

See also

`:float-complex`
2.1.3 Complex number types

:ef-mb-string *FLI Type Descriptor*

Summary

Converts between a Lisp string and a C multi-byte string.

Package

`keyword`

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 type **`:ef-mb-string`** converts between a Lisp string and a C multi-byte string. The C string may have a maximum length of *limit* bytes. *limit* can be omitted in cases where a new foreign string is being allocated.

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 Windows 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
2.2.2 Strings

:ef-wc-string *FLI Type Descriptor*

Summary

Converts between a Lisp string and a C wide-character string.

Package

keyword

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 type **:ef-wc-string** converts between a Lisp string and a C wide-character string. The C string may have a maximum length of *limit* characters. *limit* can be omitted in cases where a new foreign string is being allocated.

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`
2.2.2 Strings

:enum
:enumeration

FLI Type Descriptors

Summary

Converts between a Lisp symbol and a C **`enum`**.

Package

`keyword`

Syntax

`:enum &rest` *enum-constants*

`:enumeration &rest` *enum-constants*

enum-constants **`::= {`***entry-name* **`|`** **`(`***entry-name* *entry-value***`)}*`**

Arguments

enum-constants⇓	A sequence of one or more symbols naming the elements of the enumeration.
entry-name⇓	A symbol naming an element of the enumeration.
entry-value⇓	An integer specifying the value of *entry-name*.

Description

The FLI type **`:enum`** converts between a Lisp symbol and the C **`enum`** type. Each entry in *enum-constants* can either consist of a symbol *entry-name*, in which case the first entry has a value 0, or of a list of a symbol *entry-name* and its corresponding integer value *entry-value*.

`:enumeration` is a synonym for **`:enum`**.

Examples

See **`define-c-enum`**, for an example using the **`:enum`** type.

See also

`define-c-enum`
2.1.1 Integral types

:fixnum *FLI Type Descriptor*

Summary

Converts between a Lisp fixnum and a 32 bit raw integer.

Package

`keyword`

Syntax

`:fixnum`

Description

The FLI type **`:fixnum`** converts between a Lisp fixnum and a 32 bit integer in C.

See also

2.1.1 Integral types

:float *FLI Type Descriptor*

Summary

Converts a Lisp single float to a C **`float`**.

Package

`keyword`

Syntax

`:float`

Description

The FLI type **`:float`** 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 later versions, there are three disjoint Lisp float types in 32-bit LispWorks and two in 64-bit LispWorks, on all platforms.

See also

`:double`
2.1.2 Floating point types

:float-complex

FLI Type Descriptor

Summary

Converts a Lisp single float complex number to a C **`float complex`**.

Package

`keyword`

Syntax

`:float-complex`

Description

The FLI type **`:float-complex`** converts between a Lisp **`(complex single-float)`** and the C **`float complex`** type.

See also

`:double-complex`
2.1.3 Complex number types

:foreign-array

FLI Type Descriptor

Summary

Converts between a FLI array and a foreign array type.

Package

`keyword`

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 type **`: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*.

The **`:foreign-array`** type is an aggregate type. In particular, **`:foreign-array`** with more than one dimension is an array containing embedded arrays, not an array of pointers.

Notes

Only use the **:foreign-array** type when the corresponding foreign code uses an array with a constant declared size. If you need a dynamically sized array, then use a pointer type, allocate the array using the *nelems* argument to **allocate-foreign-object** or **with-dynamic-foreign-objects** and use **dereference** to access the elements. The pointer type is more efficient than making **:foreign-array** types dynamically with different dimensions because the FLI caches information about every different FLI type descriptor that is used.

Examples

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))))
```

The type of this is equivalent to the C declaration:

```
signed char array2[3][4];
```

See also

:c-array
foreign-aref
foreign-array-pointer
2.2.1 Arrays

foreign-block-pointer *FLI Type Descriptor*

Summary

The foreign type corresponding to the opaque "Block" object in C and derived languages.

Package

fli

Syntax

foreign-block-pointer

Description

The FLI type **foreign-block-pointer** corresponds to the opaque "Block" object in C and derived languages that are introduced in CLANG and used by Apple.

A foreign block pointer should be regarded as opaque, and should not be manipulated or used except as described in **5.7 Block objects in C (foreign blocks)**.

Notes

A foreign block that is allocated directly by the Lisp side (for example by **allocate-foreign-block** or **with-foreign-block**) prints as **"lisp-foreign-block-pointer"**.

foreign-block-pointer is implemented in LispWorks for Macintosh only.

See also

allocate-foreign-block
define-foreign-block-callable-type
define-foreign-block-invoker
foreign-block-copy
foreign-block-release
free-foreign-block
released-foreign-block-pointer
with-foreign-block
with-local-foreign-block
5.7 Block objects in C (foreign blocks)

:function

FLI Type Descriptor

Summary

Converts between Lisp and the C function type.

Package

keyword

Syntax

:function &optional *args-spec return-spec* **&key** *calling-convention*

Arguments

args-spec⇓	A list of foreign types.
return-spec⇓	A foreign type.
calling-convention⇓	A keyword naming the calling convention.

Description

The FLI type **:function** allows for conversion from the C function type. It is typically used in conjunction with the **:pointer** type to reference an existing foreign function.

args-spec and *return-spec* specify the argument types and return type respectively.

calling-convention is as described for **define-foreign-function**.

Examples

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

:int8
:int16
:int32
:int64
:intmax
:intptr

FLI Type Descriptors

Summary

The signed sized integer types.

Package

keyword

Syntax

:int8

:int16

:int32

:int64

:intmax

:intptr

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

2.1.1 Integral types

:int

FLI Type Descriptor

Summary

Converts between a Lisp integer and a C **int** type.

Package

keyword

Syntax

:int

Description

The FLI type **:int** converts between an Lisp integer and a C **int** type. It is equivalent to the **:signed** and **(:signed :int)** types.

See also

:signed
2.1.1 Integral types

:lisp-array

FLI Type Descriptor

Summary

A foreign type which passes the address of a Lisp array direct to C.

Package

keyword

Syntax

:lisp-array &optional *type*

Arguments

type⇓ A list. The default is **nil**.

Description

The FLI type **:lisp-array** 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, or allocated pinnable and pinned using **with-pinned-objects**.

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.

Examples

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];
  }
}
```

Non-Windows 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
with-pinned-objects

:lisp-double-float *FLI Type Descriptor*

Summary

A synonym for **:double**.

Package

keyword

Syntax

:lisp-double-float

Description

The FLI type **:lisp-double-float** is the same as the FLI **:double** type.

See also

:double
2.1.2 Floating point types

:lisp-float *FLI Type Descriptor*

Summary

Converts between any Lisp float and the C **double** type or the C **float** type.

Package

keyword

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 type **`:lisp-float`** 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`
2.1.2 Floating point types

:lisp-simple-1d-array *FLI Type Descriptor*

Summary

A foreign type which passes the address of a Lisp simple vector direct to C.

Package

`keyword`

Syntax

`:lisp-simple-1d-array &optional` *type*

Arguments

type⇓ A list. The default is **`nil`**.

Description

The FLI type **`:lisp-simple-1d-array`** 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.

It is vital that the garbage collector does not move the Lisp vector, hence **`:lisp-simple-1d-array`** checks that the vector is statically allocated or allocated pinnable, in which case it is pinned implicitly as if by **`with-pinned-objects`**.

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**.

Package

keyword

Syntax

:lisp-single-float

Description

The FLI type **:lisp-single-float** is the same as the FLI **:float** type.

See also

:float
2.1.2 Floating point types

:long *FLI Type Descriptor*

Summary

Converts between a Lisp **integer** and a C **long**.

Package

keyword

Syntax

:long &optional *integer-type*

integer-type **::= :int | :double | :long**

Arguments

Description

The FLI type **:long** converts between the Lisp **integer** type and the C **long** type. See **A comparison between Lisp and C long types** for comparisons between Lisp and C long types.

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
2.1.1 Integral types

:long-long

FLI Type Descriptor

Summary

Converts between a Lisp **integer** and a signed C **long long**.

Package

keyword

Syntax

:long-long

Description

The FLI type **:long-long** 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
2.1.1 Integral types

:one-of *FLI Type Descriptor*

Summary

Converts between Lisp and C types of the same underlying type.

Package

keyword

Syntax

:one-of &rest *types*

Arguments

types⇓ A list of types sharing the same underlying type.

Description

The FLI type **:one-of** is used to allocate an object which can be one of a number of types specified by *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.

Examples

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
:ptr

FLI Type Descriptors

Summary

Defines a C-style FLI pointer to an object of a specified type.

Package

`keyword`

Syntax

`:pointer` *type*

`:ptr` *type*

Arguments

type⇓	The type of FLI object pointed to by the pointer.

Description

The FLI type **`:pointer`** 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`**).

`:ptr` is a synonym for **`:pointer`**.

For more details on pointers, including examples on pointer coercion, dereferencing, making, and copying see **3 FLI Pointers**.

See also

`copy-pointer`
`dereference`
`make-pointer`
`*null-pointer*`
2.1.6 Pointer types

:ptrdiff-t

FLI Type Descriptor

Summary

Converts between a Lisp integer and an ISO C ptrdiff_t.

Package

`keyword`

Syntax

:ptrdiff-t

Description

The FLI type **:ptrdiff-t** 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.

Package

keyword

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⇓	A boolean.
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 type **:reference** 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**.

If *allow-null* is non-nil and the input argument is **nil** then a null pointer is passed instead of a reference to an object containing **nil**. *allow-null* defaults to **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.

Examples

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.

Package

keyword

Syntax

:reference-pass *type* **&key** *allow-null*

Arguments

type⇓	The type of the object to pass by reference.
allow-null⇓	A boolean.

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 of how *type* and *allow-null* are used.

See also

:reference
:reference-return

:reference-return *FLI Type Descriptor*

Summary

Passes an object from the foreign language to Lisp by reference.

Package

keyword

Syntax

:reference-return *type* **&key** *allow-null*

Arguments

type⇓	The type of the object to return by reference.
allow-null⇓	A boolean.

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 of how *type* and *allow-null* are used.

See also

:reference
:reference-pass

released-foreign-block-pointer *FLI Type Descriptor*

Summary

The type of foreign blocks that have been released.

Package

`fli`

Syntax

`released-foreign-block-pointer`

Description

The FLI type **`released-foreign-block-pointer`** is the type of released foreign blocks.

The system marks foreign blocks that have been released by **`foreign-block-release`** as being of foreign type **`released-foreign-block-pointer`**.

See also

`foreign-block-pointer`
`foreign-block-release`

:short *FLI Type Descriptor*

Summary

Converts between a Lisp **`fixnum`** type and a C **`short`** type.

Package

`keyword`

Syntax

`:short &optional` *integer-type*

integer-type **`::= :int`**

Arguments

integer-type	If specified, must be **`:int`**, which associates a Lisp **`fixnum`** with a C **`int`**.

Description

The FLI type **`:short`** 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`
2.1.1 Integral types

:signed

FLI Type Descriptor

Summary

Converts between a Lisp integer and a foreign signed integer.

Package

`keyword`

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 FLI type **`:signed`** converts between a Lisp integer and a foreign signed integer. The optional *integer-type* argument specifies other kinds of signed integer types. See Table **A comparison of Lisp and C signed types** for a comparison between Lisp and C signed types.

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`
2.1.1 Integral types

:size-t

FLI Type Descriptor

Summary

Converts between a Lisp integer and an ISO C size_t.

Package

keyword

Syntax

:size-t

Description

The FLI type **:size-t** 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.

Package

keyword

Syntax

:ssize-t

Description

The FLI type **:ssize-t** 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**.

Package

keyword

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 type **:struct** 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 *symbol* and a type *type*. A structure can also contain bit fields, which are integers of type *integer-type* with *size* 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.

Examples

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**.

```
(setf (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
2.2.3 Structures and unions

:time-t

FLI Type Descriptor

Summary

Converts between a Lisp integer and the platform-specific time_t type.

Package

keyword

Syntax

:time-t

Description

The FLI type **:time-t** 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.

Package

keyword

Syntax

:uint8

:uint16

:uint32

:uint64

:uintmax

:uintptr

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
2.1.1 Integral types

:union

FLI Type Descriptor

Summary

Converts between a FLI union and a C **union** type.

Package

keyword

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 type **`:union`** 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 *symbol* and a type *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.

Examples

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`
2.2.3 Structures and unions

:unsigned *FLI Type Descriptor*

Summary

Converts between a Lisp integer and a foreign unsigned integer.

Package

`keyword`

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 FLI type **`:unsigned`** converts between a Lisp integer and a foreign unsigned integer. The optional *integer-type* argument specifies other kinds of unsigned integer types. See Table **A comparison of Lisp and C unsigned types** for a comparison between Lisp and C unsigned types.

A comparison of Lisp and C unsigned types

Lisp type	FLI type	C type
`integer`	**`:unsigned`**	**`unsigned int`**
`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`
2.1.1 Integral types

vector-char2
vector-char3
vector-char4
vector-char8
vector-char16
vector-char32
vector-uchar2
vector-uchar3
vector-uchar4
vector-uchar8
vector-uchar16
vector-uchar32
vector-short2
vector-short3

vector-short4
vector-short8
vector-short16
vector-short32
vector-ushort2
vector-ushort3
vector-ushort4
vector-ushort8
vector-ushort16
vector-ushort32
vector-int2
vector-int3
vector-int4
vector-int8
vector-int16
vector-uint2
vector-uint3
vector-uint4
vector-uint8
vector-uint16
vector-long1
vector-long2
vector-long3
vector-long4
vector-long8
vector-ulong1
vector-ulong2
vector-ulong3
vector-ulong4
vector-ulong8
vector-float2
vector-float3
vector-float4
vector-float8
vector-float16
vector-double2

vector-double3
vector-double4
vector-double8

FLI Type Descriptors

Summary

Convert between Lisp vectors and C vector types.

Package

fli

Syntax

vector-char2

vector-char3

vector-char4

vector-char8

vector-char16

vector-char32

vector-uchar2

vector-uchar3

vector-uchar4

vector-uchar8

vector-uchar16

vector-uchar32

vector-short2

vector-short3

vector-short4

vector-short8

vector-short16

vector-short32

vector-ushort2

vector-ushort3

vector-ushort4

vector-ushort8

vector-ushort16

vector-ushort32

vector-int2

`vector-int3`

`vector-int4`

`vector-int8`

`vector-int16`

`vector-uint2`

`vector-uint3`

`vector-uint4`

`vector-uint8`

`vector-uint16`

`vector-long1`

`vector-long2`

`vector-long3`

`vector-long4`

`vector-long8`

`vector-ulong1`

`vector-ulong2`

`vector-ulong3`

`vector-ulong4`

`vector-ulong8`

`vector-float2`

`vector-float3`

`vector-float4`

`vector-float8`

`vector-float16`

`vector-double2`

`vector-double3`

`vector-double4`

`vector-double8`

Description

See **2.2.4 Vector types** for a full description.

:void

FLI Type Descriptor

Summary

Represents the C **`void`** type.

Package

`keyword`

Syntax

`:void`

Description

The FLI type **`:void`** 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`
2.5 The void type

:volatile

FLI Type Descriptor

Summary

Corresponds to the C **`volatile`** type.

Package

`keyword`

Syntax

`:volatile &optional` *type*

Arguments

type⇓	The type of the volatile. The default is **:int**.

Description

The FLI type **:volatile** 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**.

Package

keyword

Syntax

:wchar-t

Description

The FLI type **:wchar-t** 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.

Package

keyword

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 type **:wrapper** allows for an extra level of conversion between Lisp and a foreign language through the FLI. With the **:wrapper** type you can use *lisp-to-foreign* and *foreign-to-lisp* to specify conversion functions from and to an instance of another type *foreign-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.

Examples

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)
```

See also

2.4 Encapsulated types

9 The Foreign Parser

9.1 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.

9.1.1 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")
```

9.2 Loading the Foreign Parser

The Foreign Parser is in a loadable module **`foreign-parser`**.

Load it by:

```
(require "foreign-parser")
```

9.3 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 **5.2.4 Modifying a string in a C function**. The header file **`test.h`** needs to be slightly different depending on the platform.

Windows version:

```
__declspec(dllexport) void __cdecl modify(char *string)
```

Non-Windows 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"
```

9.4 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 *Editor User Guide*.

9.4.1 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**.

9.4.2 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 (see **create-temp-file**) and deleted after **register-module** is called on it.

9.5 Foreign Parser Reference

preprocessor — *Variable*

Summary

The default value for the *preprocessor* used by **process-foreign-file**.

Package

foreign-parser

Initial Value

"cc" on Non-Windows systems and **"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*

Summary

Provides the default value for the *preprocessor-format-string* used by **`process-foreign-file`**.

Package

`foreign-parser`

Initial Value

On Windows:

```
"\"~A\" /nologo /E ~A ~{/D~A ~}~{/I\"~A\" ~}/Tc \"~A\""
```

On Non-Windows systems:

```
"~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*

Summary

Provides the default value for the *preprocessor-include-path* used by **`process-foreign-file`**.

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*

Summary

Provides the default *preprocessor-options* passed to the *preprocessor* used by **`process-foreign-file`**.

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-file *Function*

Summary

Parses foreign declarations to create Lisp FLI definition.

Package

`foreign-parser`

Signature

`process-foreign-file` *source* **`&key`** *dff language preprocess preprocessor preprocessor-format-string preprocessor-options include-path case-sensitive package*

Arguments

source⇓ One or more filenames.

dff⇓ A filename.

language⇓ A keyword.

preprocess⇓ A boolean.

preprocessor⇓ A string.

preprocessor-format-string⇓
A string.

preprocessor-options⇓ A string.

include-path⇓ A list.

case-sensitive⇓ See description.

package⇓ A package designator or **`nil`**.

Description

The function **`process-foreign-file`** 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**.

(: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

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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