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Information technology — Computer graphics — Graphical Kernel System (GKS) language bindings —

Part 4:
C

Technologies de l'information — Infographie — Système graphique de base (GKS) — Interface langage —

Partie 4: C

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Contents

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

International Standard ISO/IEC 8651-4 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*.

ISO/IEC 8651 consists of the following parts, under the general title *Information technology — Computer graphics — Graphical Kernel System (GKS) language bindings*:

— *Part 1: FORTRAN 77*
— *Part 2: PASCAL*
— *Part 3: ADA*
— *Part 4: C*

Annexes A to F of this part of ISO/IEC 8651 are for information only.

Introduction

The Graphical Kernel System (GKS) functional description is registered as ISO 7942 : 1985. As explained in the Scope and Field of Application of ISO 7942, that International Standard is specified in a language independent manner and needs to be embedded in language dependent layers (language bindings) for use with particular programming languages.

The purpose of this part of ISO/IEC 8651 is to define a standard binding for the C computer programming language.

Information technology – Computer graphics – Graphical Kernel System (GKS) language bindings -

Part 4:
C

1 Scope

The Graphical Kernel System (GKS), ISO 7942 : 1985 , specifies a language independent nucleus of a graphics system. For integration into a programming language, GKS is embedded in a language dependent layer obeying the particular conventions of that language. This part of ISO/IEC 8651 specifies such a language dependent layer for the C language.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provision of this part of ISO/IEC 8651. At the time of publication, the editions indicated were valid. All standards are subject to revisions, and parties to agreements based on this part of ISO/IEC 8651 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 7942:1985, *Information processing systems – Computer graphics – Graphical Kernel System (GKS) functional description.*

ISO/IEC 8651-1:1988, *Information processing systems – Computer graphics – Graphical Kernel System (GKS) - language bindings - Part 1 : FORTRAN .*

ISO/IEC 8806-4:1991, *Information technology – Computer graphics – Graphical Kernel System for Three Dimensions (GKS-3D) language bindings - Part 4 : C.*

ISO/IEC 9899:1990, Programming languages - C.

ISO/IEC TR 9973:1988, *Information processing – Procedures for registration of graphical items.*

3 The C Language Binding of GKS

The C language binding of GKS shall be as described in clauses 3, 4, 5 and 6.

3.1 Conformance

This part of ISO/IEC 8651 incorporates the rules of conformance defined in the GKS Standard (ISO 7942) for GKS implementations, with those additional requirements specifically defined for C bindings in GKS.

The following criteria shall determine conformance of an implementation to this part of ISO/IEC 8651:

In order to conform, an implementation of the C binding of GKS shall implement a specific level of GKS as specified in ISO 7942. It shall make visible all of the declarations in the C binding specified in this part of ISO/IEC 8651 for that same level of GKS and all lower levels and for a specific level of C.

Thus, for example, the syntax of the function names shall be precisely as specified in the binding and parameters shall be of the data types stated in the binding.

3.2 Functions versus Macros

An implementation may substitute macros for functions. However, the macros shall be designed so that side-effects work properly. In general, a macro cannot be used to replace the error handling function `gerr_hand`. See also 3.10.

3.3 Character Strings

The C language represents character strings as an array of characters terminated by the null character (i.e. `'\0'`). This means that the null character is not usable as a printable character.

3.4 Function Identifiers

The function names of GKS are all mapped to C functions which begin with the letter `g`. Words and phrases used in the GKS function names are often abbreviated in the representation and are always separated with the underscore character `"_"`. The set of such abbreviations is given in 4.2, and the resulting C function names are listed in 4.3. For example, the abbreviation for the GKS function DELETE SEGMENT FROM WORKSTATION is `gdel_seg_ws`. `del`, `seg`, and `ws` are abbreviations for DELETE, SEGMENT, and WORKSTATION. The conjunctive FROM is mapped to the null string.

The C standard (ISO/IEC 9899) requires that compilers recognize internal identifiers which are distinct in at least 31 characters. That standard also requires that external identifiers (i.e. those seen by the linker) be recognized to a minimum of six characters, independent of case.

Implementations which run in environments where two distinct C internal identifiers would be equivalent, if they were both external identifiers, shall include a set of `#defines` in the header file which equate the long names to a set of short names. A possible set of short names for a compiler that accepts only eight characters for external definitions may be found in annex D.

3.5 Registration

ISO 7942 reserves certain value ranges for registration[1] as graphical items. The registered graphical items will be bound to the C programming language (and other programming languages). The registered item binding will be consistent with the binding presented in this part of ISO/IEC 8651.

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[1]) For the purpose of this part of ISO/IEC 8651 and according to the rules for the designation and operation of registration authorities in the ISO/IEC Directives, the ISO and IEC councils have designated the National Institute of Standards and Technology (Institute of Computer Sciences and Technology), A-266 Technology Building, Gaithersburg, MD 20899, USA to act as registration authority.

3.6 Identifiers for Graphical Items

Generalized Drawing Primitives and Escape functions are referenced via identifiers. This part of ISO/IEC 8651 specifies the format of the identifiers but it does not specify the registration of the identifiers. The identifiers are used as arguments to the functions `ggdp` and `gescape`.

An implementation may also represent GDPs and Escapes as separate functions, but this is not required.

There are two formats for these identifiers. One format is for registered GDPs and Escapes and the other format is for unregistered GDPs and Escapes.

The format for registered GDP identifiers is:

```
#define     GGDP_Rn     (n)   /* 'n' is the registered GDP id. */
```

The format for unregistered GDP identifiers is:

```
#define     GGDP_Un     (-n)  /* 'n' is implementation dependent */
```

The format for registered Escape function identifiers is:

```
#define    GESCAPE_Rn   (n)   /* 'n' is the registered Escape id. */
```

The format for unregistered Escape function identifiers is:

```
#define    GESCAPE_Un   (-n)  /* 'n' is implementation dependent */
```

3.7 Return Values

All GKS/C functions return `void`.

3.8 Header Files

C provides a mechanism to allow external files to be included in a compilation. Clause 5 of this part of ISO/IEC 8651 describes the data types that shall be defined in the file `gks.h` which should be included in any application program that intends to use GKS via the C binding.

This part of ISO/IEC 8651 uses the data type `size_t` (as a field in the data type `Gdata`). The type `size_t` is environment-dependent (e.g. `int`, `long int`, `unsigned int`) and is defined in the file `<stddef.h>`. Therefore the file `gks.h` shall also include the file `<stddef.h>`.

Additional implementation-dependent items may be placed in this file if needed. These items should start with the sentinel "G" or "g", as far as applicable.

The file `gks.h` shall also contain external declarations for all GKS/C functions because they return `void`. For example, the declaration for the function `gopen_gks` would look like this:

```
extern   void   gopen_gks(char *err_file, size_t mem_units);
```

3.9 Memory Management

The application shall allocate the memory needed for the data returned by the implementation. In general, the application will allocate a C structure and pass a pointer to that structure to an inquiry routine, which will then place information into the structure. However, a number of inquiry functions return variable length data, the length of which is not known *a priori* by the application.

These functions fall into two classes. One class of functions returns a simple, homogeneous, list of items. For example, the function INQUIRE SET OF SEGMENT NAMES returns a list of the segment names in use. The other class returns complex, heterogeneous data structures. For example, the function INQUIRE LOCATOR DEVICE STATE returns the device state which includes a locator data record; the data record can contain arbitrarily complex implementation-defined data structures. The binding of these two classes of functions is described in detail below. Subclause 3.10 describes the errors that can be invoked during execution of functions which use the memory management policy.

3.9.1 Functions which Return Simple Lists

Inquiry functions which return a list of items are bound such that the application can inquire about a portion of the list. This list is a subset of the implementation's internal list and is called the application's list. This allows the application to process the implementation's list in a piecewise manner rather than all at once.

The application allocates the memory for a list and passes that list to the implementation. The implementation places the results of the inquiry into the list. In order to support this policy of memory management, three additional parameters have been added to functions which return lists:

a) `num_elems_appl_list`: An integer input parameter which is the length of the application's list. The value of `num_elems_appl_list` indicates the number of items (i.e. list elements) which will fit into the application list. A value of 0 is valid and allows the application to determine the size of the implementation's list (which is returned via `num_elems_impl_list`) without having the implementation return any of the elements of its list. If `num_elems_appl_list` is negative, `GE_APPL_LIST_LENGTH_LT_ZERO` is returned as the value of the error indicator parameter.

b) `start_ind`: An integer input parameter which is an index into the implementation's list. (Index 0 is the first element of both the implementation's and application's list.) `start_ind` indicates the first item in the implementation's list that is copied into index 0 of the application's list. Items are copied sequentially from the implementation's list into the application's list until the application's list is full or there are no more items in the implementation's list. If `start_ind` is out of range, error `GE_START_IND_INVAL` is returned as the value of the error indicator parameter.

c) `num_elems_impl_list`: An output parameter which is a pointer to an integer. The implementation stores into this parameter the number of items that are in the implementation's list.

In annex E, a possible underlying mechanism is described.

3.9.2 Functions which Return Complex Data Structures

The data returned by the ESCAPE function and the functions which return input device data records or pattern tables can be complex in structure. They cannot be represented by a simple list of items. It would be an onerous task for the application to have to allocate and prepare data structures for these routines. In order to facilitate this task of using these inquiry functions, the binding defines a new resource, called a *Store*, to manage the memory for these functions.

The *Store* resource is opaque to the application. The application does not know the structure of the *Store* or how it is implemented. The *Store* is defined as a `void *`. This part of ISO/IEC 8651 defines two new functions which create (in CREATE STORE, bound as `gcreate_store`) and delete (in DELETE STORE, bound as `del_store`) a *Store*.

A *Store* is used by the implementation to manage the memory needed by the functions which return complex data structures. Without specifying an implementation of a *Store*, it is safe to say that it will contain and control memory needed to hold the data returned by these functions and also contain some bookkeeping information about the contents and size of the memory.

The semantics of the *Store* resource provide two levels of memory management. The implementation is responsible for managing the memory at a low level because it uses, reuses, allocates and deallocates memory from the system in order to return information to the application. But the application is ultimately responsible for managing the memory at a high level because it creates and deletes *Stores*.

A *Store* is passed as a parameter to a function returning complex data structures. Another parameter to this function is a pointer to a pointer to a structure which defines the format of the returned data. The *Store* contains memory for the structure and any additional memory referenced by fields within the structure. The application accesses the returned data through its pointer to the structure. It does not use the *Store* to access the data.

A *Store* continues to hold the information from the function until the *Store* is deleted by the DELETE STORE function or until the *Store* is used as an argument to a subsequent function, which returns complex

data structures. At that time, the old information is replaced with the new. Thus multiple calls to functions overwrite the contents of a *Store*. A *Store* only contains the results of the last function.

This part of ISO/IEC 8651 defines two new errors that can occur when using or creating a *Store*; these errors are described in 3.10.3. For most functions using a *Store*, these and other errors are returned via the "error indicator" parameter. However, the function ESCAPE does not have an error indicator parameter. For this function, the error reporting mechanism is used when an error is encountered. For this function, the implementation shall, in addition to reporting the error, set the pointer to the returned data to NULL when an error occurs. See the binding of these functions for more information.

The definitions for the functions CREATE STORE and DELETE STORE follow:

CREATE STORE **GKOP, WSOP, WSAC, SGOP** **L0a**

Parameters:

Out	error indicator	I
Out	store	STORE

Effect: Creates a *Store* and returns a handle to it in the output parameter *store*. If the *Store* cannot be created, the *store* parameter is set to NULL and the error indicator is set to one of the following error values:

8	GKS not in proper state; GKS shall be in one of the states GKOP, WSOP, WSAC or SGOP
2203	Error while allocating Store

Errors: None.

DELETE STORE **GKOP, WSOP, WSAC, SGOP** **L0a**

Parameters:

Out	error indicator	I
In/Out	store	STORE

Effect: Deletes the *Store* and all internal resources associated with it. If there is not an error, the parameter *store* will be set to NULL to signify that it is no longer valid. If an error is detected, the error indicator is set to one of the following values:

8	GKS not in proper state; GKS shall be in one of the states GKOP, WSOP, WSAC or SGOP

Errors: None.

In 7.10.2, the C specification of these functions is given. In annex E, a possible underlying mechanism is illustrated.

3.10 Error Handling

3.10.1 Application Supplied Error Handlers

User-defined error handlers shall accept the same arguments as the standard error handler. The user-defined error handler is specified by the utility function (see also 7.10.2)

SET ERROR HANDLER **GKCL, GKOP, WSOP, WSAC, SGOP** **L0a**

Parameters:

In	New error handling function	Function
Out	Old error handling function	Function

Effect: Sets the GKS error handling function to *New error handling function* and returns the current error handling function to *Old error handling function*.

Errors: None.

Application defined error handling functions accept the same arguments as the standard error handler. They may invoke the standard error logging function ERROR LOGGING.

ISO 7942 defines the initial error handling function to be ERROR HANDLING, that is, the value of the parameter *Old error handling function* points to ERROR HANDLING, when SET ERROR HANDLER is called for the first time.

When the application changes the error handling function, the implementation will invoke the new function when an error is detected. If the application calls the default error handling function ERROR HANDLING, ERROR HANDLING will always call the function ERROR LOGGING.

If *New error handler* is not a valid pointer, the error handling will automatically be done by the standard error handler ERROR HANDLING.

User-defined error handlers may invoke the standard error logging function ERROR LOGGING.

3.10.2 Error Codes

Hard coding numbers into a program decreases its maintainability. Therefore, this part of ISO/IEC 8651 defines a set of constants for the GKS error numbers. Each error constant begins with the characters `GE_`. See also 6.2 for the error macros.

3.10.3 C-specific GKS errors

This part of ISO/IEC 8651 knows some specific error messages. This section gives the messages and the error macros.

Value	Message
2200	Start index out of range Is issued when the start index is less than zero or larger than the last element in the implementation's list
2201	Length of application list is negative Is issued when the length of the application's list is less than zero
2202	Enumeration type out of range Is issued when a parameter value whose type is an enumeration is out range of the enumeration
2203	Error while allocating Store Is issued when an error is detected during CREATE STORE
2204	Error while allocating memory for Store Is issued when a function using a *Store* is unable to allocate memory for the *Store*

3.11 Colour Representations

A union type definition is used for colour bundles, guaranteeing upward compatibility with GKS-3D/C (ISO/IEC 8806-4), which supports at least two colour models (RGB and CIE L*u*v* 1976).

3.12 Storage of Multi-dimensional Arrays

3.12.1 Storage of 2*3 Matrices

The entries of `Gtran_matrix` data types shall be stored such that the segment transformation is defined by

```
Tp.x  =  mat[0,0]*p.x  +  mat[0,1]*p.y  +  mat[0,2];
Tp.y  =  mat[1,0]*p.x  +  mat[1,1]*p.y  +  mat[1,2];
```

where `p` is a 2D point, `Tp` its transformation and `mat` is of type `Gtran_matrix`.

3.12.2 Storage of Colour Arrays

The entries of `Gpat_rep` data types shall be stored such that the colour index at the (i,j)-th entry is given by

$$\text{Colr\_ind}_{i,j} = \texttt{colr\_rect.colr\_array[i + DX*j];}$$

$$i = 0, \ldots, DX - 1; \qquad j = 0, \ldots, DY - 1;$$

$$DX = \texttt{colr\_rect.dims.size\_x;} \qquad DY = \texttt{colr\_rect.dims.size\_y;}$$

where `colr_rect` is of type `Gpat_rep`.

4 Tables

4.1 Abbreviation Policy in Construction of Identifiers

In the construction of the several data types, function names, etc., the following policy is applied:

1) All identifiers in the C binding are abbreviated using the same abbreviations for every component and using underscores to denote blanks;
2) The plural of an expression is constructed by adding an "s" after its abbreviation; so, for example, "vector" is abbreviated to "vec" and "vectors" is abbreviated to "vecs"; if an expression is mapped to NULL, so will be its plural;
3) Digits are also preceded by underscores;
4) The words POLYLINE, POLYMARKER and FILL AREA are not abbreviated in the output primitive function names; in all other cases they are abbreviated using the list in 4.2;
5) Construction of GKS/C identifiers:
   a) Function names:
   "`g`" (lower case) followed by abbreviated function name in lower case;
   b) Data types:
   "`G`" (upper case) followed by abbreviated data type in lower case;
   c) Fields of data types; the following refinements are used: "redundant" (words in the field name that are identical to those in the structure name) parts are omitted, if the context allows this; thus the colour index in the field of `Gxxx_bundle` is abbreviated to `colr_ind`, because the context makes clear which colour index is used;
   d) Function macros:
   "`Gfn_`" followed by abbreviation of function name;
   e) GKSM item types:
   "`Gksm_`" followed by abbreviation of item name;
   f) Error macros:
   "`GE_`" followed by some abbreviated expression;
   g) Fields of enumeration types:
   "`G`" (upper case) followed by a prefix followed by an abbreviation of the field name; this prefix is constant for each enumeration field; all the fields are in upper case;

4.2 Table of Abbreviations Used

In this table, only words which are abbreviated are listed. They are used for

function names;
data types;
fields of data types;
error macros;
GKSM item types.

The word "NULL" denotes those words which are deleted completely when forming function names or data types.

Word or Phrase	Abbreviation
accepted	NULL