

A Consumer Library Interface to DWARF

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1. INTRODUCTION

This document describes an interface to *libdwarf*, a library of functions to provide access to DWARF debugging information records, DWARF line number information, DWARF address range and global names information, weak names information, DWARF frame description information, DWARF static function names, DWARF static variables, and DWARF type information.

The document has long mentioned the "Unix International Programming Languages Special Interest Group" (PLSIG), under whose auspices the DWARF committee was formed around 1991. "Unix International" was disbanded in the 1990s and no longer exists.

The DWARF committee published DWARF2 July 27, 1993.

In the mid 1990s this document and the library it describes (which the committee never endorsed, having decided not to endorse or approve any particular library interface) was made available on the internet by Silicon Graphics, Inc.

In 2005 the DWARF committee began an affiliation with FreeStandards.org. In 2007 FreeStandards.org merged with The Linux Foundation. The DWARF committee dropped its affiliation with FreeStandards.org in 2007 and established the dwarfstd.org website. See "<http://www.dwarfstd.org>" for current information on standardization activities and a copy of the standard.

1.1 Copyright

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1.2 Purpose and Scope

The purpose of this document is to document a library of functions to access DWARF debugging information. There is no effort made in this document to address the creation

of these records as those issues are addressed separately (see "A Producer Library Interface to DWARF").

Additionally, the focus of this document is the functional interface, and as such, implementation as well as optimization issues are intentionally ignored.

1.3 Document History

A document was written about 1991 which had similar layout and interfaces. Written by people from Hal Corporation, That document described a library for reading DWARF1. The authors distributed paper copies to the committee with the clearly expressed intent to propose the document as a supported interface definition. The committee decided not to pursue a library definition.

SGI wrote the document you are now reading in 1993 with a similar layout and content and organization, but it was complete document rewrite with the intent to read DWARF2 (the DWARF version then in existence). The intent was (and is) to also cover future revisions of DWARF. All the function interfaces were changed in 1994 to uniformly return a simple integer success-code (see `DW_DLV_OK` etc), generally following the recommendations in the chapter titled "Candy Machine Interfaces" of "Writing Solid Code", a book by Steve Maguire (published by Microsoft Press).

1.4 Definitions

DWARF debugging information entries (DIEs) are the segments of information placed in the `.debug_*` sections by compilers, assemblers, and linkage editors that, in conjunction with line number entries, are necessary for symbolic source-level debugging. Refer to the latest "*DWARF Debugging Information Format*" from www.dwarfstd.org for a more complete description of these entries.

In June 2021 the document was substantially revised to remove obsolete API functions. The obsolete functions could not function properly with DWARF5.

This document adopts all the terms and definitions in "*DWARF Debugging Information Format*" versions 2,3,4, and 5. It originally focused on the implementation at Silicon Graphics, Inc., but now attempts to be more generally useful.

1.5 Overview

The remaining sections of this document describe the proposed interface to `libdwarf`, first by describing the purpose of additional types defined by the interface, followed by descriptions of the available operations. This document assumes you are thoroughly familiar with the information contained in the *DWARF Debugging Information Format* document.

We separate the functions into several categories to emphasize that not all consumers want to use all the functions. We call the categories Debugger, Internal-level, High-level, and Miscellaneous not because one is more important than another but as a way of making the rather large set of function calls easier to understand.

Unless otherwise specified, all functions and structures should be taken as being designed for Debugger consumers.

The Debugger Interface of this library is intended to be used by debuggers. The interface is low-level (close to dwarf) but suppresses irrelevant detail. A debugger will want to absorb all of some sections at startup and will want to see little or nothing of some sections except at need. And even then will probably want to absorb only the information in a single compilation unit at a time. A debugger does not care about implementation details of the library.

The Internal-level Interface is for a DWARF prettyprinter and checker. A thorough prettyprinter will want to know all kinds of internal things (like actual FORM numbers and actual offsets) so it can check for appropriate structure in the DWARF data and print (on request) all that internal information for human users and libdwarf authors and compiler-writers. Calls in this interface provide data a debugger does not normally care about.

The High-level Interface is for higher level access (it is not really a high level interface!). Programs such as disassemblers will want to be able to display relevant information about functions and line numbers without having to invest too much effort in looking at DWARF.

The miscellaneous interface is just what is left over: the error handler functions.

The following is a brief mention of the changes in libdwarf from the final non-semantic-version libdwarf: libdwarf 20210528

1.6 Items Changed

Comparing libdwarf-0.3.0 to libdwarf-0.2.0

`dwarf_formsig8()` and `dwarf_formsig8_const()` return `DW_DLV_NO_ENTRY` if the attribute passed in does not have the required `DW_FORM`.

Renamed for consistency in naming: `dwarf_fde_cie_list_dealloc()` to `dwarf_dealloc_fde_cie_list()`

`dwarf_frame_instr_head_dealloc()` to `dwarf_dealloc_frame_instr_head()`

`dwarf_ranges_dealloc()` to `dwarf_dealloc_ranges()`

The `Dwarf_Block` structure `bl_data` field is now type `Dwarf_Byte_Ptr` (identical to

Dwarf_Small *) replacing Dwarf_Ptr (void *) to improve type checking. Other instances of Dwarf_Ptr in public functions were altered similarly.

struct Dwarf_Regtable_Entry3_s member fields changed slightly (one member is a Dwarf_Block) to make it easier to read and understand.

dwarf_get_fde_info_for_reg3_b() and
dwarf_get_fde_info_for_cfa_reg3_b() Dwarf_Signed arguments that have always been unsigned by definition are now changed to type Dwarf_Unsigned.

dwarf_expand_frame_instructions() arguments changed to make it possible to return actual frame instruction contents in a useful way.
dwarf_get_frame_instruction() is new and it returns details of an instruction.

dwarf_dealloc_frame_instr_head() deallocs (frees) the data in the Dwarf_Frame_Instr_Head record created by dwarf_expand_frame_instructions().

The Dwarf_Frame_Op type has been deleted, it only worked for DWARF2.

The pointless error argument to dwarf_finish() has been eliminated. The function will never return DW_DLV_ERROR so the return value is pretty much meaningless. If the DwarfDebug passed in is NULL it returns DW_DLV_NO_ENTRY, which is useless.

Comparing libdwarf-0.2.0 to libdwarf-20210528.

Some arguments to dwarf_init_b(), dwarf_init_path(), dwarf_init_path_dl(), dwarf_object_init_b(), and dwarf_finish() have been removed, they were unused and unnecessary. The argument list to dwarf_bitoffset() changed to allow use with DWARF5. Many functions that only supported DWARF before DWARF5 have been dropped in favor of functions that support all DWARF versions through DWARF5. The later versions add a _a_ (or _b_ or _c_ or _d_) to the end of the function name. In nearly all cases the current interface was already available in libdwarf-20210528 along with earlier interfaces that worked with earlier DWARF.

If dwarf_formudata() encounters a signed form it checks the value. If the value is non-negative it returns the non-negative value, otherwise it returns an error. This means success calling dwarf_formudata() does not prove the form is not DW_FORM_sdata.

The dwarf_bitoffset() function adds an argument as the bit offset in DWARF4&5 is defined differently than that in earlier DWARF and callers need to know which definition applies.

1.7 Items Removed

September 2021. Version libdwarf-0.2.0 Many obsolete functions have been removed. These functions were obsolete as they could not properly handle some features of DWARF.

1.8 Revision History

September 2021 Version libdwarf-0.3.0 should be the last major revision for quite a long time.

June 2021 Version libdwarf-0.1.1 The functions for initializing, `dwarf_init_path()` etc and other init functions were changed no longer have unused/unnecessary arguments so users must change their code. Many interfaces have been removed from the API in favor of new ones (most of the new ones have been present in the library for years) with improved functionality. The new ones have the same name but with a trailing `_a` or `_b` or the like.

2. Types Definitions

2.1 General Description

The *libdwarf.h* header file contains typedefs and preprocessor definitions of types and symbolic names used to reference objects of *libdwarf*. The types defined by typedefs contained in *libdwarf.h* all use the convention of adding `Dwarf_` as a prefix and can be placed in three categories:

- Scalar types : The scalar types defined in *libdwarf.h* are defined primarily for notational convenience and identification. Depending on the individual definition, they are interpreted as a value, a pointer, or as a flag.
- Aggregate types : Some values can not be represented by a single scalar type; they must be represented by a collection of, or as a union of, scalar and/or aggregate types.
- Opaque types : The complete definition of these types is intentionally omitted; their use is as handles for query operations, which will yield either an instance of another opaque type to be used in another query, or an instance of a scalar or aggregate type, which is the actual result.

2.2 Scalar Types

The following are the defined by *libdwarf.h*:

```
typedef int Dwarf_Bool;
typedef unsigned long long Dwarf_Off;
typedef unsigned long long Dwarf_Unsigned;
typedef unsigned short Dwarf_Half;
typedef unsigned char Dwarf_Small;
typedef signed long long Dwarf_Signed;
typedef unsigned long long Dwarf_Addr;
typedef void *Dwarf_Ptr;
typedef void (*Dwarf_Handler)(Dwarf_Error error, Dwarf_Ptr errarg);
```

Dwarf_Ptr is an address for use by the host program calling the library, not for representing pc-values/addresses within the target object file. Dwarf_Addr is for pc-values within the target object file. The sample scalar type assignments above are for a *libdwarf.h* that can read and write 32-bit or 64-bit binaries on a 32-bit or 64-bit host machine. The types must be defined appropriately for each implementation of libdwarf. A description of these scalar types in the SGI/MIPS environment is given in Figure 1.

NAME	SIZE	ALIGNMENT	PURPOSE
Dwarf_Bool	4	4	Boolean states
Dwarf_Off	8	8	Unsigned file offset
Dwarf_Unsigned	8	8	Unsigned large integer
Dwarf_Half	2	2	Unsigned medium integer
Dwarf_Small	1	1	Unsigned small integer
Dwarf_Signed	8	8	Signed large integer
Dwarf_Addr	8	8	Program address (target program)
Dwarf_Ptr	4 8	4 8	Dwarf section pointer (host program)
Dwarf_Handler	4 8	4 8	Pointer to error handler function

Figure 1. Scalar Types

2.3 Aggregate Types

The following aggregate types are defined by *libdwarf.h*: Dwarf_Locdesc_c, Dwarf_Block, Dwarf_Regtable3, Dwarf_Regtable_Entry3, Dwarf_Form_data16, Dwarf_Ranges, Dwarf_Sig8, Dwarf_Obj_Access_Section_a_s, Dwarf_Obj_Access_Methods_a_s, Dwarf_Obj_Access_Interface_a_s, Dwarf_Macro_Details_s, Dwarf_Printf_Callback_Info_s, Dwarf_Debug_Fission_Per_CU_s, Dwarf_Cmdline_Options. While most of libdwarf acts on or returns simple values or opaque pointer types, this small set of structures seems useful. Yet, at the same time, these public structures are inflexible as any change in format or content breaks binary (and possibly source in some cases) compatibility.

ld_s field points to an array of Dwarf_Loc records.

2.3.1 Data Block

The Dwarf_Block type is used to contain the value of something describing a block of bytes. The FORM whose form is sometimes DW_FORM_block1, DW_FORM_block2, DW_FORM_block4, DW_FORM_block8, or DW_FORM_block. In the case it holds a location expression bl_from_loclist and bl_section_offset may be set.

In some cases its intended use is to just provide a single field value for a block of data (such as a Dwarf_Expression in a set of Frame instructions) so bl_from_loclist and bl_section_offset will be zero.

```
typedef struct {
    Dwarf_Unsigned    bl_len;
    Dwarf_Small *     bl_data;
    Dwarf_Small       bl_from_loclist;
    Dwarf_Unsigned    bl_section_offset;
} Dwarf_Block;
```

The bl_len field contains the length in bytes of the data pointed to by the bl_data field.

The bl_data field contains a pointer to the uninterpreted data. The data pointed to by bl_data is not necessarily at any useful alignment.

2.3.2 Frame Operation Codes: DWARF 3 (for DWARF2 and later)

This interface was intended to be adequate for DWARF3 and for DWARF2 (and DWARF4) but was never implemented.

2.3.3 Frame Regtable3: DWARF2 and later

This interface is adequate for DWARF2 and later versions. It is new in libdwarf as of April 2006. The default configure of libdwarf inserts DW_FRAME_CFA_COL3 as the default CFA column. Or add a call dwarf_set_frame_cfa_value(dbg,DW_FRAME_CFA_COL3) after your dwarf_init_b() call, this call replaces the default libdwarf-compile-time value with DW_FRAME_CFA_COL3.

The Dwarf_Regtable3 type is used to contain the register-restore information for all registers at a given PC value. Normally used by debuggers. A couple of the struct members changed for version 0.3.0 so they are easier to understand.

```
typedef struct Dwarf_Regtable_Entry3_s {
    Dwarf_Small      dw_offset_relevant;
    Dwarf_Small      dw_value_type;
    Dwarf_Half        dw_regnum;
    Dwarf_Unsigned    dw_offset;
    Dwarf_Unsigned    dw_args_size; /* Not dealt with.*/
    Dwarf_Block        dw_block;
} Dwarf_Regtable_Entry3;

typedef struct Dwarf_Regtable3_s {
    struct Dwarf_Regtable_Entry3_s    rt3_cfa_rule;
    Dwarf_Half                        rt3_reg_table_size;
    struct Dwarf_Regtable_Entry3_s * rt3_rules;
} Dwarf_Regtable3;
```

The array is indexed by register number. The field values for each index are described next. For clarity we describe the field values for index rules[M] (M being any legal array element index). (DW_FRAME_CFA_COL3 DW_FRAME_SAME_VAL, DW_FRAME_UNDEFINED_VAL are not legal array indexes, nor is any index < 0 or >= rt3_reg_table_size); The caller of routines using this struct must create data space for rt3_reg_table_size entries of struct Dwarf_Regtable_Entry3_s and arrange that rt3_rules points to that space and that rt3_reg_table_size is set correctly. The caller need not (but may) initialize the contents of the rt3_cfa_rule or the rt3_rules array. The following applies to each rt3_rules rule M:

dw_regnum is the register number applicable. If dw_regnum is DW_FRAME_UNDEFINED_VAL, then the register I has undefined value. If dw_regnum is DW_FRAME_SAME_VAL, then the register I has the same value as in the previous frame.

If dw_regnum is neither of these two, then the following apply:

dw_value_type determines the meaning of the other fields. It is one of DW_EXPR_OFFSET (0), DW_EXPR_VAL_OFFSET(1), DW_EXPR_EXPRESSION(2) or DW_EXPR_VAL_EXPRESSION(3).

If dw_value_type is DW_EXPR_OFFSET (0) then this is as in DWARF2 and the offset(N) rule or the register(R) rule of the DWARF3 and DWARF2 document applies. The value is either:

If dw_offset_relevant is non-zero, then dw_regnum is effectively ignored but must be identical to DW_FRAME_CFA_COL3 (and the dw_offset value applies. The value of register M is therefore the value of CFA plus the value of dw_offset. The result of the calculation is the address in memory where the value of register M resides. This is the offset(N) rule of the DWARF2 and DWARF3 documents.

`dw_offset_relevant` is zero it indicates the `dw_offset` field is not meaningful. The value of register `M` is the value currently in register `dw_regnum` (the value `DW_FRAME_CFA_COL3` must not appear, only real registers). This is the `register(R)` rule of the DWARF3 spec.

If `dw_value_type` is `DW_EXPR_OFFSET` (1) then this is the `val_offset(N)` rule of the DWARF3 spec applies. The calculation is identical to that of `DW_EXPR_OFFSET` (0) but the value is interpreted as the value of register `M` (rather than the address where register `M`'s value is stored).

If `dw_value_type` is `DW_EXPR_EXPRESSION` (2) then this is the `expression(E)` rule of the DWARF3 document.

`block.bl_len` is the length in bytes of the in-memory block pointed at by `block.bl_data` and the dwarf expression is pointed-to by `block_.bl_data`. Evaluate that expression and the result is the address where the previous value of register `M` is found.

If `dw_value_type` is `DW_EXPR_VAL_EXPRESSION` (3) then this is the `val_expression(E)` rule of the DWARF3 spec.

`block.bl_len` is the length in bytes of the in-memory block pointed at by `block.bl_data`. Evaluate that expression and the result is the previous value of register `M`.

The rule `rt3_cfa_rule` is the current value of the CFA. It is interpreted exactly like any register `M` rule (as described just above) except that `dw_regnum` cannot be `CW_FRAME_CFA_REG3` or `DW_FRAME_UNDEFINED_VAL` or `DW_FRAME_SAME_VAL` but must be a real register number.

2.3.4 Macro Details Record

The `Dwarf_Macro_Details` type gives information about a single entry in the `.debug.macro` section (DWARF2, DWARF3, and DWARF4). It is not useful for DWARF 5 `.debug_macro` section data.

```
struct Dwarf_Macro_Details_s {
    Dwarf_Off    dmd_offset;
    Dwarf_Small  dmd_type;
    Dwarf_Signed dmd_lineno;
    Dwarf_Signed dmd_fileindex;
    char *       dmd_macro;
};
typedef struct Dwarf_Macro_Details_s Dwarf_Macro_Details;
```

`dmd_offset` is the byte offset, within the `.debug_macinfo` section, of this macro information.

`dmd_type` is the type code of this macro info entry (or 0, the type code indicating that this is the end of macro information entries for a compilation unit. See `DW_MACINFO_define`, etc in the DWARF document.

`dmd_lineno` is the line number where this entry was found, or 0 if there is no applicable line number.

`dmd_fileindex` is the file index of the file involved. This is only guaranteed meaningful on a `DW_MACINFO_start_file` `dmd_type`. Set to -1 if unknown (see the functional interface for more details).

`dmd_macro` is the applicable string. For a `DW_MACINFO_define` this is the macro name and value. For a `DW_MACINFO_undef`, or this is the macro name. For a `DW_MACINFO_vendor_ext` this is the vendor-defined string value. For other `dmd_types` this is 0.

2.4 Opaque Types

The opaque types declared in *libdwarf.h* are used as descriptors for queries against DWARF information stored in various debugging sections. Each time an instance of an opaque type is returned as a result of a *libdwarf* operation (`Dwarf_Debug` excepted), it should be freed, using `dwarf_dealloc()` when it is no longer of use (read the following documentation for details, as in at least one case there is a special routine provided for deallocation and `dwarf_dealloc()` is not directly called: see `dwarf_srclines_b()`). Some functions return a number of instances of an opaque type in a block, by means of a pointer to the block and a count of the number of opaque descriptors in the block: see the function description for deallocation rules for such functions. The list of opaque types defined in *libdwarf.h* that are pertinent to the Consumer Library, and their intended use is described below. This is not a full list of the opaque types, see *libdwarf.h* for the full list.

```
typedef struct Dwarf_Debug_s* Dwarf_Debug;
```

An instance of the `Dwarf_Debug` type is created as a result of a successful call to `dwarf_init_b()`, or `dwarf_elf_init_b()`, and is used as a descriptor for subsequent access to most *libdwarf* functions on that object. The storage pointed to by this descriptor should be not be freed, using the `dwarf_dealloc()` function. Instead free it with `dwarf_finish()`.

```
typedef struct Dwarf_Die_s* Dwarf_Die;
```

An instance of a `Dwarf_Die` type is returned from a successful call to the `dwarf_siblingof()`, `dwarf_child`, or `dwarf_offdie_b()` function, and is used as a descriptor for queries about information related to that DIE. The storage pointed to by this descriptor should be freed, using `dwarf_dealloc()` with the

allocation type `DW_DLA_DIE` when no longer needed, or, preferably, call `dwarf_dealloc_die()` instead.

```
typedef struct Dwarf_Line_s* Dwarf_Line;
```

Instances of `Dwarf_Line` type are returned from a successful call to the `dwarf_srclines_from_linecontext()` function, and are used as descriptors for queries about source lines. The storage pointed to by these descriptors should be freed using `dwarf_srclines_dealloc_b(line_context,error)`. when no longer needed.

```
typedef struct Dwarf_Global_s* Dwarf_Global;
```

Instances of `Dwarf_Global` type are returned from a successful call to the `dwarf_get_globals()` function, and are used as descriptors for queries about global names (pubnames).

```
typedef struct Dwarf_Weak_s* Dwarf_Weak;
```

Instances of `Dwarf_Weak` type are returned from a successful call to the SGI-specific `dwarf_get_weak()` function, and are used as descriptors for queries about weak names. The storage pointed to by these descriptors should be individually freed, using `dwarf_dealloc()` with the allocation type `DW_DLA_WEAK_CONTEXT` (or `DW_DLA_WEAK`, an older name, supported for compatibility) when no longer needed.

```
typedef struct Dwarf_Func_s* Dwarf_Func;
```

Instances of `Dwarf_Func` type are returned from a successful call to the SGI-specific `dwarf_get_funcs()` function, and are used as descriptors for queries about static function names.

```
typedef struct Dwarf_Type_s* Dwarf_Type;
```

Instances of `Dwarf_Type` type are returned from a successful call to the SGI-specific `dwarf_get_types()` function, and are used as descriptors for queries about user defined types.

```
typedef struct Dwarf_Var_s* Dwarf_Var;
```

Instances of `Dwarf_Var` type are returned from a successful call to the SGI-specific `dwarf_get_vars()` function, and are used as descriptors for queries about static variables.

```
typedef struct Dwarf_Error_s* Dwarf_Error;
```

This descriptor points to a structure that provides detailed information about errors detected by `libdwarf`. Users typically provide a location for `libdwarf` to store this

descriptor for the user to obtain more information about the error. The storage pointed to by this descriptor should be freed, using `dwarf_dealloc_error()`. See functions `dwarf_errno()` and `dwarf_errmsg()` which give access to the useful data about an error.

```
typedef struct Dwarf_Attribute_s* Dwarf_Attribute;
```

Instances of `Dwarf_Attribute` type are returned from a successful call to the `dwarf_attrlist()`, or `dwarf_attr()` functions, and are used as descriptors for queries about attribute values. The storage pointed to by this descriptor should be individually freed, using `dwarf_dealloc()` with the allocation type `DW_DLA_ATTR` when no longer needed, or call `dwarf_dealloc_attribute()` instead.

```
typedef struct Dwarf_Abbrev_s* Dwarf_Abbrev;
```

An instance of a `Dwarf_Abbrev` type is returned from a successful call to `dwarf_get_abbrev()`, and is used as a descriptor for queries about abbreviations in the `.debug_abbrev` section. The storage pointed to by this descriptor should be freed, using `dwarf_dealloc()` with the allocation type `DW_DLA_ABBREV` when no longer needed.

```
typedef struct Dwarf_Fde_s* Dwarf_Fde;
```

Instances of `Dwarf_Fde` type are returned from a successful call to the `dwarf_get_fde_list()`, `dwarf_get_fde_for_die()`, or `dwarf_get_fde_at_pc()` functions, and are used as descriptors for queries about frames descriptors.

```
typedef struct Dwarf_Cie_s* Dwarf_Cie;
```

Instances of `Dwarf_Cie` type are returned from a successful call to the `dwarf_get_fde_list()` function, and are used as descriptors for queries about information that is common to several frames.

```
typedef struct Dwarf_Arange_s* Dwarf_Arange;
```

Instances of `Dwarf_Arange` type are returned from successful calls to the `dwarf_get_aranges()`, or `dwarf_get_arange()` functions, and are used as descriptors for queries about address ranges. The storage pointed to by this descriptor should be individually freed, using `dwarf_dealloc()` with the allocation type `DW_DLA_ARANGE` when no longer needed.

```
typedef struct Dwarf_Gdbindex_s* Dwarf_Gdbindex;
```

Instances of `Dwarf_Gdbindex` type are returned from successful calls to the `dwarf_gdbindex_header()` function and are used to extract information from a

.gdb_index section. This section is a gcc/gdb extension and is designed to allow a debugger fast access to data in .debug_info. The storage pointed to by this descriptor should be freed using a call to dwarf_gdbindex_free() with a valid Dwarf_Gdbindex pointer as the argument.

```
typedef struct Dwarf_Xu_Index_Header_s* Dwarf_Xu_Index_header;
```

Instances of Dwarf_Xu_Index_Header_s type are returned from successful calls to the dwarf_get_xu_index_header() function and are used to extract information from a .debug_cu_index or .debug_tu_index section. These sections are used to make possible access to .dwo sections gathered into a .dwp object as part of the DebugFission (ie Split Dwarf) project allowing separation of an executable from most of its DWARF debugging information. As of May 2015 these sections are accepted into DWARF5 but the standard has not been released. The storage pointed to by this descriptor should be freed using a call to dwarf_xh_header_free() with a valid Dwarf_XuIndexHeader pointer as the argument.

```
typedef struct Dwarf_Line_Context_s * Dwarf_Line_Context;
```

dwarf_srclines_b() returns a Dwarf_Line_Context through an argument and the new structure pointer lets us access line header information conveniently.

```
typedef struct Dwarf_Locdesc_c_s * Dwarf_Locdesc_c;
typedef struct Dwarf_Loc_Head_c_s * Dwarf_Loc_Head_c;
```

Dwarf_Loc* are involved in the DWARF5 interfaces to location lists. The new interfaces are all functional and contents of the above types are not exposed.

```
typedef struct Dwarf_Macro_Context_s * Dwarf_Macro_Context;
```

dwarf_get_macro_context() and
dwarf_get_macro_context_by_offset() return a Dwarf_Line_Context through an argument and the new structure pointer lets us access macro data from the .debug_macro section.

```
typedef struct Dwarf_Dsc_Head_s * Dwarf_Dsc_Head;
```

dwarf_discr_list() returns a Dwarf_Dsc_Head through an argument and the new structure pointer lets us access macro data from a DW_AT_discr_list attribute.

3. UTF-8 strings

libdwarf is defined, at various points, to return string pointers or to copy strings into string areas you define. DWARF allows the use of DW_AT_use_UTF8 (DWARF3 and later) DW_ATE_UTF (DWARF4 and later) to specify that the strings returned are actually in UTF-8 format. What this means is that if UTF-8 is specified on a particular object it is

up to callers that wish to print all the characters properly to use language-appropriate functions to print Unicode strings appropriately. All ASCII characters in the strings will print properly whether printed as wide characters or not. The methods to convert UTF-8 strings so they will print correctly for all such strings is beyond the scope of this document, but *dwarfdump* does such conversions when printing strings.

If UTF-8 is not specified then one is probably safe in assuming the strings are iso_8859-15 and normal C `printf()` will work fine..

In either case one should be wary of corrupted (accidentally or intentionally) strings with ASCII control characters in the text. Such can cause bad effects if simply printed to a device (such as a terminal).

4. Error Handling

The method for detection and disposition of error conditions that arise during access of debugging information via *libdwarf* is consistent across all *libdwarf* functions that are capable of producing an error. This section describes the method used by *libdwarf* in notifying client programs of error conditions.

Most functions within *libdwarf* accept as an argument a pointer to a `Dwarf_Error` descriptor where a `Dwarf_Error` descriptor is stored if an error is detected by the function. Routines in the client program that provide this argument can query the `Dwarf_Error` descriptor to determine the nature of the error and perform appropriate processing. The intent is that clients do the appropriate processing immediately on encountering an error and then the client calls `dwarf_dealloc_error` to free the `Dwarf_Error` descriptor (at which point the client should zero that descriptor as the non-zero value is stale).

We think the following is appropriate as a general outline. See *dwarfdump* source for many examples of both of the following incomplete examples. The very few functions not following this general call/return plan are specifically documented.

```
int example_codea(Dwarf_Debug dbg, Dwarf_Die indie,
int is_info, Dwarf_Die *sibdie, Dwarf_Error *err)
{
    int res = 0;
    const char *secname = 0;
    res = dwarf_siblingof_b(dbg, indie, is_info, sibdie,
        err);
    if (res == DW_DLV_ERROR) {
        return res; /*Let higher level decide what to do
            and it will eventually need to do
            dwarf_dealloc_error() appropriately,
            the sibdie argument is not touched
            or used by the called function */
    } else if (res == DW_DLV_NO_ENTRY) {
        return res; /* No sibdie created. Nothing done,
            the sibdie argument is not touched
            or used by the called function */
    }
    /* sibdie created. The function stored
        a DIE pointer (pointing to a created
        DIE record) through the sibdie pointer.
        Caller should eventually
        do dwarf_dealloc_die() appropriately. */
    ...
    return DW_DLV_OK;
}
```

In a case where it is ok to suppress the error as being unimportant, this is an outline, not a useful function.

```
int example_codeb(Dwarf_Debug dbg, const char **sec_name,
int is_info)
{
    Dwarf_Error e = 0;
    int res = 0;
    res = dwarf_get_die_section_name(dbg, is_info,
    sec_name, &e);
    if (res == DW_DLV_ERROR) {
        dwarf_dealloc_error(e);
        e = 0;
        return res; /*let higher level decide what to do,
        Nothing allocated in the call still exists. */
    } if (res == DW_DLV_NO_ENTRY) {
        ....
    }
    ...
}
```

In the rare case where the malloc arena is exhausted when trying to create a Dwarf_Error descriptor a pointer to a statically allocated descriptor will be returned. This static descriptor is new in December 2014. A call to dwarf_dealloc() to free the statically allocated descriptor is harmless (it sets the error value in the descriptor to DW_DLE_FAILSAFE_ERRVAL). The possible conflation of errors when the arena is exhausted (and a dwarf_error descriptor is saved past the next reader call in any thread) is considered better than having *libdwarf* call abort() (as earlier *libdwarf* did).

We strongly suggest most applications calling *libdwarf* follow the suggestion above (passing a valid Dwarf_Error address in the last argument when calling *libdwarf* where there are such Dwarf_Error arguments) there are other approaches described just below that might be worth considering in small simple applications as they reduce the Dwarf_Error argument to just passing 0 (null pointer)..

The cases that arise when passing a null for the Dwarf_Error and where there is an error detected are A) with an error handler function *libdwarf* will call that function and on return to *libdwarf*, *libdwarf* will return DW_DLV_ERROR to the original client call.. or B) with no error handler function (see below) *libdwarf* will, as of July 2021, return a DW_DLV_ERROR to the caller and and print a message with the word 'libdwarf' and error number on stderr.

- A. For the error-handler case a client program can specify a function to be invoked upon detection of an error at the time the library is initialized (see dwarf_init_b() or dwarf_init_path() for example). When a *libdwarf* routine detects an error, this function is called with two arguments: a code indicating the nature of the error and a pointer provided by the client at initialization (again see dwarf_init_b() or dwarf_init_path()). This pointer argument can be used to relay information between the error handler and other routines of the client program. When the client error function returns

`libdwarf` returns `DW_DLV_ERROR`.

- B. In the final case, where *libdwarf* functions are not provided a pointer to a `Dwarf_Error` descriptor, and no error handling function was provided at initialization, *libdwarf* functions return `DW_DLV_ERROR` with while printing a short message with the error number on `stderr`.

Before March 2016 *libdwarf* gave up when there was no error handling by emitting a short message on `stderr` and calling `abort(3C)`. It no longer aborts.

The following lists the processing steps taken upon detection of an error:

1. Check the `error` argument; if not a *NULL* pointer, allocate and initialize a `Dwarf_Error` descriptor with information describing the error, place this descriptor in the area pointed to by `error`, and return a value indicating an error condition.
2. If an `errhand` argument was provided to `dwarf_init_b()` at initialization, call `errhand()` passing it the error descriptor and the value of the `errarg` argument provided to `dwarf_init_b()`. If the error handling function returns, return `DW_DLV_ERROR` indicating an error condition.
3. If neither the `error` argument nor an `errhand` argument was provided the function which got the error simply returns `DW_DLV_ERROR` with no indication of what the error is.

In all cases, it is clear from the value returned from a function that an error occurred in executing the function, since `DW_DLV_ERROR` is returned.

As can be seen from the above steps, the client program can provide an error handler at initialization, and still provide an `error` argument to *libdwarf* functions when it is not desired to have the error handler invoked.

If a *libdwarf* function is called with invalid arguments, the behavior is undefined. In particular, supplying a *NULL* pointer to a *libdwarf* function (except where explicitly permitted), or pointers to invalid addresses or uninitialized data causes undefined behavior; the return value in such cases is undefined, and the function may fail to invoke the caller supplied error handler or to return a meaningful error number.

Some errors are so inconsequential that it does not warrant rejecting an object or returning an error. Examples would be a frame length not being a multiple of an address-size, an arange in `.debug_aranges` has some padding bytes, or a relocation could not be completed. To make it possible for a client to report such errors the function `dwarf_get_harmless_error_list` returns strings with error text in them. This function may be ignored if client code does not want to bother with such error reporting.

4.1 Returned values in the functional interface

Values returned by `libdwarf` functions to indicate success and errors are enumerated in Figure 2. The `DW_DLV_NO_ENTRY` case is useful for functions need to indicate that while there was no data to return there was no error either. For example, `dwarf_siblingof()` may return `DW_DLV_NO_ENTRY` to indicate that that there was no sibling to return.

SYMBOLIC NAME	VALUE	MEANING
<code>DW_DLV_ERROR</code>	1	Error
<code>DW_DLV_OK</code>	0	Successful call
<code>DW_DLV_NO_ENTRY</code>	-1	No applicable value

Figure 2. Error Indications

Each function in the interface that returns a value returns one of the integers in the above figure.

If `DW_DLV_ERROR` is returned and a pointer to a `Dwarf_Error` pointer is passed to the function, then a `Dwarf_Error` handle is returned through the pointer. No other pointer value in the interface returns a value. After the `Dwarf_Error` is no longer of interest, a `dwarf_dealloc(dbg, dw_err, DW_DLA_ERROR)` on the error pointer is appropriate to free any space used by the error information.

If `DW_DLV_NO_ENTRY` is returned no pointer value in the interface returns a value.

If `DW_DLV_OK` is returned, the `Dwarf_Error` pointer, if supplied, is not touched, but any other values to be returned through pointers are returned. In this case calls (depending on the exact function returning the error) to `dwarf_dealloc()` may be appropriate once the particular pointer returned is no longer of interest.

Pointers passed to allow values to be returned through them are uniformly the last pointers in each argument list.

All the interface functions are defined from the point of view of the writer-of-the-library (as is traditional for UN*X library documentation), not from the point of view of the user of the library. The caller might code:

```
Dwarf_Line line;
Dwarf_Unsigned ret_loff;
Dwarf_Error err;
int retval = dwarf_lineno_b(line, &ret_loff, &err);
```

for the function defined as

```
int dwarf_lineno_b(Dwarf_Line line,
    Dwarf_Unsigned *return_lineno,
    Dwarf_Error* err);
```

and this document refers to the function as returning the value through `*err` or `*return_lineno` or uses the phrase "returns in the location pointed to by `err`". Sometimes other similar phrases are used.

5. Memory Management

Several of the functions that comprise *libdwarf* return pointers (opaque descriptors) to structures that have been dynamically allocated by the library. To manage dynamic memory the function `dwarf_dealloc()` is provided to free storage allocated as a result of a call to a *libdwarf* function. Some additional functions (described later) are provided to free storage in particular circumstances. This section describes the general strategy that should be taken by a client program in managing dynamic storage.

By default `libdwarf` tracks its allocations and `dwarf_finish()` cleans up allocations where `dwarf_dealloc()` was not called. See `dwarf_set_de_alloc_flag()` below.

5.1 Read-only Properties

All pointers (opaque descriptors) returned by or as a result of a *libdwarf Consumer Library* call should be assumed to point to read-only memory. The results are undefined for *libdwarf* clients that attempt to write to a region pointed to by a value returned by a *libdwarf Consumer Library* call.

5.2 Storage Deallocation

See the section "Returned values in the functional interface", above, for the general rules where calls to `dwarf_dealloc()` are appropriate.

As of May 2020 there are additional dealloc calls which enable type-checking the calls: `dwarf_dealloc_error()`, `dwarf_dealloc_die()`, and `dwarf_dealloc_attribute()`.

5.2.1 dwarf_dealloc()

The first prototype is the generic one that can dealloc any of the *libdwarf* types, such as `DW_DLA_DIE` etc.. This has the disadvantages that the `space_to_dealloc` argument cannot be type checked and the `appropriate_dla_name` is a simple integer, hence not meaningfully checkable either.

Whenever possible, use a type-safe deallocation call (for several types that is the only documented deallocation call) and for `Dwarf_Die` `Dwarf_Attribute` or `Dwarf_Error` use the following dealloc functions instead of this one. The use of this form remains fully supported,

```
void dwarf_dealloc(Dwarf_Debug dbg,
                  void *space_to_dealloc,
                  int appropriate_dla_name);
```

Figure 3. Example_dwarf_dealloc()

```
void exampledealloc(Dwarf_Debug dbg,Dwarf_Die somedie)
{
    dwarf_dealloc(dbg,somedie,DW_DLA_DIE);
}
```

5.2.2 dwarf_dealloc_die()

The second prototype is only to dealloc a Dwarf_Die. Any call to this is typechecked.

```
void dwarf_dealloc_die(Dwarf_Die mydie);
```

Figure 4. Example_dwarf_dealloc_die()

```
void exampledeallocdie(Dwarf_Die somedie)
{
    dwarf_dealloc_die(somedie);
}
```

5.2.3 dwarf_dealloc_attribute()

The second prototype is only to dealloc a Dwarf_Attribute. These arise from calls from dwarf_attrlist() Any call to this is typechecked.

```
void dwarf_dealloc_error(Dwarf_Debug dbg,
    Dwarf_Die mydie);
```

Figure 5. Example_dwarf_dealloc_attribute()

```
void exampledeallocattr(Dwarf_Attribute attr)
{
    dwarf_dealloc_attribute(attr);
}
```

5.2.4 dwarf_dealloc_error()

The second prototype is only to dealloc a Dwarf_Error. These arise when some libdwarf call returns DW_DLV_ERROR. Any call to this is typechecked.

```
void dwarf_dealloc_error(Dwarf_Debug dbg,
    Dwarf_Die mydie);
```

Figure 6. Example_dwarf_dealloc_error()

```
void exampledeallocerror(Dwarf_Debug dbg,Dwarf_Error err)
{
    dwarf_dealloc_error(dbg,err);
}
```

See also Errors Returned from dwarf_init* calls (below).

In some cases the pointers returned by a *libdwarf* call are pointers to data which is not freeable. The library knows from the allocation type provided to it whether the space is freeable or not and will not free inappropriately when `dwarf_dealloc()` is called. So it is vital that `dwarf_dealloc()` be called with the proper allocation type.

For all storage allocated by *libdwarf*, the client can free the storage for reuse by calling `dwarf_dealloc()`, providing it with the `Dwarf_Debug` descriptor specifying the object for which the storage was allocated, a pointer to the area to be free-ed, and an identifier that specifies what the pointer points to (the allocation type). For example, to free a `Dwarf_Die` `die` belonging to the object represented by `Dwarf_Debug` `dbg`, allocated by a call to `dwarf_siblingof()`, the call to `dwarf_dealloc()` would be:

```
dwarf_dealloc(dbg, die, DW_DLA_DIE);
or, preferably,
dwarf_dealloc_die(die);
```

To free storage allocated in the form of a list of pointers (opaque descriptors), each member of the list should be deallocated, followed by deallocation of the actual list itself. The following code fragment uses an invocation of `dwarf_attrlist()` as an example to illustrate a technique that can be used to free storage from any *libdwarf* routine that returns a list:

Figure 7. Example1 dwarf_attrlist()

```
void example1(Dwarf_Debug dbg,Dwarf_Die somedie)
{
    Dwarf_Signed atcount = 0;
    Dwarf_Attribute *atlist = 0;
    Dwarf_Error error = 0;
    Dwarf_Signed i = 0;
    int errv = 0;

    errv = dwarf_attrlist(somedie, &atlist,&atcount, &error);
    if (errv == DW_DLV_OK) {
        for (i = 0; i < atcount; ++i) {
            /* use atlist[i] */
            dwarf_dealloc_attribute(atlist[i]);
            /* This original form still works.
            dwarf_dealloc(dbg, atlist[i], DW_DLA_ATTR);
            */
        }
        dwarf_dealloc(dbg, atlist, DW_DLA_LIST);
    }
}
```

dwarf_finish() will deallocate all dynamic storage associated with an instance of a Dwarf_Debug type. In particular, it will deallocate all dynamically allocated space associated with the Dwarf_Debug descriptor, and finally make the descriptor invalid.

5.2.5 Errors Returned from dwarf_init* calls

These errors are almost always due to fuzzing objects, injecting random values into objects. Rarely seen in any valid object file. See "<https://en.wikipedia.org/wiki/Fuzzing>"

A Dwarf_Error returned from any dwarf_init*() should be dealt with like any other error. We start with an example of how to deal with this class of errors. See just below the example for a further discussion.

```
void exampleinitfail(const char *path,
    char *true_pathbuf,
    unsigned tpathlen,
    unsigned groupnumber)
{
    Dwarf_Handler errhand = 0;
    Dwarf_Ptr errarg = 0;
    Dwarf_Error error = 0;
    Dwarf_Debug dbg = 0;
    int res = 0;

    res = dwarf_init_path(path,true_pathbuf,
        tpathlen,groupnumber,errhand,
        errarg,&dbg,
        &error);
    /* Preferred version */
    if (res == DW_DLV_ERROR) {
        /* Valid call even though dbg is null! */
        dwarf_dealloc(dbg,error,DW_DLA_ERROR);
        /* Simpler newer form in
           this comment, but use the
           older form above for compatibility
           with older libdwarf.
           dwarf_dealloc_error(dbg,error);
           With libdwarf before September 2020
           these dealloc calls will leave
           a few bytes allocated.
           */
        /* The original recommendation to call
           free(error) in this case is still
           valid though it will not necessarily
           free every byte allocated with
           September 2020 and later libdwarf. */
    }
    /* Horrible messy alternative, best effort
       if dwarf_package_version exists
       (function created in October 2019
       package version 20191106). */
    if (res == DW_DLV_ERROR) {
        const char *ver = dwarf_package_version();
        int cmpres = 0;
        cmpres = strcmp(ver,"20200822");
        if (cmpres > 0) {
            dwarf_dealloc_error(dbg,error);
        } else {
            free(error);
        }
    }
}
```

```
    }  
  }  
}
```

If your application needs to be absolutely sure not even a single byte leaks from a failed libdwarf init function call the only sure approach is to ensure you use a September 2020 (version 20200908) or later libdwarf. Versions between 20191104 and 20200908 have no available function that will guarantee freeing these last few bytes.

If your application does not care if a failed libdwarf init function leaks a few bytes then the September 2020 advice of calling `dwarf_dealloc(dbg,error,DW_DLA_ERROR)` is best, as though leaks a few bytes with libdwarf before September 2020.

If your application is using 20191104 or earlier libdwarf the choice of `free(error)` will avoid a leak from a failed dwarf init call, though changing to a more recent libdwarf will then make a few bytes leak quite possible until the application is changed to use the `dwarf_dealloc` call.

5.2.6 Error DW_DLA error free types

The codes that identify the storage pointed to in calls to `dwarf_dealloc()` are described in figure 8.

IDENTIFIER	USED TO FREE
DW_DLA_STRING	char*
DW_DLA_LOC	Dwarf_Loc
DW_DLA_LOCDISC	Dwarf_Locdesc
DW_DLA_ELLIST	Dwarf_Ellist (not used)
DW_DLA_BOUNDS	Dwarf_Bounds (not used)
DW_DLA_BLOCK	Dwarf_Block
DW_DLA_DEBUG	Dwarf_Debug (do not use)
DW_DLA_DIE	Dwarf_Die
DW_DLA_LINE	Dwarf_Line
DW_DLA_ATTR	Dwarf_Attribute
DW_DLA_TYPE	Dwarf_Type (not used)
DW_DLA_SUBSCR	Dwarf_Subscr (not used)
DW_DLA_GLOBAL	Dwarf_Global
DW_DLA_ERROR	Dwarf_Error
DW_DLA_LIST	a list of opaque descriptors
DW_DLA_LINEBUF	Dwarf_Line* (not used)
DW_DLA_ARANGE	Dwarf_Arange
DW_DLA_ABBREV	Dwarf_Abbrev
DW_DLA_FRAME_OP	Dwarf_Frame_Op
DW_DLA_CIE	Dwarf_Cie
DW_DLA_FDE	Dwarf_Fde
DW_DLA_LOC_BLOCK	Dwarf_Loc Block
DW_DLA_FRAME_BLOCK	Dwarf_Frame Block (not used)
DW_DLA_FUNC	Dwarf_Func
DW_DLA_TYPENAME	Dwarf_Type
DW_DLA_VAR	Dwarf_Var
DW_DLA_WEAK	Dwarf_Weak
DW_DLA_ADDR	Dwarf_Addr
DW_DLA_RANGES	Dwarf_Ranges
DW_DLA_GNU_INDEX_HEAD	.debug_gnu_type/pubnames
DW_DLA_RNGLISTS_HEAD	.debug_rnglists
DW_DLA_DGBINDEX	Dwarf_Gdbindex
DW_DLA_XU_INDEX	Dwarf_Xu_Index_Header
DW_DLA_LOC_BLOCK_C	Dwarf_Loc_c
DW_DLA_LOCDISC_C	Dwarf_Locdesc_c
DW_DLA_LOC_HEAD_C	Dwarf_Loc_Head_c
DW_DLA_MACRO_CONTEXT	Dwarf_Macro_Context
DW_DLA_DSC_HEAD	Dwarf_Dsc_Head
DW_DLA_DNAMES_HEAD	Dwarf_Dnames_Head
DW_DLA_STR_OFFSETS	Dwarf_Str_Offsets_Table

Figure 8. Allocation/Deallocation Identifiers

6. Functional Interface

This section describes the functions available in the *libdwarf* library. Each function description includes its definition, followed by one or more paragraph describing the function's operation.

The following sections describe these functions.

6.1 Initialization Operations

These functions are concerned with preparing an object file for subsequent access by the functions in *libdwarf* and with releasing allocated resources when access is complete. `dwarf_init_path()` or `dwarf_init_path_dl()` are the initialization functions to use if one actually has a path (if you just have an open fd or open libelf handle you cannot use the `_path_` versions that's fine). These both allow *libdwarf* to attempt to follow GNU `debuglink` hints in a specially produced executable/shared-object to find the object file with the DWARF sections to match the executable(or shared-object). For non-`debuglink` executables these two functions behave identically.

GNU `debuglink` is completely different than and separate from Split Dwarf and MacOS `dSYM`. it would seem unlikely that these could be combined in any single executable/shared-object. All are intended to have DWARF fully available but not taking space in the executable/shared object. See <https://sourceware.org/gdb/onlinedocs/gdb/Separate-Debug-Files.html> for information on `debuglink` and the related `build-id`.

`dwarf_init_path()` provides no way to add extra global paths to `debuglink` searches. But `dwarf_init_path_dl()` has 2 extra arguments to make adding extra paths easy.

libdwarf lets one access the executable's section `.eh_frame` with frame/backtrace information by turning off recognition of GNU `debuglink` in the `Dwarf_Debug` being opened by passing in `true_path_out_buffer` `true_path_bufferlen` as zero.

6.1.1 `dwarf_init_path()`

```
int dwarf_init_path(
    const char *    path,
    char *          true_path_out_buffer,
    unsigned        true_path_bufferlen,
    unsigned        groupnumber,
    Dwarf_Handler   errhand,
    Dwarf_Ptr       errarg,
    Dwarf_Debug*    dbg,
    Dwarf_Error*    * error);
```

On success the function returns `DW_DLV_OK`, and returns a pointer to an initialized `Dwarf_Debug` through the `dbg` argument. All this work identically across all supported

object file types.

If `DW_DLV_NO_ENTRY` is returned there is no such file and nothing else is done or returned.

If `DW_DLV_ERROR` is returned a `Dwarf_Error` is returned through the error pointer. and nothing else is done or returned.

Now we turn to the arguments.

Pass in the name of the object file via the `path` argument.

For MacOS pass in a pointer to `true_path_out_buffer` big pointing to a buffer large enough to hold the passed-in path if that were doubled plus adding 100 characters. Then pass that length in the `true_path_bufferlen` argument. If a file is found (the `dSYM` path or if not that the original path) the final path is copied into `true_path_out_buffer`. In any case, This is harmless with non-MacOS executables, but for non-MacOS non `GNU_debuglink` objects `true_path_out_buffer` will just match `path`.

For Elf executables/shared-objects using `GNU_debuglink` The same considerations apply: pass in a pointer to `true_path_out_buffer` big pointing to a buffer large enough to hold the passed-in path if that were doubled plus adding 100 characters (a heuristic) (the 100 is arbitrary: `GNU_debuglink` paths can be long but not likely longer than this suggested size.

When you know you won't be reading MacOS executables and won't be accessing `GNU_debuglink` executables special treatment by passing 0 as arguments to `true_path_out_buffer` and `true_path_bufferlen`. If those are zero the MacOS/ `GNU_debuglink` special processing will not occur.

The `groupnumber` argument indicates which group is to be accessed. Group one is normal dwarf sections such as `.debug_info`. Group two is DWARF5 dwo split-dwarf dwarf sections such as `.debug_info.dwo`.

Groups three and higher are for COMDAT groups. If an object file has only sections from one of the groups then passing zero will access that group. Otherwise passing zero will access only group one.

See `dwarf_sec_group_sizes()` and `dwarf_sec_group_map()` for more group information.

Typically pass in `DW_GROUPNUMBER_ANY` to `groupnumber`. Non-elf objects do not use this field.

The `errhand` argument is a pointer to a function that will be invoked whenever an error is detected as a result of a *libdwarf* operation. The `errarg` argument is passed as an argument to the `errhand` function.

dbg is used to return an initialized Dwarf_Debug pointer.

Pass in a pointer to a Dwarf_Error to the error argument if you wish libdwarf to return an error code.

6.1.2 dwarf_init_path_dl()

```
int dwarf_init_path_dl(  
    const char *      path,  
    char *            true_path_out_buffer,  
    unsigned           true_path_bufferlen,  
    unsigned           groupnumber,  
    Dwarf_Handler     errhand,  
    Dwarf_Ptr         errarg,  
    Dwarf_Debug*      dbg,  
    char              ** gl_path_array,  
    unsigned int       global_paths_count,  
    unsigned char      * path_source,  
    Dwarf_Error*       * error);
```

This function is identical to dwarf_init_path() in every respect except if you know that you must use special paths to find the GNU debuglink target file with DWARF information.

global_paths allows you to specify such paths. Pass in gl_path_array as a pointer to an array of pointer-to-char, each pointing to a global path string. Pass in global_paths_count with the number of entries in the pointer array. Pass both as zero if there are no debuglink global paths other than the default standard /usr/lib/debug.

path_source is a pointer to a flag set to one of DW_PATHSOURCE_unspecified, or DW_PATHSOURCE_basic, or DW_PATHSOURCE_dsym, or DW_PATHSOURCE_debuglink. by the call. It tells the caller what sort of file was opened, respectively no object, ordinary object, a MacOS DSYM object, or a GNU debuglink object. In the third and fourth case the true_path_out_buffer contains the file path actually opened.

6.1.3 dwarf_init_b()

```
int dwarf_init_b(int fd,  
    unsigned group_number,  
    Dwarf_Handler errhand,  
    Dwarf_Ptr errarg,  
    Dwarf_Debug * dbg,  
    Dwarf_Error *error)
```

When it returns `DW_DLV_OK`, the function `dwarf_init_b()` returns through `dbg` a `Dwarf_Debug` descriptor that represents a handle for accessing debugging records associated with the open file descriptor `fd`. `DW_DLV_NO_ENTRY` is returned if the object does not contain DWARF debugging information. `DW_DLV_ERROR` is returned if an error occurred.

The `groupnumber` argument indicates which group is to be accessed. Group one is normal dwarf sections such as `.debug_info`. Group two is DWARF5 dwo split-dwarf dwarf sections such as `.debug_info.dwo`. If you don't know specific value, use `DW_GROUPNUMBER_ANY` and it will work for you in almost all cases.

Groups three and higher are for COMDAT groups. If an object file has only sections from one of the groups then passing zero will access that group. Otherwise passing zero will access only group one.

See `dwarf_sec_group_sizes()` and `dwarf_sec_group_map()` for more group information.

The `errhand` argument is a pointer to a function that will be invoked whenever an error is detected as a result of a *libdwarf* operation. The `errarg` argument is passed as an argument to the `errhand` function.

The file descriptor associated with the `fd` argument must refer to an ordinary file (i.e. not a pipe, socket, device, `/proc` entry, etc.), be opened with the at least as much permission as specified by the `access` argument, and cannot be closed or used as an argument to any system calls by the client until after `dwarf_finish()` is called. The seek position of the file associated with `fd` is undefined upon return of `dwarf_init_b()`.

Since `dwarf_init_b()` uses the same error handling processing as other *libdwarf* functions (see *Error Handling* above), client programs will generally supply an `error` parameter to bypass the default actions during initialization unless the default actions are appropriate.

6.1.4 `dwarf_set_de_alloc_flag()`

```
int dwarf_set_de_alloc_flag(  
    int v)
```

`dwarf_set_de_alloc_flag()` sets and returns a flag value applying to the current running instance of *libdwarf*. It's action sets an internal value, and that value should be set/changed (if you wish to do that) before any other *libdwarf* calls.

The flag setting is global in *libdwarf*, it is not a per open `Dwarf_Debug`. The call can be made before or after opening a `Dwarf_Debug`, but for maximum time savings call this before opening a `Dwarf_Debug`.

By default *libdwarf* keeps track of all its internal allocations. So if the documentation here says you should do `dwarf_dealloc()` calls (or other calls documented here for specific functions) and you omit some or all of them then calling `dwarf_finish()`

will clean up all those allocations left undone.

If you call `dwarf_set_de_alloc_flag(0)` then libdwarf will not keep track of allocations so your code must do all `dwarf_dealloc()` calls as defined below.

If you call `dwarf_set_de_alloc_flag(1)` that sets/restores the setting to its default value so from that point all new internal allocations will be tracked and `dwarf_finish()` can clean the new ones up.

The return value of `dwarf_set_de_alloc_flag()` is the previous value of the internal flag: One (1) is the default, meaning record allocations.. Zero (0) is the other possible value, meaning do not record libdwarf allocations.

It is best to ignore this call unless you have gigantic DWARF sections and you need whatever percent speed improvement from libdwarf that you can get. If you do use it then by all means use tools such as `cc --fsanitize...` or `valgrind` to ensure there are no leaks in your application (at least given your test cases).

The function name echos the spelling of a libdwarf-internal field in struct `Dwarf_Debug_s` named `de_alloc_tree`.

6.1.5 Dwarf_Handler function

This is an example of a valid error handler function. A pointer to this (or another like it) may be passed to `dwarf_elf_init_b()` or `dwarf_init_b()`.

```
static void
simple_error_handler(Dwarf_Error error, Dwarf_Ptr errarg)
{
    printf("libdwarf error: %d  %s\n",
           dwarf_errno(error), dwarf_errmsg(error));
    exit(1);
}
```

This will only be called if an error is detected inside libdwarf and the `Dwarf_Error` argument passed to libdwarf is `NULL`. A `Dwarf_Error` will be created with the error number assigned by the library and passed to the error handler.

The second argument is a copy of the value passed in to `dwarf_elf_init_b()` as the `errarg()` argument. Typically the init function would be passed a pointer to an application-created struct containing the data the application needs to do what it wants to do in the error handler.

In a language with exceptions or exception-like features an exception could be thrown here. Or the application could simply give up and call `exit()` as in the sample given above.

6.1.6 dwarf_set_tied_dbg()

```
int dwarf_set_tied_dbg(  
    Dwarf_Debug dbg,  
    Dwarf_Debug tieddbg,  
    Dwarf_Error *error)
```

The function enables cross-object access of DWARF data. If a DWARF5 Package object has DW_FORM_addrx or DW_FORM_GNU_addr_index or one of the other indexed forms in DWARF5 in an address attribute one needs both the Package file and the executable to extract the actual address with dwarf_formaddr(). The utility function dwarf_addr_form_is_indexed(form) is a handy way to know if an address form is indexed. One does a normal dwarf_init_b() on each object and then tie the two together with a call such as:

Figure 9. Example2 dwarf_set_died_dbg()

```
void example2(Dwarf_Debug dbg, Dwarf_Debug tieddbg)  
{  
    Dwarf_Error error = 0;  
    int res = 0;  
  
    /* Do the dwarf_init_b()  
       calls to set  
       dbg, tieddbg at this point. Then: */  
    res = dwarf_set_tied_dbg(dbg,tieddbg,&error);  
    if (res != DW_DLV_OK) {  
        /* Something went wrong*/  
    }  
}
```

When done with both dbg and tieddbg do the normal finishing operations on both in any order.

It is possible to undo the tying operation with

Figure 10. Example3 dwarf_set_tied_dbg() obsolete

```
void example3(Dwarf_Debug dbg)  
{  
    Dwarf_Error error = 0;  
    int res = 0;  
    res = dwarf_set_tied_dbg(dbg,NULL,&error);  
    if (res != DW_DLV_OK) {  
        /* Something went wrong*/  
    }  
}
```

It is not necessary to undo the tying operation before finishing on the dbg and tieddbg.

6.1.7 dwarf_get_tied_dbg()

```
int dwarf_get_tied_dbg(  
    Dwarf_Debug /*dbg*/,  
    Dwarf_Debug * /*tieddbg_out*/,  
    Dwarf_Error * /*error*/)
```

`dwarf_get_tied_dbg` returns `DW_DLV_OK` and sets `tieddbg_out` to the pointer to the 'tied' `Dwarf_Debug`. If there is no 'tied' object `tieddbg_out` is set to `NULL`.

On error it returns `DW_DLV_ERROR`.

It never returns `DW_DLV_NO_ENTRY`.

6.1.8 dwarf_finish()

```
int dwarf_finish(Dwarf_Debug dbg)
```

The function releases all *Libdwarf* internal resources associated with the descriptor `dbg`, and invalidates `dbg`. It returns `DW_DLV_OK` for a successful operation. It returns `DW_DLV_NO_ENTRY` if the passed in argument is `NULL`.

6.1.9 dwarf_set_stringcheck()

```
int dwarf_set_stringcheck(  
    int stringcheck)
```

The function sets a global flag and returns the previous value of the global flag.

If the `stringcheck` global flag is zero (the default) `libdwarf` does string length validity checks (the checks do slow `libdwarf` down very slightly). If the `stringcheck` global flag is non-zero `libdwarf` does not do string length validity checks.

The global flag is really just 8 bits long, upperbits are not noticed or recorded.

6.1.10 dwarf_set_reloc_application()

```
int dwarf_set_reloc_application(  
    int apply)
```

The function sets a global flag and returns the previous value of the global flag.

If the `reloc_application` global flag is non-zero (the default) then the applicable `.rela` section (if one exists) will be processed and applied to any DWARF section when it is read in. If the `reloc_application` global flag is zero no such relocation-application is attempted.

Not all machine types (elf header `e_machine`) or all relocations are supported, but then

very few relocation types apply to DWARF debug sections.

The global flag is really just 8 bits long, upperbits are not noticed or recorded.

It seems unlikely anyone will need to call this function.

6.1.11 dwarf_record_cmdline_options()

```
int dwarf_record_cmdline_options(  
    Dwarf_Cmdline_Options options)
```

The function copies a Dwarf_Cmdline_Options structure from consumer code to libdwarf.

The structure is defined in `libdwarf.h`.

The initial version of this structure has a single field `check_verbose_mode` which, if non-zero, tells libdwarf to print some detailed messages to `stdout` in case certain errors are detected.

The default for this value is FALSE (0) so the extra messages are off by default.

6.1.12 dwarf_object_init_b()

```
int dwarf_object_init_b(  
    Dwarf_Obj_Access_Interface* obj,  
    Dwarf_Handler errhand,  
    Dwarf_Ptr errarg,  
    unsigned groupnumber,  
    Dwarf_Debug* dbg,  
    Dwarf_Error* error)
```

The function enables access to non-Elf object files or even in-memory data by allowing the caller to then provide function pointers to code (user-written, not part of libdwarf) that will look, to libdwarf, as if libdwarf was reading Elf. For a fully worked-out example see the source code in *src/bin/dwarfexample/jitreader.c*.

See `int dwarf_init_b()` for additional information on the arguments passed in (the `obj` argument here is a set of function pointers and describing how to access non-Elf files is beyond the scope of this document).

Writing the functions needed to support non-Elf will require study of Elf and of the object format involved. The topic is beyond the scope of this document.

6.1.13 dwarf_object_finish()

```
int dwarf_object_finish(Dwarf_Debug dbg)
```

For use with `dwarf_object_init_b()`, this frees all that libdwarf allocates.

It can only return `DW_DLV_OK` or `DW_DLV_NO_ENTRY` and there is really nothing one can do in either case.

6.1.14 `dwarf_get_real_section_name()`

```
int dwarf_get_real_section_name( Dwarf_Debug dbg,
    const char * std_section_name,
    const char ** actual_sec_name_out,
    Dwarf_Small * marked_compressed,
    Dwarf_Small * marked_zlib_compressed,
    Dwarf_Small * marked_shf_compressed,
    Dwarf_Unsigned * compressed_length,
    Dwarf_Unsigned * uncompressed_length,
    Dwarf_Error * error);
```

Elf sections are sometimes compressed to reduce the disk footprint of the sections. It's sometimes interesting to library users what the real name was in the object file and whether it was compressed. Libdwarf uncompresses such sections automatically. It's not usually necessary to know the true name or anything about compression.

The caller passes in a `Dwarf_Debug` pointer and a standard section name such as `".debug_info"`. On success the function returns (through the other arguments) the true section name and a flag which, if non-zero means the section was compressed and a flag which, if non-zero means the section had the Elf section flag `SHF_COMPRESSED` set. The caller must ensure that the memory pointed to by `actual_sec_name_out`, `marked_zcompressed`, and `marked_zlib_compressed`, `marked_shf_compressed`, `compressed_length`, `uncompressed_length`, is zero at the point of call.

The flag `*marked_compressed`, if non-zero, means the section name started with `.zdebug` (indicating compression was done).

The flag `marked_zlib_compressed`, if non-zero means the initial bytes of the section start with the ASCII characters `ZLIB` and the section was compressed.

The flag `marked_shf_compressed` if non-zero means the Elf section `sh_flag` `SHF_COMPRESSED` is set and the section was compressed.. The flag value in an elf section header is $(1 < 11)$ (0x800).

The value `compressed_length` is passed back through the pointer if and only if the section is compressed and the pointer is non-null.

The value `uncompressed_length` is passed back through the pointer if and only if the section is compressed and the pointer is non-null.

If the section name passed in is not used by libdwarf for this object file the function returns `DW_DLV_NO_ENTRY`

On error the function returns DW_DLV_ERROR.

The string pointed to by `*actual_sec_name_out` must not be `free()`d.

6.1.15 dwarf_package_version()

```
const char * dwarf_package_version(void);
```

The package version is set in `config.h` (from its value in `configure.ac` and in `CMakeLists.txt` in the source tree) at the build time of the library. A pointer to a static string is returned by this function. The format is standard ISO date format. For example "20180718". It's not entirely clear how this actually helps. But there is a request for this and we provide it as of 23 October 2019.

6.2 Object Type Detectors

These are used by `libdwarf` and may be of use generally. They have no connection to any Dwarf_Debug data as you see from the arguments passed in.

6.2.1 dwarf_object_detector_path_b()

This returns basic object file information and make it possible to resolve GNU debuglink paths to a file with DWARF.

```
int dwarf_object_detector_path_b(const char *path,
    char *      outpath,
    unsigned long outpath_len,
    char **     gl_pathnames,
    unsigned    gl_pathcount,
    unsigned *  ftype,
    unsigned *  endian,
    unsigned *  offsetsize,
    Dwarf_Unsigned * filesize,
    unsigned char * pathsource,
    int * errcode);
```

On success the function returns DW_DLV_OK, and returns various data through the arguments (described just below). This works identically across all supported object file types.

If DW_DLV_NO_ENTRY is returned there is no such file and nothing else is done or returned.

If DW_DLV_ERROR is returned a Dwarf_Error is returned through the error pointer. and nothing else is done or returned.

Now we turn to the arguments.

The required arguments are `path`, `ftype`, `endian`, `offsetsize`, and `filesize`. All others should be passed as 0 unless GNU debuglink processing is needed. See below.

Pass in the name of the object file via the `path` argument.

For `ftype`, `endian`, and `filesize` pass pointers. `ftype` will be returned as one of the `DW_TYPE*` values (see `libdwarf.h`). `endian` will be returned as one of the `DW_END_*` values, (see `dwarf.h`). `offsetsize` will be returned as 32 or 64 as found in the object file header(s). The meaning of `offsetsize` may differ depending on the particular object format. `filesize` will be returned as the size of the file found in bytes.

Now we turn to the arguments involved in GNU debuglink processing: `outpath`, `outpath_len`, `gl_pathnames`, `gl_pathcount`, and `pathsource`. Usually one will pass all these as 0 and avoid special processing.

To `outpath` pass in a pointer big enough to hold the passed-in path if that were doubled plus adding 100 characters. (that is a rather arbitrary size request, a larger value might be better in some circumstances) Then pass that length in the `outpath_len` argument. The path will be copied to `outpath`. If a GNU debuglink file is found the path to that file will be copied to `outpath`.

To `pathsource` pass in a pointer to an unsigned char containing the value `DW_PATHSOURCE_basic`. If a debuglink file is found `outpath` will be set to the debuglink target file and `*pathsource` will be set to `DW_PATHSOURCE_debuglink`.

The `ftype` pointer argument returns `DW_FTYPE_ELF`, `DW_FTYPE_MACH_O`, `DW_FTYPE_PE`, `DW_FTYPE_ARCHIVE` or `DW_FTYPE_UNKNOWN` to the caller. The `DW_FTYPE_ARCHIVE` value says nothing whatever about the contents of the archive.

The `endian` pointer argument returns `DW_END_big`, `DW_END_little`, or `DW_END_unknown` to the caller.

The `offsetsize` pointer argument returns a size value from the object file. If the object file uses 32-bit offsets it returns 32, and if 64-bit offsets it returns 64. Each object type uses such values but the meanings vary between object types.

The `filesize` pointer argument returns the size, in bytes, of the object file. This is essentially useless for `DW_FTYPE_ARCHIVE` files.

The `gl_pathnames` and `gl_pathcount` arguments provide a way to give the GNU debuglink logic additional directories beyond the standard location to search for object files. `gl_pathnames` must, if non-zero, point to an array of pointers to character strings with file paths to search. `gl_pathcount` must contain the number of such paths in the pathname array.

The `errcode` pointer argument returns (if and only if `DW_DLV_ERROR` is returned by the function) an integer error code. At this time there is no handy function to turn that error code into a string. In the `libdwarf` source you will find that code in the `DW_DLE_*` error list.

6.2.2 dwarf_object_detector_path_dSYM()

This returns basic object file data and makes it possible to resolve MacOS paths and return the path to the MacOS dSYM object file with DWARF if one exists.

```
int dwarf_object_detector_path_dSYM(const char *path,
    char *      outpath,
    unsigned long outpath_len,
    char **     gl_pathnames,
    unsigned    gl_pathcount,
    unsigned *   ftype,
    unsigned *   endian,
    unsigned *   offsetsize,
    Dwarf_Unsigned * filesize,
    unsigned char * pathsource,
    int * errcode);
```

On success the function returns DW_DLV_OK, and returns various data through the arguments (described just below). This works identically across all supported object file types.

If DW_DLV_NO_ENTRY is returned there is no such file and nothing else is done or returned.

If DW_DLV_ERROR is returned a Dwarf_Error is returned through the error pointer. and nothing else is done or returned.

Now we turn to the arguments.

The required arguments are path ftype endian offsetsize and filesize. All others should be passed as 0 unless MacOS dSYM processing is needed. See below.

Pass in the name of the object file via the path argument.

For ftype, endian, offsetsize, and filesize pass pointers. ftype will be returned as one of the DW_TYPE* values (see libdwarf.h). endian will be returned as one of the DW_END_* values, (see dwarf.h). filesize will be returned as the size of the file found in bytes. offsetsize will be returned as the a value of 32 or 64 as defined by the object format, but the meaning may vary by object format.

Now we turn to the arguments involved in MacOS dSYM processing: outpath, outpath_len, gl_pathnames, gl_pathcount, and pathsource. Usually one will pass all these as 0 and avoid special processing.

For MacOS dSym processing the gl_pathnames and gl_pathcount are not used, so pass them as 0.

To outpath pass in a pointer big enough to hold the passed-in path if that were doubled plus adding 100 characters. Then pass that length in the outpath_len argument. The path will be copied to outpath. For MacOS dSYM object files the final outpath of the dSYM file (with MacOS conventional directories added) is copied into outpath. Where the MacOS local directory tree is missing or incomplete outpath will be left as

a zero-length string.

The `errcode` pointer argument returns (if and only if `DW_DLV_ERROR` is returned by the function) an integer error code. At this time there is no handy function to turn that error code into a string. In the `libdwarf` source you will find that code in the `DW_DLE_*` error list.

6.2.3 `dwarf_object_detector_fd()`

```
int dwarf_object_detector_fd(int fd,
    unsigned *ftype,
    unsigned *endian,
    unsigned *offsetsize,
    Dwarf_Unsigned *filesize,
    int * errcode);
```

`dwarf_object_detector_fd()` is the same as `dwarf_object_detector_path()` except that no path strings apply to `dwarf_object_detector_fd()`.

6.3 Section Group Operations

The section group data is essential information when processing an object with COMDAT section group DWARF sections or with both split-dwarf (.dwo sections) and non-split dwarf sections.

It relies on Elf section groups, whereas some compilers rely instead on relocation information to identify section groups. These relocation-specified groupings are not understood at this time.

A standard DWARF2 or DWARF3 or DWARF4 object (Old Standard Object, or OSO) will not contain any of those new sections. The DWARF4 standard, Appendix E.1 "Using Compilation Units" offers an overview of COMDAT section groups. `libdwarf` assigns the group number one(1) to OSO DWARF. Any sections that are split dwarf (section name ending in .dwo or one of the two special DWP index sections) are assigned group number two(2) by `libdwarf`. COMDAT section groups are assigned groups numbers 3 and higher as needed.

The COMDAT section group uses are not well defined, but popular compilations systems are using such sections. There is no meaningful documentation that we can find (so far) on how the COMDAT section groups are used, so `libdwarf` is based on observations of what compilers generate.

6.3.1 `dwarf_sec_group_map()`

```
int dwarf_sec_group_map(  
    Dwarf_Debug      dbg,  
    Dwarf_Unsigned   map_entry_count,  
    Dwarf_Unsigned * group_numbers_array,  
    Dwarf_Unsigned * section_numbers_array,  
    const char      ** sec_names_array,  
    Dwarf_Error      * error)
```

The function may be called on any open Dwarf_Debug.

The caller must allocate map_entry_count arrays used in the following three arguments the and pass the appropriate pointer into the function as well as passing in map_entry_count itself.

The map entries returned cover all the DWARF related sections in the object though the selected_group value will dictate which of the sections in the Dwarf_Debug will actually be accessed via the usual libdwarf functions. That is, only sections in the selected group may be directly accessed though libdwarf may indirectly access sections in section group one(1) so relevant details can be accessed, such as abbreviation tables etc. Describing the details of this access outside the current selected_group goes beyond what this document covers (as of this writing).

It returns DW_DLV_OK on success and sets values into the user-allocated array elements (sorted by section number):

```
group_numbers_array[0]... group_numbers_array[map_entry_count-1]  
section_numbers_array[0]... section_numbers_array[map_entry_count-1]  
sec_names_array[0]... sec_names_array[map_entry_count-1]
```

group_numbers_array[0] for example is set to a group number. One(1), or two(2) or if there are COMDAT groups it will be three(3) or higher.

section_numbers_array[0] for example is set to a valid Elf section number relevant to DWARF (each section number shown will be greater than zero).

sec_names_array[0] for example is set to a pointer to a string containing the Elf section name of the Elf section number in sections_number_array[0].

On error the function will return DW_DLV_ERROR or DW_DLV_NO_ENTRY which indicates a serious problem with this object.

Here is an example of use of these functions.

```
void examplesecgroup(Dwarf_Debug dbg)
{
    int res = 0;
    Dwarf_Unsigned section_count = 0;
    Dwarf_Unsigned group_count;
    Dwarf_Unsigned selected_group = 0;
    Dwarf_Unsigned group_map_entry_count = 0;
    Dwarf_Unsigned *sec_nums = 0;
    Dwarf_Unsigned *group_nums = 0;
    const char ** sec_names = 0;
    Dwarf_Error error = 0;
    Dwarf_Unsigned i = 0;

    res = dwarf_sec_group_sizes(dbg, &section_count,
                               &group_count, &selected_group, &group_map_entry_count,
                               &error);
    if(res != DW_DLV_OK) {
        /* Something is badly wrong*/
        return;
    }
    /* In an object without split-dwarf sections
       or COMDAT sections we now have
       selected_group == 1. */
    sec_nums = calloc(group_map_entry_count, sizeof(Dwarf_Unsigned));
    if(!sec_nums) {
        /* FAIL. out of memory */
        return;
    }
    group_nums = calloc(group_map_entry_count, sizeof(Dwarf_Unsigned));
    if(!group_nums) {
        free(group_nums);
        /* FAIL. out of memory */
        return;
    }
    sec_names = calloc(group_map_entry_count, sizeof(char*));
    if(!sec_names) {
        free(group_nums);
        free(sec_nums);
        /* FAIL. out of memory */
        return;
    }

    res = dwarf_sec_group_map(dbg, group_map_entry_count,
                              group_nums, sec_nums, sec_names, &error);
    if(res != DW_DLV_OK) {
```



```
        /* FAIL. Something badly wrong. */
    }
    for( i = 0; i < group_map_entry_count; ++i) {
        /* Now do something with
           group_nums[i], sec_nums[i], sec_names[i] */
    }
    free(group_nums);
    free(sec_nums);
    /* The strings are in Elf data.
       Do not free() the strings themselves.*/
    free(sec_names);
}
```

6.4 Section size operations

These operations are informative but not normally needed.

6.4.1 dwarf_get_section_max_offsets_d()

```
int dwarf_get_section_max_offsets_d(Dwarf_debug dbg,
    Dwarf_Unsigned * debug_info_size,
    Dwarf_Unsigned * debug_abbrev_size,
    Dwarf_Unsigned * debug_line_size,
    Dwarf_Unsigned * debug_loc_size,
    Dwarf_Unsigned * debug_aranges_size,
    Dwarf_Unsigned * debug_macinfo_size,
    Dwarf_Unsigned * debug_pubnames_size,
    Dwarf_Unsigned * debug_str_size,
    Dwarf_Unsigned * debug_frame_size,
    Dwarf_Unsigned * debug_ranges_size,
    Dwarf_Unsigned * debug_typenames_size,
    Dwarf_Unsigned * debug_types_size,
    Dwarf_Unsigned * debug_macro_size,
    Dwarf_Unsigned * debug_str_offsets_size,
    Dwarf_Unsigned * debug_sup_size,
    Dwarf_Unsigned * debug_cu_index_size,
    Dwarf_Unsigned * debug_tu_index_size,
    Dwarf_Unsigned * debug_names_size,
    Dwarf_Unsigned * debug_loclists_size,
    Dwarf_Unsigned * debug_rnglists_size);
```

The function reports on the section sizes by pushing section size values back through the pointers. Null arguments are safe to pass in.

6.5 Printf Callbacks

This was new in August 2013.

The `dwarf_print_lines()` function is intended as a helper to programs like `dwarfdump` and show some line internal details in a way only the internals of `libdwarf` can show them. But using `printf` directly in `libdwarf` means the caller has limited control of where the output appears. So now the 'printf' output is passed back to the caller through a callback function whose implementation is provided by the caller.

Any code calling `libdwarf` can ignore the functions described in this section completely. If the functions are ignored the messages (if any) from `libdwarf` will simply not appear anywhere.

The `libdwarf.h` header file defines `struct Dwarf_Printf_Callback_Info_s` and `dwarf_register_printf_callback` for those `libdwarf` callers wishing to implement the callback. In this section we describe how one uses that interface. The applications `dwarfdump` and `dwarfdump2` are examples of how these may be used.

6.5.1 dwarf_print_lines()

```
int dwarf_print_lines(  
    Dwarf_Die die,  
    Dwarf_Error *error,  
    int *error_count)
```

Passing a compilation-unit DIE results `libdwarf` traversing the internals of the line table for the compilation unit and writing full details of the line table internals to the callback function registered to `libdwarf`, which is described next. It returns `f(CDW_DLV_NO_ENTRY)` if the `f(CDwarf_Die)` passed in has no `f(CDW_AT_stmt_list)` attribute.

If there is a serious error (such as corrupt DWARF) it may return `f(CDW_DLV_ERROR)`.

6.5.2 dwarf_register_printf_callback

```
struct Dwarf_Printf_Callback_Info_s  
dwarf_register_printf_callback(Dwarf_Debug dbg,  
    struct Dwarf_Printf_Callback_Info_s * newvalues);
```

The `dwarf_register_printf_callback()` function can only be called after the `Dwarf_Debug` instance has been initialized, the call makes no sense at other times. The function returns the current value of the structure. If `newvalues` is non-null then the passed-in values are used to initialize the `libdwarf` internal callback data (the values returned are the values before the `newvalues` are recorded). If `newvalues` is null no change is made to the `libdwarf` internal callback data.

6.5.3 Dwarf_Printf_Callback_Info_s

```
struct Dwarf_Printf_Callback_Info_s {  
    void *                dp_user_pointer;  
    dwarf_printf_callback_function_type dp_fptr;  
    char *                dp_buffer;  
    unsigned int          dp_buffer_len;  
    int                   dp_buffer_user_provided;  
    void *                dp_reserved;  
};
```

First we describe the fields as applicable in setting up for a call to `dwarf_register_printf_callback()`.

The field `dp_user_pointer` is remembered by libdwarf and passed back in any call libdwarf makes to the user's callback function. It is otherwise ignored by libdwarf.

The field `dp_fptr` is either NULL or a pointer to a user-implemented function.

If the field `dp_buffer_user_provided` is non-zero then `dp_buffer_len` and `dp_buffer` must be set by the user and libdwarf will use that buffer without doing any malloc of space. If the field `dp_buffer_user_provided` is zero then the input fields `dp_buffer_len` and `dp_buffer` are ignored by libdwarf and space is malloc'd as needed.

The field `dp_reserved` is ignored, it is reserved for future use.

When the structure is returned by `dwarf_register_printf_callback()` the values of the fields before the `dwarf_register_printf_callback()` call are returned.

6.5.4 dwarf_printf_callback_function_type

```
typedef void (* dwarf_printf_callback_function_type)(void * user_pointer,  
    const char * linecontent);
```

Any application using the callbacks needs to use the function `dwarf_register_printf_callback()` and supply a function matching the above function prototype from libdwarf.h.

6.5.5 Example of printf callback use in a C++ application using libdwarf

```
struct Dwarf_Printf_Callback_Info_s printfcallbackdata;  
    memset(&printfcallbackdata, 0, sizeof(printfcallbackdata));  
    printfcallbackdata.dp_fptr = printf_callback_for_libdwarf;  
    dwarf_register_printf_callback(dbg, &printfcallbackdata);
```

Assuming the user implements something like the following function in her application:

```
void  
printf_callback_for_libdwarf(void *userdata, const char *data)  
{  
    cout << data;  
}
```

It is crucial that the user's callback function copies or prints the data immediately. Once the user callback function returns the data pointer may change or become stale without warning.

6.6 Debugging Information Entry Delivery Operations

These functions are concerned with accessing debugging information entries, whether from a `.debug_info`, `.debug_types`, `.debug_info.dwo`, or `.debug_types.dwo`.

Since all such sections use similar formats, one set of functions suffices.

6.6.1 `dwarf_get_die_section_name()`

```
int  
dwarf_get_die_section_name(Dwarf_Debug dbg,  
    Dwarf_Bool is_info,  
    const char ** sec_name,  
    Dwarf_Error * error);
```

The function lets consumers access the object section name when no specific DIE is at hand. This is useful for applications wanting to print the name, but of course the object section name is not really a part of the DWARF information. Most applications will probably not call this function. It can be called at any time after the `Dwarf_Debug` initialization is done. See also `dwarf_get_die_section_name_b()`.

The function operates on either the `.debug_info[dwo]` section (if `is_info` is non-zero) or `.debug_types[dwo]` section (if `is_info` is zero).

If the function succeeds, `*sec_name` is set to a pointer to a string with the object section name and the function returns `DW_DLV_OK`. Do not free the string whose pointer is returned. For non-Elf objects it is possible the string pointer returned will be `NULL` or will point to an empty string. It is up to the calling application to recognize this possibility and deal with it appropriately.

If the section does not exist the function returns DW_DLV_NO_ENTRY.

If there is an internal error detected the function returns DW_DLV_ERROR and sets the *error pointer.

6.6.2 dwarf_get_die_section_name_b()

```
int
dwarf_get_die_section_name_b(Dwarf_Die die,
    const char ** sec_name,
    Dwarf_Error * error);
```

dwarf_get_die_section_name_b() lets consumers access the object section name when one has a DIE. This is useful for applications wanting to print the name, but of course the object section name is not really a part of the DWARF information. Most applications will probably not call this function. It can be called at any time after the Dwarf_Debug initialization is done. See also dwarf_get_die_section_name().

If the function succeeds, *sec_name is set to a pointer to a string with the object section name and the function returns DW_DLV_OK. Do not free the string whose pointer is returned. For non-Elf objects it is possible the string pointer returned will be NULL or will point to an empty string. It is up to the calling application to recognize this possibility and deal with it appropriately.

If the section does not exist the function returns DW_DLV_NO_ENTRY.

If there is an internal error detected the function returns DW_DLV_ERROR and sets the *error pointer.

6.6.3 dwarf_next_cu_header_d()

```
int dwarf_next_cu_header_d(
    Dwarf_debug dbg,
    Dwarf_Bool is_info,
    Dwarf_Unsigned *cu_header_length,
    Dwarf_Half *version_stamp,
    Dwarf_Unsigned *abbrev_offset,
    Dwarf_Half *address_size,
    Dwarf_Half *offset_size,
    Dwarf_Half *extension_size,
    Dwarf_Sig8 *signature,
    Dwarf_Unsigned *typeoffset,
    Dwarf_Unsigned *next_cu_header,
    Dwarf_Half *header_cu_type,
    Dwarf_Error *error);
```

The function operates on the either the .debug_info section (if is_info is non-zero) or

.debug_types section (if `is_info` is zero). Only DWARF4 allows a .debug_types section.

The function returns `DW_DLV_ERROR` if it fails, and `DW_DLV_OK` if it succeeds. It returns `DW_DLV_NO_ENTRY` when there are no more compilation units in the object file

If it succeeds, `*next_cu_header` is set to the offset in the .debug_info section of the next compilation-unit header if it succeeds. On reading the last compilation-unit header in the .debug_info section it contains the size of the .debug_info or debug_types section.

Beginning 22 April 2019 `next_cu_header` and indeed all the arguments following `is_info` may be passed as `NULL` (0) if one is not interested in the value.

The next call to `dwarf_next_cu_header_d()` returns `DW_DLV_NO_ENTRY` without reading a compilation-unit or setting `*next_cu_header`. Subsequent calls to `dwarf_next_cu_header()` repeat the cycle by reading the first compilation-unit and so on.

The other values returned through pointers are the values in the compilation-unit header.

`cu_header_length` returns the length in bytes of the compilation unit header.

`version_stamp` returns the section version, which would be (for .debug_info) 2 for DWARF2, 3 for DWARF3, 4 for DWARF4, or 5 for DWARF5..

`abbrev_offset` returns the .debug_abbrev section offset of the abbreviations for this compilation unit.

`address_size` returns the size of an address in this compilation unit. Which is usually 4 or 8.

`offset_size` returns the size in bytes of an offset for the compilation unit. The offset size is 4 for 32bit dwarf and 8 for 64bit dwarf. This is the offset size in dwarf data, not the address size inside the executable code. The offset size can be 4 even if embedded in a 64bit elf file (which is normal for 64bit elf), and can be 8 even in a 32bit elf file (which probably will never be seen in practice).

The `extension_size` pointer is only relevant if the `offset_size` pointer returns 8. The value is not normally useful but is returned through the pointer for completeness. The pointer `extension_size` returns 0 if the CU is MIPS/IRIX non-standard 64bit dwarf (MIPS/IRIX 64bit dwarf was created years before DWARF3 defined 64bit dwarf) and returns 4 if the dwarf uses the standard 64bit extension (the 4 is the size in bytes of the 0xffffffff in the initial length field which indicates the following 8 bytes in the .debug_info section are the real length). See the DWARF3 or DWARF4 standard, section 7.4.

The `signature` pointer is only relevant if the CU has a type signature, and if relevant the 8 byte type signature of the .debug_types CU header is assigned through the pointer.

The `typeoffset` pointer is only relevant the CU has a type signature if relevant the local offset within the CU of the the type offset the .debug_types entry represents is assigned through the pointer. The `typeoffset` matters because a `DW_AT_type`

referencing the type unit may reference an inner type, such as a C++ class in a C++ namespace, but the type itself has the enclosing namespace in the `.debug_type` `type_unit`.

The `header_cu_type` pointer is applicable to all CU headers. The value returned through the pointer is either `DW_UT_compile` `DW_UT_partial` `DW_UT_type` and identifies the header type of this CU. In DWARF4 a `DW_UT_type` will be in `.debug_types`, but in DWARF5 these compilation units are in `.debug_info` and the Debug Fission (ie Split Dwarf) `.debug_info.dwo` sections.

6.6.4 `dwarf_siblingof_b()`

```
int dwarf_siblingof_b(  
    Dwarf_Debug dbg,  
    Dwarf_Die die,  
    Dwarf_Bool is_info,  
    Dwarf_Die *return_sib,  
    Dwarf_Error *error)
```

The function returns `DW_DLV_ERROR` and sets the error pointer on error. If there is no sibling it returns `DW_DLV_NO_ENTRY`. When it succeeds, `dwarf_siblingof_b()` returns `DW_DLV_OK` and sets `*return_sib` to the `Dwarf_Die` descriptor of the sibling of `die`.

If `is_info` is non-zero then the `die` is assumed to refer to a `.debug_info` DIE. If `is_info` is zero then the `die` is assumed to refer to a `.debug_types` DIE. Note that the first call (the call that gets the compilation-unit DIE in a compilation unit) passes in a `NULL` `die` so having the caller pass in `is_info` is essential. And if `die` is non-`NULL` it is still essential for the call to pass in `is_info` set properly to reflect the section the DIE came from. The function `dwarf_get_die_infotypes_flag()` is of interest as it returns the proper `is_info` value from any non-`NULL` `die` pointer.

If `die` is `NULL`, the `Dwarf_Die` descriptor of the first die in the compilation-unit is returned. This die has the `DW_TAG_compile_unit`, `DW_TAG_partial_unit`, or `DW_TAG_type_unit` tag.

Figure 11. Example4 `dwarf_siblingof_b()`

```
void example4(Dwarf_Debug dbg,Dwarf_Die in_die,Dwarf_Bool is_info)
{
    Dwarf_Die return_sib = 0;
    Dwarf_Error error = 0;
    int res = 0;

    /* in_die might be NULL or a valid Dwarf_Die */
    res = dwarf_siblingof_b(dbg,in_die,is_info,&return_sib, &error);
    if (res == DW_DLV_OK) {
        /* Use return_sib here. */
        dwarf_dealloc_die(return_sib);
        /* This original form still works.
           dwarf_dealloc(dbg, return_sib, DW_DLA_DIE);
        */
        /* return_sib is no longer usable for anything, we
           ensure we do not use it accidentally with: */
        return_sib = 0;
    }
}
```

6.6.5 dwarf_child()

```
int dwarf_child(
    Dwarf_Die die,
    Dwarf_Die *return_kid,
    Dwarf_Error *error)
```

The function returns DW_DLV_ERROR and sets the error die on error. If there is no child it returns DW_DLV_NO_ENTRY. When it succeeds, dwarf_child() returns DW_DLV_OK and sets *return_kid to the Dwarf_Die descriptor of the first child of die. The function dwarf_siblingof() can be used with the return value of dwarf_child() to access the other children of die.

Figure 12. Example5 dwarf_child()


```
void example5(Dwarf_Die in_die)
{
    Dwarf_Die return_kid = 0;
    Dwarf_Error error = 0;
    int res = 0;

    res = dwarf_child(in_die, &return_kid, &error);
    if (res == DW_DLV_OK) {
        /* Use return_kid here. */
        dwarf_dealloc_die(return_kid);
        /* The original form of dealloc still works
           dwarf_dealloc(dbg, return_kid, DW_DLA_DIE);
           */
        /* return_die is no longer usable for anything, we
           ensure we do not use it accidentally with: */
        return_kid = 0;
    }
}
```

6.6.6 dwarf_offdie_b()

```
int dwarf_offdie_b(
    Dwarf_Debug dbg,
    Dwarf_Off offset,
    Dwarf_Bool is_info,
    Dwarf_Die *return_die,
    Dwarf_Error *error)
```

The function returns DW_DLV_ERROR and sets the error die on error. When it succeeds, dwarf_offdie_b() returns DW_DLV_OK and sets *return_die to the Dwarf_Die descriptor of the debugging information entry at offset in the section containing debugging information entries i.e the .debug_info section. A return of DW_DLV_NO_ENTRY means that the offset in the section is of a byte containing all 0 bits, indicating that there is no abbreviation code. Meaning this 'die offset' is not the offset of a real die, but is instead an offset of a null die, a padding die, or of some random zero byte: this should not be returned in normal use.

It is the user's responsibility to make sure that offset is the start of a valid debugging information entry. The result of passing it an invalid offset could be chaos.

If is_info is non-zero the offset must refer to a .debug_info section offset. If is_info zero the offset must refer to a .debug_types section offset. Error returns or misleading values may result if the is_info flag or the offset value are incorrect.

Figure 13. Example6 dwarf_offdie_b()

```
void example6(Dwarf_Debug dbg,Dwarf_Off die_offset,Dwarf_Bool is_info)
{
    Dwarf_Error error = 0;
    Dwarf_Die return_die = 0;
    int res = 0;

    res = dwarf_offdie_b(dbg,die_offset,is_info,&return_die, &error);
    if (res == DW_DLV_OK) {
        /* Use return_die here. */
        dwarf_dealloc_die(return_die);
        /* The original form still works:
           dwarf_dealloc(dbg, return_die, DW_DLA_DIE);
        */
        /* return_die is no longer usable for anything, we
           ensure we do not use it accidentally with: */
        return_die = 0;
    } else {
        /* res could be NO ENTRY or ERROR, so no
           dealloc necessary. */
    }
}
```

6.6.7 dwarf_validate_die_sibling()

```
int dwarf_validate_die_sibling(
    Dwarf_Die sibling,
    Dwarf_Off *offset)
```

When used correctly in a depth-first walk of a DIE tree this function validates that any DW_AT_sibling attribute gives the same offset as the direct tree walk. That is the only purpose of this function.

The function returns DW_DLV_OK if the last die processed in a depth-first DIE tree walk was the same offset as generated by a call to dwarf_siblingof(). Meaning that the DW_AT_sibling attribute value, if any, was correct.

If the conditions are not met then DW_DLV_ERROR is returned and *offset is set to the offset in the .debug_info section of the last DIE processed. If the application prints the offset a knowledgeable user may be able to figure out what the compiler did wrong.

6.7 Debugging Information Entry Query Operations

These queries return specific information about debugging information entries or a descriptor that can be used on subsequent queries when given a Dwarf_Die descriptor. Note that some operations are specific to debugging information entries that are represented by a Dwarf_Die descriptor of a specific type. For example, not all debugging information entries contain an attribute having a name, so consequently, a call

to `dwarf_diename()` using a `Dwarf_Die` descriptor that does not have a name attribute will return `DW_DLV_NO_ENTRY`. This is not an error, i.e. calling a function that needs a specific attribute is not an error for a die that does not contain that specific attribute.

There are several methods that can be used to obtain the value of an attribute in a given die:

1. Call `dwarf_hasattr()` to determine if the debugging information entry has the attribute of interest prior to issuing the query for information about the attribute.
2. Supply an `error` argument, and check its value after the call to a query indicates an unsuccessful return, to determine the nature of the problem. The `error` argument will indicate whether an error occurred, or the specific attribute needed was missing in that die.
3. Arrange to have an error handling function invoked upon detection of an error (see `dwarf_init_b()`).
4. Call `dwarf_attrlist()` and iterate through the returned list of attributes, dealing with each one as appropriate.

6.7.1 `dwarf_get_die_infotypes_flag()`

`Dwarf_Bool dwarf_get_die_infotypes_flag(Dwarf_Die die)`

The function returns the section flag indicating which section the DIE originates from. If the returned value is non-zero the DIE originates from the `.debug_info` section. If the returned value is zero the DIE originates from the `.debug_types` section.

6.7.2 `dwarf_cu_header_basics()`

```
int dwarf_cu_header_basics(Dwarf_Die die
    Dwarf_Half *version,
    Dwarf_Bool *is_info,
    Dwarf_Bool *is_dwo,
    Dwarf_Half *offset_size,
    Dwarf_Half *address_size,
    Dwarf_Half *extension_size,
    Dwarf_Sig8 **signature,
    Dwarf_Off *offset_of_length,
    Dwarf_Unsigned *total_byte_length,
    Dwarf_Error *error)
```

On success, the function `cu_header_basics()` various data items from the CU

header and the CU die passed in. Any return-value pointer may be passed in as NULL, indicating that the value is not needed.

Summing `offset_size` and `extension_size` gives the length of the CU length field, which is immediately followed by the CU header.

`is_dwo` field will surely always be 0 as `dwo/dwp.debug_info` cannot be skeleton CUs.

The signature value is returned if there a signature in the DWARF5 CU header or the CU die.

The `offset_of_length` returned is the offset of the first byte of the length field of the CU.

The `total_byte_Length` returned is the length of data in the CU counting from the first byte at `offset_of_length`.

6.7.3 dwarf_tag()

```
int dwarf_tag(  
    Dwarf_Die die,  
    Dwarf_Half *tagval,  
    Dwarf_Error *error)
```

The function returns the tag of `die` through the pointer `tagval` if it succeeds. It returns `DW_DLV_OK` if it succeeds. It returns `DW_DLV_ERROR` on error.

6.7.4 dwarf_dieoffset()

```
int dwarf_dieoffset(  
    Dwarf_Die die,  
    Dwarf_Off * return_offset,  
    Dwarf_Error *error)
```

When it succeeds, the function `dwarf_dieoffset()` returns `DW_DLV_OK` and sets `*return_offset` to the position of `die` in the section containing debugging information entries (the `return_offset` is a section-relative offset). In other words, it sets `return_offset` to the offset of the start of the debugging information entry described by `die` in the section containing dies i.e `.debug_info`. It returns `DW_DLV_ERROR` on error.

6.7.5 dwarf_addr_form_is_indexed()

`dwarf_addr_form_is_indexed(form)` is a utility function to make it simple to determine if a form is one of the indexed forms (there are several such in DWARF5). See DWARF5 section 7.5.5 `Classes and Forms` for more information.

```
int dwarf_addr_form_is_indexed(Dwarf_Half form);
```

It returns TRUE if the form is one of the indexed address forms (such as DW_FORM_addrx1) and FALSE otherwise.

6.7.6 dwarf_debug_addr_index_to_addr()

```
int dwarf_debug_addr_index_to_addr(Dwarf_Die /*die*/,  
    Dwarf_Unsigned index,  
    Dwarf_Addr *return_addr,  
    Dwarf_Error *error);
```

Attributes with form DW_FORM_addrx, the operation DW_OP_addrx, or certain of the split-dwarf location list entries give an index value to a machine address in the .debug_addr section (which is always in .debug_addr even when the form/operation are in a split dwarf .dwo section).

On successful return this function turns such an index into a target address value through the pointer return_addr .

If there is an error this may return DW_DLV_ERROR and it will have returned an error through *error.

If there is no available .debug_addr section this may return DW_DLV_NO_ENTRY.

6.7.7 dwarf_die_CU_offset()

```
int dwarf_die_CU_offset(  
    Dwarf_Die die,  
    Dwarf_Off *return_offset,  
    Dwarf_Error *error)
```

The function is similar to dwarf_dieoffset(), except that it puts the offset of the DIE represented by the Dwarf_Die die, from the start of the compilation-unit that it belongs to rather than the start of .debug_info (the return_offset is a CU-relative offset).

6.7.8 dwarf_die_offsets()

```
int dwarf_die_offsets(  
    Dwarf_Die die,  
    Dwarf_Off *global_off,  
    Dwarf_Off *cu_off,  
    Dwarf_Error *error)
```

The function is a combination of dwarf_dieoffset() and dwarf_die_cu_offset() in that it returns both the global .debug_info offset and the CU-relative offset of the die in a single call.

6.7.9 dwarf_CU_dieoffset_given_die()

```
int dwarf_CU_dieoffset_given_die(  
    Dwarf_Die given_die,  
    Dwarf_Off *return_offset,  
    Dwarf_Error *error)
```

The function is similar to `dwarf_die_CU_offset()`, except that it puts the global offset of the CU DIE owning `given_die` of `.debug_info` (the `return_offset` is a global section offset).

This is useful when processing a DIE tree and encountering an error or other surprise in a DIE, as the `return_offset` can be passed to `dwarf_offdie_b()` to return a pointer to the CU die of the CU owning the `given_die` passed to `dwarf_CU_dieoffset_given_die()`. The consumer can extract information from the CU die and the `given_die` (in the normal way) and print it.

An example (a snippet) of code using this function follows. It assumes that `in_die` is a DIE in `.debug_info` that, for some reason, you have decided needs CU context printed (assuming `print_die_data` does some reasonable printing).

Figure 14. Example7 `dwarf_CU_dieoffset_given_die()`

```
void example7(Dwarf_Debug dbg, Dwarf_Die in_die, Dwarf_Bool is_info)  
{  
    int res = 0;  
    Dwarf_Off cudieoff = 0;  
    Dwarf_Die cudie = 0;  
    Dwarf_Error error = 0;  
  
    res = dwarf_CU_dieoffset_given_die(in_die, &cudieoff, &error);  
    if(res != DW_DLV_OK) {  
        /* FAIL */  
        return;  
    }  
    res = dwarf_offdie_b(dbg, cudieoff, is_info, &cudie, &error);  
    if(res != DW_DLV_OK) {  
        /* FAIL */  
        return;  
    }  
    /* do something with cu_die */  
    dwarf_dealloc_die(cudie);  
    /* The original form still works.  
       dwarf_dealloc(dbg, cudie, DW_DLA_DIE);  
    */  
}  
y
```

6.7.10 dwarf_find_die_given_sig8()

```
int dwarf_find_die_given_sig8(Dwarf_Dbg dbg,
    Dwarf_Sig8 *ref,
    Dwarf_Die *die_found,
    Dwarf_Bool *is_info,
    Dwarf_Error *error)
```

This is often a search for a DW_UT_split_type or a DW_UT_type.

On success it returns DW_DLV_OK and puts a pointer to the found target DIE into `die_found` and sets `is_info` to either TRUE (if the target is in `.debug_info`) or FALSE (if the target is in `.debug_types`).

Of course both DW_DLV_NO_ENTRY and DW_DLV_ERROR are possible returns with the side effects.

6.7.11 dwarf_die_CU_offset_range()

```
int dwarf_die_CU_offset_range(
    Dwarf_Die die,
    Dwarf_Off *cu_global_offset,
    Dwarf_Off *cu_length,
    Dwarf_Error *error)
```

The function `dwarf_die_CU_offset_range()` returns the offset of the beginning of the CU and the length of the CU. The offset and length are of the entire CU that this DIE is a part of. It is used by `dwarfdump` (for example) to check the validity of offsets. Most applications will have no reason to call this function.

6.7.12 dwarf_diename()

```
int dwarf_diename(
    Dwarf_Die die,
    char ** return_name,
    Dwarf_Error *error)
```

When it succeeds, the function `dwarf_diename()` returns DW_DLV_OK and sets `*return_name` to a pointer to a null-terminated string of characters that represents the name attribute (DW_AT_name) of `die`.

The storage pointed to by a successful return of `dwarf_diename()` should not be freed as the text is a string in static memory (for some error cases) or a string residing in a DWARF data section.

Up to March 2020 this document said that `dwarf_dealloc` with `DW_DLA_STRING` should be applied to the string returned through the pointer. That was always incorrect. However, doing the `dwarf_dealloc(dbg,xxx,DW_DLA_STRING)` that was previously called for does not result in any error (`dwarf_dealloc` avoids freeing strings like this).

It returns `DW_DLV_NO_ENTRY` if `die` does not have a name attribute. It returns `DW_DLV_ERROR` if an error occurred.

6.7.13 `dwarf_die_text()`

```
int dwarf_die_text(  
    Dwarf_Die die,  
    Dwarf_Half attrnum,  
    char ** return_name,  
    Dwarf_Error *error)
```

When it succeeds, the function `dwarf_die_text()` returns `DW_DLV_OK` and sets `*return_name` to a pointer to a null-terminated string of characters that represents a string-value attribute of `die` if an attribute `attrnum` is present.

The storage pointed to by a successful return of `dwarf_die_text()` must never be freed, the string is in the DWARF data and is not dynamically allocated.

As of March 2020 the description here has been corrected. `dwarf_dealloc()` should never have been applied to a string returned by `dwarf_die_text()`.

It returns `DW_DLV_NO_ENTRY` if `die` does not have the attribute `attrnum`. It returns `DW_DLV_ERROR` if an error occurred.

6.7.14 `dwarf_die_abbrev_code()`

```
int dwarf_die_abbrev_code( Dwarf_Die die)
```

The function returns the abbreviation code of the DIE. That is, it returns the abbreviation "index" into the abbreviation table for the compilation unit of which the DIE is a part. It cannot fail. No errors are possible. The pointer `die()` must not be NULL.

6.7.15 `dwarf_die_abbrev_children_flag()`

```
int dwarf_die_abbrev_children_flag( Dwarf_Die die,  
    Dwarf_Half *has_child)
```

The function returns the has-children flag of the `die` passed in through the `*has_child` passed in and returns `DW_DLV_OK` on success. A non-zero value of `*has_child` means the `die` has children.

On failure it returns `DW_DLV_ERROR`.

The function was developed to let consumer code do better error reporting in some circumstances, it is not generally needed.

6.7.16 dwarf_die_abbrev_global_offset()

```
int dwarf_die_abbrev_global_offset(Dwarf_Die die,  
    Dwarf_Off * abbrev_offset,  
    Dwarf_Unsigned * abbrev_count,  
    Dwarf_Error* error);
```

The function allows more detailed printing of abbreviation data. It is handy for analyzing abbreviations but is not normally needed by applications. The function first appears in March 2016.

On success the function returns DW_DLV_OK and sets *abbrev_offset to the global offset in the .debug_abbrev section of the abbreviation. It also sets *abbrev_count to the number of attribute/form pairs in the abbreviation entry. It is possible, though unusual, for the count to be zero (meaning there is abbreviation instance and a TAG instance which have no attributes).

On failure it returns DW_DLV_ERROR and sets *error

It should never return DW_DLV_NO_ENTRY, but callers should allow for that possibility..

6.7.17 dwarf_get_version_of_die()

```
int dwarf_get_version_of_die(Dwarf_Die die,  
    Dwarf_Half *version,  
    Dwarf_Half *offset_size)
```

The function returns the CU context version through *version and the CU context offset-size through *offset_size and returns DW_DLV_OK on success.

In case of error, the only errors possible involve an inappropriate NULL die pointer so no Dwarf_Debug pointer is available. Therefore setting a Dwarf_Error would not be very meaningful (there is no Dwarf_Debug to attach it to). The function returns DW_DLV_ERROR on error.

The values returned through the pointers are the values two arguments to dwarf_get_form_class() requires.

6.7.18 dwarf_attrlist()

```
int dwarf_attrlist(  
    Dwarf_Die die,  
    Dwarf_Attribute** attrbuf,  
    Dwarf_Signed *attrcount,  
    Dwarf_Error *error)
```

When it returns DW_DLV_OK, the function dwarf_attrlist() sets attrbuf to point to an array of Dwarf_Attribute descriptors corresponding to each of the attributes in die, and returns the number of elements in the array through attrcount.

DW_DLV_NO_ENTRY is returned if the count is zero (no attrbuf is allocated in this case). DW_DLV_ERROR is returned on error. On a successful return from dwarf_attrlist(), each of the Dwarf_Attribute descriptors should be individually freed using dwarf_dealloc() with the allocation type DW_DLA_ATTR, followed by free-ing the list pointed to by *attrbuf using dwarf_dealloc() with the allocation type DW_DLA_LIST, when no longer of interest (see dwarf_dealloc()).

Freeing the attrlist:

Figure 15. Example8 dwarf_attrlist() free

```
void example8(Dwarf_Debug dbg, Dwarf_Die somedie)
{
    Dwarf_Signed atcount = 0;
    Dwarf_Attribute *atlist = 0;
    Dwarf_Error error = 0;
    int errv = 0;

    errv = dwarf_attrlist(somedie, &atlist, &atcount, &error);
    if (errv == DW_DLV_OK) {
        Dwarf_Signed i = 0;

        for (i = 0; i < atcount; ++i) {
            /* use atlist[i] */
            dwarf_dealloc_attribute(atlist[i]);
            /* The original form still works.
               dwarf_dealloc(dbg, atlist[i], DW_DLA_ATTR);
            */
        }
        dwarf_dealloc(dbg, atlist, DW_DLA_LIST);
    }
}
```

6.7.19 dwarf_hasattr()

```
int dwarf_hasattr(
    Dwarf_Die die,
    Dwarf_Half attr,
    Dwarf_Bool *return_bool,
    Dwarf_Error *error)
```

When it succeeds, the function dwarf_hasattr() returns DW_DLV_OK and sets *return_bool to *non-zero* if die has the attribute attr and *zero* otherwise. If it fails, it returns DW_DLV_ERROR.

6.7.20 dwarf_attr()

```
int dwarf_attr(  
    Dwarf_Die die,  
    Dwarf_Half attr,  
    Dwarf_Attribute *return_attr,  
    Dwarf_Error *error)
```

When it returns DW_DLV_OK, the function dwarf_attr() sets *return_attr to the Dwarf_Attribute descriptor of die having the attribute attr. When one no longer needs the attribute call dwarf_dealloc_attribute(return_attr).

It returns DW_DLV_NO_ENTRY if attr is not contained in die.

It returns DW_DLV_ERROR and sets the *error argument if an error occurred.

6.7.21 dwarf_lowpc()

```
int dwarf_lowpc(  
    Dwarf_Die die,  
    Dwarf_Addr * return_lowpc,  
    Dwarf_Error * error)
```

The function dwarf_lowpc() returns DW_DLV_OK and sets *return_lowpc to the low program counter value associated with the die descriptor if die represents a debugging information entry with the DW_AT_low_pc attribute. It returns DW_DLV_NO_ENTRY if die does not have this attribute. It returns DW_DLV_ERROR if an error occurred.

6.7.22 dwarf_highpc_b()

```
int dwarf_highpc_b(  
    Dwarf_Die die,  
    Dwarf_Addr * return_highpc,  
    Dwarf_Half * return_form/,  
    enum Dwarf_Form_Class * return_class*/,  
    Dwarf_Error *error)
```

The function dwarf_highpc_b() returns DW_DLV_OK and sets *return_highpc to the value of the DW_AT_high_pc attribute.

It also sets *return_form to the FORM of the attribute. Beginning 22 April 2019 return_form will not be used to return the form class if return_form is null. Be cautious using a null argument unless you know that only a suitably recent version of libdwarf will be used.

It sets *return_class to the form class of the attribute. Beginning 22 April 2019 return_class will not be used to return the form class if return_class is null. Be cautious using a null argument unless you know that only a suitably recent version of

libdwarf will be used.

If the form class returned is DW_FORM_CLASS_ADDRESS the return_highpc is an actual pc address (1 higher than the address of the last pc in the address range).. If the form class returned is DW_FORM_CLASS_CONSTANT the return_highpc is an offset from the value of the the DIE's low PC address (see DWARF4 section 2.17.2 Contiguous Address Range).

It returns DW_DLV_NO_ENTRY if die does not have the DW_AT_high_pc attribute.

It returns DW_DLV_ERROR if an error occurred.

6.7.23 dwarf_dietype_offset()

```
int dwarf_dietype_offset(Dwarf_Die /*die*/,
    Dwarf_Off * /*return_off*/,
    Dwarf_Error * /*error*/);
```

On success the function dwarf_dietype_offset() returns the section global offset referred to by DW_AT_type attribute of die. The Attribute used is DW_AT_type so unless the form is DW_FORM_reg_sig8 (which is not handled here by libdwarf at this time) the offset is in the same section as 'die'.

DW_DLV_NO_ENTRY is returned and *return_off is set to zero if the die has no DW_AT_type attribute.

DW_DLV_ERROR is returned and *return_off is set to zero if an error is detected.

This feature was introduced in February 2016.

6.7.24 dwarf_offset_list()

```
int dwarf_offset_list(Dwarf_Debug dbg,
    Dwarf_Off offset,
    Dwarf_Bool is_info,
    Dwarf_Off ** offbuf,
    Dwarf_Unsigned * offcnt,
    Dwarf_Error * error);
```

On success The function dwarf_offset_list() returns DW_DLV_OK and sets *offbuf to point to an array of the offsets of the direct children of the die at offset. It sets *offcnt to point to the count of entries in the offset array

In case of error it returns DW_DLV_OK.

It does not return DW_DLV_NO_ENTRY but callers should allow for that possibility anyway.

This feature was introduced in March 2016.

Freeing the offset_list is done as follows.:

Figure 16. Exampleoffset_list dwarf_offset_list() free

```
void exampleoffset_list(Dwarf_Debug dbg, Dwarf_Off dieoffset,
    Dwarf_Bool is_info)
{
    Dwarf_Unsigned offcnt = 0;
    Dwarf_Off *offbuf = 0;
    Dwarf_Error error = 0;
    int errv = 0;

    errv = dwarf_offset_list(dbg, dieoffset, is_info,
        &offbuf, &offcnt, &error);
    if (errv == DW_DLV_OK) {
        Dwarf_Unsigned i = 0;

        for (i = 0; i < offcnt; ++i) {
            /* use offbuf[i] */
        }
        dwarf_dealloc(dbg, offbuf, DW_DLA_LIST);
    }
}
```

6.7.25 dwarf_bytesize()

```
Dwarf_Signed dwarf_bytesize(
    Dwarf_Die      die,
    Dwarf_Unsigned *return_size,
    Dwarf_Error     *error)
```

When it succeeds, dwarf_bytesize() returns DW_DLV_OK and sets *return_size to the number of bytes needed to contain an instance of the aggregate debugging information entry represented by die. It returns DW_DLV_NO_ENTRY if die does not contain the byte size attribute DW_AT_byte_size. It returns DW_DLV_ERROR if an error occurred.

6.7.26 dwarf_bitsize()

```
int dwarf_bitsize(
    Dwarf_Die die,
    Dwarf_Unsigned *return_size,
    Dwarf_Error *error)
```

When it succeeds, `dwarf_bitsize()` returns `DW_DLV_OK` and sets `*return_size` to the number of bits occupied by the bit field value that is an attribute of the given die. It returns `DW_DLV_NO_ENTRY` if die does not contain the bit size attribute `DW_AT_bit_size`. It returns `DW_DLV_ERROR` if an error occurred.

6.7.27 dwarf_bitoffset()

```
int dwarf_bitoffset(Dwarf_Die die,
                   Dwarf_Half *attrnum,
                   Dwarf_Unsigned *return_size,
                   Dwarf_Error *error)
```

When it succeeds, `dwarf_bitoffset()` returns `DW_DLV_OK` and sets `*return_size` to the number of bits to the left of the most significant bit of the bit field value. This bit offset is not necessarily the net bit offset within the structure or class, since `DW_AT_data_member_location` may give a byte offset to this DIE and the bit offset returned through the pointer does not include the bits in the byte offset.

The `attrnum` argument returns the actual attribute number that applies to the bit offset. When the value is from `DW_AT_bitoffset` the meaning is as defined in DWARF2 and DWARF3. When the value is from `DW_AT_data_bit_offset` the meaning is as defined in DWARF4 and DWARF5.

It returns `DW_DLV_NO_ENTRY` if die does not contain the bit offset attribute `DW_AT_bit_offset`. It returns `DW_DLV_ERROR` if an error occurred.

6.7.28 dwarf_srclang()

```
int dwarf_srclang(
    Dwarf_Die die,
    Dwarf_Unsigned *return_lang,
    Dwarf_Error *error)
```

When it succeeds, `dwarf_srclang()` returns `DW_DLV_OK` and sets `*return_lang` to a code indicating the source language of the compilation unit represented by the descriptor die. It returns `DW_DLV_NO_ENTRY` if die does not represent a source file debugging information entry (i.e. contain the attribute `DW_AT_language`). It returns `DW_DLV_ERROR` if an error occurred.

6.7.29 dwarf_arrayorder()

```
int dwarf_arrayorder(
    Dwarf_Die die,
    Dwarf_Unsigned *return_order,
    Dwarf_Error *error)
```

When it succeeds, `dwarf_arrayorder()` returns `DW_DLV_OK` and sets

`*return_order` a code indicating the ordering of the array represented by the descriptor `die`.

It returns `DW_DLV_NO_ENTRY` if `die` does not contain the array order attribute `DW_AT_ordering`.

It returns `DW_DLV_ERROR` if an error occurred.

6.8 Attribute Queries

Based on the attributes form, these operations are concerned with returning uninterpreted attribute data. Since it is not always obvious from the return value of these functions if an error occurred, one should always supply an `error` parameter or have arranged to have an error handling function invoked (see `dwarf_init_b()`) to determine the validity of the returned value and the nature of any errors that may have occurred.

A `Dwarf_Attribute` descriptor describes an attribute of a specific `die`. Thus, each `Dwarf_Attribute` descriptor is implicitly associated with a specific `die`.

6.8.1 dwarf_hasform()

```
int dwarf_hasform(  
    Dwarf_Attribute attr,  
    Dwarf_Half form,  
    Dwarf_Bool *return_hasform,  
    Dwarf_Error *error)
```

The function `dwarf_hasform()` returns `DW_DLV_OK` and puts a *non-zero* value in the `*return_hasform` boolean if the attribute represented by the `Dwarf_Attribute` descriptor `attr` has the attribute form `form`. If the attribute does not have that form *zero* is put into `*return_hasform`. `DW_DLV_ERROR` is returned on error.

6.8.2 dwarf_whatform()

```
int dwarf_whatform(  
    Dwarf_Attribute attr,  
    Dwarf_Half *return_form,  
    Dwarf_Error *error)
```

When it succeeds, `dwarf_whatform()` returns `DW_DLV_OK` and sets `*return_form` to the attribute form code of the attribute represented by the `Dwarf_Attribute` descriptor `attr`. It returns `DW_DLV_ERROR` on error.

An attribute using `DW_FORM_indirect` effectively has two forms. This function returns the 'final' form for `DW_FORM_indirect`, not the `DW_FORM_indirect` itself. This function is what most applications will want to call.

6.8.3 dwarf_whatform_direct()

```
int dwarf_whatform_direct(  
    Dwarf_Attribute attr,  
    Dwarf_Half      *return_form,  
    Dwarf_Error *error)
```

When it succeeds, `dwarf_whatform_direct()` returns `DW_DLV_OK` and sets `*return_form` to the attribute form code of the attribute represented by the `Dwarf_Attribute` descriptor `attr`. It returns `DW_DLV_ERROR` on error. An attribute using `DW_FORM_indirect` effectively has two forms. This returns the form 'directly' in the initial form field. That is, it returns the 'initial' form of the attribute.

So when the form field is `DW_FORM_indirect` this call returns the `DW_FORM_indirect` form, which is sometimes useful for dump utilities.

It is confusing that the `_direct()` function returns `DW_FORM_indirect` if an indirect form is involved. Just think of this as returning the initial form the first form value seen for the attribute, which is also the final form unless the initial form is `DW_FORM_indirect`.

6.8.4 dwarf_whatattr()

```
int dwarf_whatattr(  
    Dwarf_Attribute attr,  
    Dwarf_Half      *return_attr,  
    Dwarf_Error *error)
```

When it succeeds, `dwarf_whatattr()` returns `DW_DLV_OK` and sets `*return_attr` to the attribute code represented by the `Dwarf_Attribute` descriptor `attr`. It returns `DW_DLV_ERROR` on error.

6.8.5 dwarf_attr_offset()

```
int dwarf_attr_offset(  
    Dwarf_Attribute attr,  
    Dwarf_Off      *return_offset,  
    Dwarf_Error *error)
```

When it succeeds, `dwarf_attr_offset()` returns `DW_DLV_OK` and sets `*return_offset` to the section offset of the offset represented by the `Dwarf_Attribute` descriptor `attr`. It returns `DW_DLV_ERROR` on error.

6.8.6 dwarf_formref()

```
int dwarf_formref(  
    Dwarf_Attribute attr,  
    Dwarf_Off      *return_offset,  
    Dwarf_Error *error)
```


When it succeeds, `dwarf_formref()` returns `DW_DLV_OK` and sets `*return_offset` to the CU-relative offset represented by the descriptor `attr` if the form of the attribute belongs to the `REFERENCE` class. `attr` must be a CU-local reference, not form `DW_FORM_ref_addr` and not `DW_FORM_sec_offset`. It is an error for the form to not belong to the `REFERENCE` class. It returns `DW_DLV_ERROR` on error.

Beginning November 2010: All `DW_DLV_ERROR` returns set `*return_offset`. Most errors set `*return_offset` to zero, but for error `DW_DLE_ATTR_FORM_OFFSET_BAD` the function sets `*return_offset` to the invalid offset (which allows the caller to print a more detailed error message).

6.8.7 dwarf_global_formref()

```
int dwarf_global_formref(  
    Dwarf_Attribute attr,  
    Dwarf_Off      *return_offset,  
    Dwarf_Error *error)
```

For DWARF4 this function does not suffice since the returned offset might be in `.debug_info` or in `.debug_types`. In particular the `DW_FORM_ref_sig8` signature in the DWARF4 case will normally refer from `.debug_info` to `.debug_types`. See the `offset_is_info` returned value of `dwarf_global_formref_b` below, that value is essential for fully reading DWARF4.

Otherwise is the same as `dwarf_global_formref_b()`.

6.8.8 dwarf_global_formref_b()

```
int dwarf_global_formref_b(  
    Dwarf_Attribute attr,  
    Dwarf_Off      *return_offset,  
    Dwarf_Bool * offset_is_info,  
    Dwarf_Error *error)
```

When it succeeds, `dwarf_global_formref_b()` returns `DW_DLV_OK` and sets `*return_offset` to the section-relative offset represented by the descriptor `attr` if the form of the attribute belongs to the `REFERENCE` or other section-references classes.

`attr` can be any legal `REFERENCE` class form plus `DW_FORM_ref_addr` or `DW_FORM_sec_offset`. It is an error for the form to not belong to one of the reference classes.

It returns `DW_DLV_NO_ENTRY` if it wants to resolve a `Dwarf_Sig8` signature but the target type cannot be located.

In DWARF4 the target type might be in `.debug_types`, and in that case `_offset_is_info` is set `FALSE`.

It returns DW_DLV_ERROR on error. See also dwarf_formref above.

The caller must determine which section the offset returned applies to. The function dwarf_get_form_class() is useful to determine the applicable section.

The function converts CU relative offsets from forms such as DW_FORM_ref4 into global section offsets.

6.8.9 dwarf_convert_to_global_offset()

```
int dwarf_convert_to_global_offset(  
    Dwarf_Attribute attr,  
    Dwarf_Off      offset,  
    Dwarf_Off      *return_offset,  
    Dwarf_Error    *error)
```

When it succeeds, dwarf_convert_to_global_offset() returns DW_DLV_OK and sets *return_offset to the section-relative offset represented by the cu-relative offset offset if the form of the attribute belongs to the REFERENCE class. attr must be a CU-local reference (DWARF class REFERENCE) or form DW_FORM_ref_addr and the attr must be directly relevant for the calculated *return_offset to mean anything.

The function returns DW_DLV_ERROR on error.

The function is not strictly necessary but may be a convenience for attribute printing in case of error.

6.8.10 dwarf_formaddr()

```
int dwarf_formaddr(  
    Dwarf_Attribute attr,  
    Dwarf_Addr      * return_addr,  
    Dwarf_Error     *error)
```

When it succeeds, dwarf_formaddr() returns DW_DLV_OK and sets *return_addr to the address represented by the descriptor attr if the form of the attribute belongs to the ADDRESS class. It is an error for the form to not belong to this class. It returns DW_DLV_ERROR on error.

One possible error that can arise (in a .dwo object file or a .dwp package file) is DW_DLE_MISSING_NEEDED_DEBUG_ADDR_SECTION. Such an error means that the .dwo or .dwp file is missing the .debug_addr section. When opening a .dwo object file or a .dwp package file one should also open the corresponding executable and use dwarf_set_tied_dbg() to associate the objects before calling dwarf_formaddr().

H 3 "dwarf_get_debug_addr_index()"

```
int dwarf_get_debug_addr_index(  
    Dwarf_Attribute attr,  
    Dwarf_Unsigned * return_index,  
    Dwarf_Error *error)
```

dwarf_get_debug_addr_index() is only valid on attributes with form DW_FORM_GNU_addr_index or DW_FORM_addrx.

The function makes it possible to print the index from a dwarf dumper program.

When it succeeds, dwarf_get_debug_addr_index() returns DW_DLV_OK and sets *return_index to the attribute's index (into the .debug_addr section).

It returns DW_DLV_ERROR on error.

6.8.11 dwarf_get_debug_str_index()

```
int dwarf_get_debug_str_index(  
    Dwarf_Attribute attr,  
    Dwarf_Unsigned * return_index,  
    Dwarf_Error * error);
```

For an attribute with form DW_FORM_strx or DW_FORM_GNU_str_index this function retrieves the index (which refers to a .debug_str_offsets section in this .dwo).

If successful, the function dwarf_get_debug_str_index() returns DW_DLV_OK and returns the index through the return_index() pointer.

If the passed in attribute does not have this form or there is no valid compilation unit context for the attribute the function returns DW_DLV_ERROR.

DW_DLV_NO_ENTRY is not returned.

6.8.12 dwarf_formflag()

```
int dwarf_formflag(  
    Dwarf_Attribute attr,  
    Dwarf_Bool * return_bool,  
    Dwarf_Error *error)
```

When it succeeds, dwarf_formflag() returns DW_DLV_OK and sets *return_bool to the (one unsigned byte) flag value. Any non-zero value means true. A zero value means false.

Before 29 November 2012 this would only return 1 or zero through the pointer, but that was always a strange thing to do. The DWARF specification has always been clear that any non-zero value means true. The function should report the value found truthfully, and now it does.

It returns DW_DLV_ERROR on error or if the attr does not have form flag.

6.8.13 dwarf_formudata()

```
int dwarf_formudata(  
    Dwarf_Attribute attr,  
    Dwarf_Unsigned * return_uvalue,  
    Dwarf_Error * error)
```

The function dwarf_formudata() returns DW_DLV_OK and sets *return_uvalue to the Dwarf_Unsigned value of the attribute represented by the descriptor attr if the form of the attribute belongs to the CONSTANT class and the value is non-negative (if the form is DW_FORM_sdata for example, but the value is non-negative, the non-negative value is returned).

If the data is definitely a signed type, the form will be DW_FORM_sdata.

It is an error for the form to not belong to class CONSTANT or (in case the FORM is a signed form) for the value to be negative. It returns DW_DLV_ERROR on error.

The function never returns DW_DLV_NO_ENTRY.

For DWARF2 and DWARF3, DW_FORM_data4 and DW_FORM_data8 are possibly class CONSTANT, and for DWARF4 and later they are definitely class CONSTANT.

6.8.14 dwarf_formsdata()

```
int dwarf_formsdata(  
    Dwarf_Attribute attr,  
    Dwarf_Signed * return_svalue,  
    Dwarf_Error *error)
```

The function dwarf_formsdata() returns DW_DLV_OK and sets *return_svalue to the Dwarf_Signed value of the attribute represented by the descriptor attr if the form of the attribute belongs to the CONSTANT class. It is an error for the form to not belong to this class. If the size of the data attribute referenced is smaller than the size of the Dwarf_Signed type, its value is sign extended. It returns DW_DLV_ERROR on error.

Never returns DW_DLV_NO_ENTRY.

For DWARF2 and DWARF3, DW_FORM_data4 and DW_FORM_data8 are possibly class CONSTANT, and for DWARF4 and later they are definitely class CONSTANT.

6.8.15 dwarf_formdata16()

```
int dwarf_formdata16(Dwarf_Attribute attr,  
    Dwarf_Form_data16 * return_value,  
    Dwarf_Error *error)
```

This enables access to a DW_FORM_data16 value. The FORM appeared in DWARF5.

On success it returns DW_DLV_OK and stores the bytes in the struct.

6.8.16 dwarf_formblock()

```
int dwarf_formblock(  
    Dwarf_Attribute attr,  
    Dwarf_Block ** return_block,  
    Dwarf_Error * error)
```

The function `dwarf_formblock()` returns DW_DLV_OK and sets `*return_block` to a pointer to a `Dwarf_Block` structure containing the value of the attribute represented by the descriptor `attr` if the form of the attribute belongs to the BLOCK class. It is an error for the form to not belong to this class. The storage pointed to by a successful return of `dwarf_formblock()` should be freed using the allocation type DW_DLA_BLOCK, when no longer of interest (see `dwarf_dealloc()`). It returns DW_DLV_ERROR on error.

6.8.17 dwarf_formstring()

```
int dwarf_formstring(  
    Dwarf_Attribute attr,  
    char ** return_string,  
    Dwarf_Error *error)
```

The function `dwarf_formstring()` returns DW_DLV_OK and sets `*return_string` to a pointer to a null-terminated string containing the value of the attribute represented by the descriptor `attr` if the form of the attribute belongs to the STRING class. It is an error for the form to not belong to this class.

The storage pointed to by a successful return of `dwarf_formstring()` should not be freed. The pointer points into existing DWARF memory and the pointer becomes stale/invalid after a call to `dwarf_finish`. `dwarf_formstring()` returns DW_DLV_ERROR on error.

6.8.18 dwarf_formsig8()

```
int dwarf_formsig8(  
    Dwarf_Attribute attr,  
    Dwarf_Sig8 * return_sig8,  
    Dwarf_Error * error)
```

Use with an attribute form DW_FORM_data8. The function dwarf_formsig8() returns DW_DLV_OK and copies the 8 byte signature to a Dwarf_Sig8 structure provided by the caller if the form of the attribute is of form DW_FORM_data8 (a member of the REFERENCE class). Before DWARF4 this was the only FORM that could be used for an 8-byte signature. Modern DWARF should use DW_FORM_ref_sig8 instead.

It returns DW_DLV_NO_ENTRY if the attribute form is not DW_FORM_data8.

It returns DW_DLV_ERROR on error.

6.8.19 dwarf_formsig8_const()

Use with an attribute form DW_FORM_ref_sig8.

```
int dwarf_formsig8_const(  
    Dwarf_Attribute attr,  
    Dwarf_Sig8 * return_sig8,  
    Dwarf_Error * error)
```

The function dwarf_formsig8() returns DW_DLV_OK and copies the 8 byte signature to a Dwarf_Sig8 structure provided by the caller if the form of the attribute is of form DW_FORM_ref_sig8 (a member of the REFERENCE class).

DW_FORM_ref_sig8 first appears in DWARF4.

It returns DW_DLV_NO_ENTRY if the attribute form is not DW_FORM_ref_sig8.

It returns DW_DLV_ERROR on error.

6.8.20 dwarf_formexprloc()

```
int dwarf_formexprloc(  
    Dwarf_Attribute attr,  
    Dwarf_Unsigned * return_exprlen,  
    Dwarf_Ptr * block_ptr,  
    Dwarf_Error * error)
```

The function dwarf_formexprloc() returns DW_DLV_OK and sets the two values thru the pointers to the length and bytes of the DW_FORM_exprloc entry if the form of the attribute is of form DW_FORM_exprloc.

It is an error for the form to be anything but DW_FORM_exprloc. It returns DW_DLV_ERROR on error.

On success the value set through the return_exprlen pointer is the length of the location expression. On success the value set through the block_ptr pointer is a

pointer to the bytes of the location expression itself.

6.8.21 dwarf_uncompress_integer_block_a()

```
int dwarf_uncompress_integer_block_a(Dwarf_Debug dbg,
    Dwarf_Unsigned    input_length_in_bytes,
    void              * input_block,
    Dwarf_Unsigned    * value_count,
    Dwarf_Signed      ** value_array,
    Dwarf_Error        * error)
```

This was contributed around 2007 for Sun Sparc but it is not clear any existing compiler does the sort of compression it assumes. Logically it is a block of integers, each having been converted to signed leb values. So this function expands the block to an array of Dwarf_Signed it allocates (value_array), with value_count entries, and returns DW_DLV_OK.

The attribute with a compressed block value is DW_AT_SUN_func_offsets and the form is DW_FORM_block.

It returns DW_DLV_ERROR on error.

It never returns DW_DLV_NO_ENTRY.

Use dwarf_dealloc_uncompressed_block() (below) to dealloc(free) the space allocated.

6.8.22 dwarf_dealloc_uncompressed_block()

```
int dwarf_dealloc_uncompressed_block(Dwarf_Debug dbg,
    void *space)
```

Frees (deallocs) a block that dwarf_uncompress_integer_block_a() returned.

6.8.23 dwarf_get_form_class()

```
enum Dwarf_Form_Class dwarf_get_form_class(
    Dwarf_Half dwversion,
    Dwarf_Half attrnum,
    Dwarf_Half offset_size,
    Dwarf_Half form)
```

The function is just for the convenience of libdwarf clients that might wish to categorize the FORM of a particular attribute. The DWARF specification divides FORMs into classes in Chapter 7 and this function figures out the correct class for a form.

The dwversion passed in shall be the dwarf version of the compilation unit involved (2 for DWARF2, 3 for DWARF3, 4 for DWARF 4, 5 for DWARF5). The attrnum passed in shall be the attribute number of the attribute involved (for example, DW_AT_name). The offset_size passed in shall be the length of an offset in the current compilation

unit (4 for 32bit dwarf or 8 for 64bit dwarf). The form passed in shall be the attribute form number. If form DW_FORM_indirect is passed in DW_FORM_CLASS_UNKNOWN will be returned as this form has no defined 'class'.

When it returns DW_FORM_CLASS_UNKNOWN the function is simply saying it could not determine the correct class given the arguments presented. Some user-defined attributes might have this problem.

The function dwarf_get_version_of_die() may be helpful in filling out arguments for a call to dwarf_get_form_class().

6.8.24 dwarf_discr_list()

```
int dwarf_discr_list(  
    Dwarf_Debug dbg,  
    Dwarf_Small * blockpointer,  
    Dwarf_Unsigned blocklen,  
    Dwarf_Dsc_Head * dsc_head_out,  
    Dwarf_Unsigned * dsc_array_length_out,  
    Dwarf_Error * error)  
    Dwarf_Error *error)
```

When it succeeds, dwarf_discr_list() returns DW_DLV_OK and sets *dsc_head_out to a pointer to the discriminant information for the discriminant list and sets *dsc_array_length_out to the count of discriminant entries. The only current applicability is the block value of a DW_AT_discr_list attribute.

Those values are useful for calls to dwarf_discr_entry_u() or dwarf_discr_entry_s() to get the actual discriminant values. See the example below. It returns DW_DLV_NO_ENTRY if the block is empty. It returns DW_DLV_ERROR if an error occurred.

When the call was successful and the Dwarf_Dsc_Head is no longer needed, call dwarf_dealloc() to free all the space related to this.


```
void example_discr_list(Dwarf_Debug dbg,
    Dwarf_Die die,
    Dwarf_Attribute attr,
    Dwarf_Half attrnum,
    Dwarf_Bool isunsigned,
    Dwarf_Half theform,
    Dwarf_Error *err)
{
    /* The example here assumes that
       attribute attr is a DW_AT_discr_list.
       isunsigned should be set from the signedness
       of the parent of 'die' per DWARF rules for
       DW_AT_discr_list. */
    enum Dwarf_Form_Class fc = DW_FORM_CLASS_UNKNOWN;
    Dwarf_Half version = 0;
    Dwarf_Half offset_size = 0;
    int wres = 0;

    wres = dwarf_get_version_of_die(die,&version,&offset_size);
    if (wres != DW_DLV_OK) {
        /* FAIL */
        return;
    }
    fc = dwarf_get_form_class(version,attrnum,offset_size,theform);
    if (fc == DW_FORM_CLASS_BLOCK) {
        int fres = 0;
        Dwarf_Block *tempb = 0;
        fres = dwarf_formblock(attr, &tempb, err);
        if (fres == DW_DLV_OK) {
            Dwarf_Dsc_Head h = 0;
            Dwarf_Unsigned u = 0;
            Dwarf_Unsigned arraycount = 0;
            int sres = 0;

            sres = dwarf_discr_list(dbg,
                (Dwarf_Small *)tempb->bl_data,
                tempb->bl_len,
                &h,&arraycount,err);
            if (sres == DW_DLV_NO_ENTRY) {
                /* Nothing here. */
                dwarf_dealloc(dbg, tempb, DW_DLA_BLOCK);
                return;
            }
            if (sres == DW_DLV_ERROR) {
                /* FAIL . */
                dwarf_dealloc(dbg, tempb, DW_DLA_BLOCK);
            }
        }
    }
}
```

```
    return;
}
for(u = 0; u < arraycount; u++) {
    int u2res = 0;
    Dwarf_Half dtype = 0;
    Dwarf_Signed dlow = 0;
    Dwarf_Signed dhigh = 0;
    Dwarf_Unsigned ulow = 0;
    Dwarf_Unsigned uhigh = 0;

    if (isunsigned) {
        u2res = dwarf_discr_entry_u(h,u,
            &dtype,&ulow,&uhigh,err);
    } else {
        u2res = dwarf_discr_entry_s(h,u,
            &dtype,&dlow,&dhigh,err);
    }
    if( u2res == DW_DLV_ERROR) {
        /* Something wrong */
        dwarf_dealloc(dbg,h,DW_DLA_DSC_HEAD);
        dwarf_dealloc(dbg, tempb, DW_DLA_BLOCK);
        return;
    }
    if( u2res == DW_DLV_NO_ENTRY) {
        /* Impossible. u < arraycount. */
        dwarf_dealloc(dbg,h,DW_DLA_DSC_HEAD);
        dwarf_dealloc(dbg, tempb, DW_DLA_BLOCK);
        return;
    }
    /* Do something with dtype, and whichever
       of ulow, uhigh,dlow,dhigh got set.
       Probably save the values somewhere.
       Simple casting of dlow to ulow (or vice versa)
       will not get the right value due to the nature
       of LEB values. Similarly for uhigh, dhigh.
       One must use the right call.

       */
}
dwarf_dealloc(dbg,h,DW_DLA_DSC_HEAD);
dwarf_dealloc(dbg, tempb, DW_DLA_BLOCK);
}
}
```

6.8.25 dwarf_discr_entry_u()

```
int dwarf_discr_entry_u(  
    Dwarf_Dsc_Head dsc_head,  
    Dwarf_Unsigned dsc_array_index,  
    Dwarf_Half *dsc_type,  
    Dwarf_Unsigned *dsc_low,  
    Dwarf_Unsigned *dsc_high,  
    Dwarf_Error *error)
```

When it succeeds, `dwarf_discr_entry_u()` returns `DW_DLV_OK` and sets `*dsc_type`, `*dsc_low`, and `*dsc_high` to the discriminant values for that index. Valid `dsc_array_index` values are zero to `(dsc_array_length_out - 1)` from a `dwarf_discr_list()` call.

If `*dsc_type` is `DW_DSC_label` `*dsc_low` is set to the discriminant value and `*dsc_high` is set to zero.

If `*dsc_type` is `DW_DSC_range` `*dsc_low` is set to the low end of the discriminant range and `*dsc_high` is set to the high end of the discriminant range.

Due to the nature of the LEB numbers in the discriminant representation in DWARF one must call the correct one of `dwarf_discr_entry_u()` or `dwarf_discr_entry_s()` based on whether the discriminant is signed or unsigned. Casting an unsigned to signed is not always going to get the right value.

If `dsc_array_index` is outside the range of valid indexes the function returns `DW_DLV_NO_ENTRY`. On error it returns `DW_DLV_ERROR` and sets `*error` to an error pointer.

6.8.26 dwarf_discr_entry_s()

```
int dwarf_discr_entry_s(  
    Dwarf_Dsc_Head dsc_head,  
    Dwarf_Unsigned dsc_array_index,  
    Dwarf_Half *dsc_type,  
    Dwarf_Signed *dsc_low,  
    Dwarf_Signed *dsc_high,  
    Dwarf_Error *error)
```

This is identical to `dwarf_discr_entry_u()` except that the discriminant values are signed values in this interface. Callers must check the discriminant type and call the correct function.

6.9 Location List Operations, Raw `.debug_loclists`

This set of interfaces is to read the (entire) `.debug_loclists` section without reference to any DIE. As such these can only present the raw data from the file. There is

no way in these interfaces to get actual addresses. These might be of interest if you want to know exactly what the compiler output in the `.debug_loclists` section. "dwarfdump ----print-raw-loclists" (try adding -v or -vvv) makes these calls.

Here is an example using all the following calls.

Figure 17. Example Raw Loclist

```
int example_raw_loclist(Dwarf_Debug dbg,Dwarf_Error *error)
{
    Dwarf_Unsigned count = 0;
    int res = 0;
    Dwarf_Unsigned i = 0;

    res = dwarf_load_loclists(dbg,&count,error);
    if (res != DW_DLV_OK) {
        return res;
    }
    for(i=0 ; i < count ; ++i) {
        Dwarf_Unsigned header_offset = 0;
        Dwarf_Small    offset_size = 0;
        Dwarf_Small    extension_size = 0;
        unsigned        version = 0; /* 5 */
        Dwarf_Small    address_size = 0;
        Dwarf_Small    segment_selector_size = 0;
        Dwarf_Unsigned offset_entry_count = 0;
        Dwarf_Unsigned offset_of_offset_array = 0;
        Dwarf_Unsigned offset_of_first_locentry = 0;
        Dwarf_Unsigned offset_past_last_locentry = 0;

        res = dwarf_get_loclist_context_basics(dbg,i,
            &header_offset,&offset_size,&extension_size,
            &version,&address_size,&segment_selector_size,
            &offset_entry_count,&offset_of_offset_array,
            &offset_of_first_locentry,
            &offset_past_last_locentry,error);
        if (res != DW_DLV_OK) {
            return res;
        }
        {
            Dwarf_Unsigned e = 0;
            unsigned colmax = 4;
            unsigned col = 0;
            Dwarf_Unsigned global_offset_of_value = 0;

            for ( ; e < offset_entry_count; ++e) {
                Dwarf_Unsigned value = 0;
                int resc = 0;

                resc = dwarf_get_loclist_offset_index_value(dbg,
                    i,e,&value,
                    &global_offset_of_value,error);
                if (resc != DW_DLV_OK) {
                    return resc;
                }
            }
        }
    }
}
```

```
    }
    /* Do something */
    col++;
    if (col == colmax) {
        col = 0;
    }
}

}
{
    Dwarf_Unsigned curoffset = offset_of_first_loceentry;
    Dwarf_Unsigned endoffset = offset_past_last_loceentry;
    int rese = 0;
    Dwarf_Unsigned ct = 0;

    for ( ; curoffset < endoffset; ++ct ) {
        unsigned entrylen = 0;
        unsigned code = 0;
        Dwarf_Unsigned v1 = 0;
        Dwarf_Unsigned v2 = 0;
        rese = dwarf_get_loclist_lle(dbg,i,
                                    curoffset,endoffset,
                                    &entrylen,
                                    &code,&v1,&v2,error);
        if (rese != DW_DLV_OK) {
            return rese;
        }
        curoffset += entrylen;
        if (curoffset > endoffset) {
            return DW_DLV_ERROR;
        }
    }
}
}
return DW_DLV_OK;
}
```

6.9.1 dwarf_load_loclists()

```
int dwarf_load_loclists(
    Dwarf_Debug dbg,
    Dwarf_Unsigned *loclists_count,
    Dwarf_Error *error)
```

On a successful call to dwarf_load_loclists() the function returns DW_DLV_OK,

sets `*loclists_count` (if and only if `loclists_count` is non-null) to the number of distinct section contents that exist. A small amount of data for each Location List Table (DWARF5 section 7.29) is recorded in `dbg` as a side effect. Normally `libdwarf` will have already called this, but if an application never requests any `.debug_info` data the section might not be loaded. If the section is loaded this returns very quickly and will set `*loclists_count` just as described in this paragraph.

If there is no `.debug_loclists` section in the object file this function returns `DW_DLV_NO_ENTRY`.

If something is malformed it returns `DW_DLV_ERROR` and sets `*error` to the applicable error pointer describing the problem.

There is no `dealloc` call. Calling `dwarf_finish()` releases the modest amount of memory recorded for this section as a side effect.

6.9.2 `dwarf_get_loclist_context_basics()`

```
int dwarf_get_loclist_context_basics(Dwarf_Debug dbg,
    Dwarf_Unsigned context_index,
    Dwarf_Unsigned * header_offset,
    Dwarf_Small    * offset_size,
    Dwarf_Small    * extension_size,
    unsigned       * version, /* 5 */
    Dwarf_Small    * address_size,
    Dwarf_Small    * segment_selector_size,
    Dwarf_Unsigned * offset_entry_count,
    Dwarf_Unsigned * offset_of_offset_array,
    Dwarf_Unsigned * offset_of_first_locentry,
    Dwarf_Unsigned * offset_past_last_locentry,
    Dwarf_Error *   /*err*/);
```

On success this returns `DW_DLV_OK` and returns values through the pointer arguments (other than `dbg` or `error`)

A call to `dwarf_load_loclists()` that succeeds gets you the count of contexts and `dwarf_get_loclist_context_basics()` for any "`i >= 0` and `i < count`" gets you the context values relevant to `.debug_loclists`.

Any of the pointer-arguments for returning context values can be passed in as 0 (in which case they will be skipped).

You will want `*offset_entry_count` so you can call `dwarf_get_loclist_offset_index_value()` usefully.

If the `context_index` passed in is out of range the function returns `DW_DLV_NO_ENTRY`

At the present time `DW_DLV_ERROR` is never returned.

6.9.3 dwarf_get_loclist_offset_index_value()

```
int dwarf_get_loclist_offset_index_value(Dwarf_Debug dbg,
    Dwarf_Unsigned context_index,
    Dwarf_Unsigned offsetentry_index,
    Dwarf_Unsigned * offset_value_out,
    Dwarf_Unsigned * global_offset_value_out,
    Dwarf_Error *error)
```

On success `dwarf_get_loclist_offset_index_value()` returns `DW_DLV_OK`, sets `* offset_value_out` to the value in the Range List Table offset array, and sets `* global_offset_value_out` to the section offset (in `.debug_addr`) of the offset value.

Pass in `context_index` exactly as the same field passed to `dwarf_get_loclist_context_basics()`.

Pass in `offset_entry_index` based on the return field `offset_entry_count` from `dwarf_get_loclist_context_basics()`, meaning for that `context_index` an `offset_entry_index` ≥ 0 and $< \text{offset_entry_count}$.

Pass in `offset_entry_count` exactly as the same field passed to `dwarf_get_loclist_context_basics()`.

If one of the indexes passed in is out of range `DW_DLV_NO_ENTRY` will be returned and no return arguments touched.

If there is some corruption of DWARF5 data then `DW_DLV_ERROR` might be returned and `*error` set to the error details.

6.9.4 dwarf_get_loclist_lle()

```
int dwarf_get_loclist_lle(
    Dwarf_Debug dbg,
    Dwarf_Unsigned contextnumber,
    Dwarf_Unsigned entry_offset,
    Dwarf_Unsigned endoffset,
    unsigned *entrylen,
    unsigned *entry_kind,
    Dwarf_Unsigned *entry_operand1,
    Dwarf_Unsigned *entry_operand2,
    Dwarf_Unsigned *expr_ops_blocksize,
    Dwarf_Unsigned *expr_ops_offset,
    Dwarf_Small **expr_opsdata,
    Dwarf_Error *error)
```

On success it returns a single `DW_RLE*` record (see `dwarf.h`) fields.

`contextnumber` is the number of the current loclist context.

`entry_offset` is the section offset (section-global offset) of the next record.

`endoffset` is one past the last entry in this rle context.

`*entrylen` returns the length in the `.debug_loclists` section of the particular record returned. It's used to increment to the next record within this loclist context.

`*entrykind` returns is the `DW_RLE*` number.

Some record kinds have 1 or 0 operands, most have two operands (the records describing ranges).

`*expr_ops_blocksize` returns the size, in bytes, of the Dwarf Expression (some operations have no Dwarf Expression and those that do can have a zero length blocksize).

`*expr_ops_offset` returns the offset (in the `.debug_loclists` section) of the first byte of the Dwarf Expression.

`*expr_opsdata` returns a pointer to the bytes of the Dwarf Expression.

If the `contextnumber` is out of range it will return `DW_DLV_NO_ENTRY`.

If the `.debug_loclists` section is malformed or the `entry_offset` is incorrect it may return `DW_DLV_ERROR`.

6.10 Location List operations `.debug_loc` & `.debug_loclists`

These operations apply to the `.debug_loc` section in DWARF2, DWARF3, DWARF4, and DWARF5 object files. Earlier versions still work as well as ever, but they only deal with, at most, DWARF2, DWARF3, and DWARF4.

6.10.1 `dwarf_get_loclist_c()`

```
int dwarf_get_loclist_c(Dwarf_Attribute attr,  
    Dwarf_Loc_Head_c * loclist_head,  
    Dwarf_Unsigned    * locCount,  
    Dwarf_Error       * error);
```

This function returns a pointer that is, in turn, used to make possible calls to return the details of the location list.

The incoming argument `attr` should have one of the FORMs of a location expression or location list.

On success this returns `DW_DLV_OK` and sets `*loclist_head` to a pointer used in further calls (see the example and descriptions that follow it). `locCount` is set to the number of entries in the location list (or if the FORM is of a location expression the `locCount` will be set to one). At this point one cannot yet tell if it was a location list or a location expression (see `. dwarf_get_locdesc_entry_d{ }`).

In case of error DW_DLVS_ERROR is returned and *error is set to an error designation.

A return of DW_DLVS_NO_ENTRY may be possible but is a bit odd.

```
void example_loclistcv5(Dwarf_Debug dbg,Dwarf_Attribute someattr)
{
    Dwarf_Unsigned lcount = 0;
    Dwarf_Loc_Head_c loclist_head = 0;
    Dwarf_Error error = 0;
    int lres = 0;

    lres = dwarf_get_loclist_c(someattr,&loclist_head,
        &lcount,&error);
    if (lres == DW_DLV_OK) {
        Dwarf_Unsigned i = 0;

        /* Before any return remember to call
           dwarf_loc_head_c_dealloc(loclist_head); */
        for (i = 0; i < lcount; ++i) {
            Dwarf_Small loclist_lkind = 0;
            Dwarf_Small lle_value = 0;
            Dwarf_Unsigned rawval1 = 0;
            Dwarf_Unsigned rawval2 = 0;
            Dwarf_Bool debug_addr_unavailable = FALSE;
            Dwarf_Addr lopc = 0;
            Dwarf_Addr hipc = 0;
            Dwarf_Unsigned loclist_expr_op_count = 0;
            Dwarf_Locdesc_c locdesc_entry = 0;
            Dwarf_Unsigned expression_offset = 0;
            Dwarf_Unsigned locdesc_offset = 0;

            lres = dwarf_get_locdesc_entry_d(loclist_head,
                i,
                &lle_value,
                &rawval1,&rawval2,
                &debug_addr_unavailable,
                &lopc,&hipc,
                &loclist_expr_op_count,
                &locdesc_entry,
                &loclist_lkind,
                &expression_offset,
                &locdesc_offset,
                &error);
            if (lres == DW_DLV_OK) {
                Dwarf_Unsigned j = 0;
                int opres = 0;
                Dwarf_Small op = 0;

                for (j = 0; j < loclist_expr_op_count; ++j) {
                    Dwarf_Unsigned raw1 = 0;
```

```
Dwarf_Unsigned raw2 = 0;
Dwarf_Unsigned raw3 = 0;
Dwarf_Unsigned opd1 = 0;
Dwarf_Unsigned opd2 = 0;
Dwarf_Unsigned opd3 = 0;
Dwarf_Unsigned offsetforbranch = 0;

opres = dwarf_get_location_op_value_d(
    locdesc_entry,
    j,&op,
    &opd1, &opd2,&opd3,
    &raw1,&raw2,&raw3,
    &offsetforbranch,
    &error);
if (opres == DW_DLV_OK) {
    /* Do something with the operators.
       Usually you want to use opd1,2,3
       as appropriate. Calculations
       involving base addresses etc
       have already been incorporated
       in opd1,2,3. */
} else {
    dwarf_dealloc_error(dbg,error);
    dwarf_loc_head_c_dealloc(loclist_head);
    /*Something is wrong. */
    return;
}
}
} else {
    /* Something is wrong. Do something. */
    dwarf_loc_head_c_dealloc(loclist_head);
    dwarf_dealloc_error(dbg,error);
    return;
}
}
}
/* Always call dwarf_loc_head_c_dealloc()
   to free all the memory associated with loclist_head. */
if (error) {
    dwarf_dealloc_error(dbg,error);
}
dwarf_loc_head_c_dealloc(loclist_head);
loclist_head = 0;
return;
}
```

6.10.2 dwarf_get_locdesc_entry_d()

Earlier versions of this work with earlier versions of DWARF. This works with all DWARF from DWARF2 on.

```
int dwarf_get_locdesc_entry_d(Dwarf_Loc_Head_c /*loclist_head*/,
    Dwarf_Unsigned    index,
    Dwarf_Small       *lle_value_out,
    Dwarf_Addr        *rawval1_out,
    Dwarf_Addr        *rawval2_out,
    Dwarf_Bool        *debug_addr_unavailable,
    Dwarf_Addr        *lopc_out,
    Dwarf_Addr        *hipc_out,
    Dwarf_Unsigned    *loc_expr_op_count_out,
    Dwarf_Locdesc_c   *locentry_out,
    Dwarf_Small       *loclist_kind,
    Dwarf_Unsigned    *expression_offset_out,
    Dwarf_Unsigned    *locdesc_offset_out,
    Dwarf_Error       *error);
```

This function returns overall information about a location list or location description. Details about location operators are retrieved by a call to `dwarf_get_location_op_value_d()` (described below). In case of success `DW_DLV_OK` is returned and arguments are set through the pointers to return values to the caller. Now we describe each argument.

`*loclist_kind` returns `DW_LKIND_expression`, `DW_LKIND_loclist`, `DW_LKIND_GNU_exp_list`, or `DW_LKIND_loclists`.

`DW_LKIND_expression` means the 'list' is really just a location expression. The only entry is with index zero. In this case `*lle_value_out` will have the value `DW_LLE_start_end`.

`DW_LKIND_loclist`, means the list is from DWARF2, DWARF3, or DWARF4. The `*lle_value_out` value has been synthesized as if it were a DWARF5 expression.

`DW_LKIND_GNU_exp_list`, means the list is from a DWARF4 `.debug_loc.dwo` object section. It is an experimental version from before DWARF5 was published. The `*lle_value_out` is `DW_LLEX_start_end_entry` (or one of the other `DW_LLEX` values).

`DW_LKIND_loclists` means this is a DWARF5 loclist, so `DW_LLE_start_end` is an example of one possible `*lle_value_out` values. In addition, if `*debug_addr_unavailable` is set it means the `*lopc_out` and `*hipc_out` could not be correctly set (so are meaningless) because the `.debug_addr` section is missing. Very likely the `.debug_addr` section is in the executable and that file needs to be opened and attached to the current `Dwarf_Debug` with `dwarf_set_tied_dbg()`.

*rawval1_out returns the value of the first operand in the location list entry. Uninterpreted. Useful for reporting or for those wishing to do their own calculation of lopc.

*rawval2_out returns the value of the second operand in the location list entry. Uninterpreted. Useful for reporting or for those wishing to do their own calculation of hipc.

The argument loc_expr_op_count_out returns the number of operators in the location expression involved (which may be zero).

The argument locentry_out returns an identifier used in calls to dwarf_get_location_op_value_d().

The argument expression_offset_out returns the offset (in the .debug_loc(.dso) or .debug_info(.dwo) of the location expression itself (possibly useful for debugging).

The argument locdesc_offset_out returns the offset (in the section involved (see loclist_kind) of the location list entry itself (possibly useful for debugging).

In case of error DW_DLV_ERROR is returned and *error is set to an error designation.

A return of DW_DLV_NO_ENTRY may be possible but is a bit odd.

6.10.3 dwarf_get_loclist_head_kind()

```
int dwarf_get_loclist_head_kind(  
    Dwarf_Loclists_Head head,  
    unsigned int * kind,  
    Dwarf_Error *error)
```

Though one should test the return code, at present this always returns DW_DLV_OK, and sets *kind to one of DW_LKIND_expression, DW_LKIND_loclist, DW_LKIND_GNU_exp_list, DW_LKIND_loclists, or DW_LKIND_unknown, for this head.

At the present time neither DW_DLV_ERROR nor DW_DLV_NO_ENTRY is returned.

6.10.4 dwarf_get_loclist_head_basics()

```
int dwarf_get_loclist_head_basics(Dwarf_Loc_Head_c head,
    Dwarf_Small      * lkind,
    Dwarf_Unsigned   * lle_count,
    Dwarf_Unsigned   * loclists_version,
    Dwarf_Unsigned   * loclists_index_returned,
    Dwarf_Unsigned   * bytes_total_in_rle,
    Dwarf_Half       * offset_size,
    Dwarf_Half       * address_size,
    Dwarf_Half       * segment_selector_size,
    Dwarf_Unsigned   * overall_offset_of_this_context,
    Dwarf_Unsigned   * total_length_of_this_context,
    Dwarf_Unsigned   * offset_table_offset,
    Dwarf_Unsigned   * offset_table_entrycount,
    Dwarf_Bool       * loclists_base_present,
    Dwarf_Unsigned   * loclists_base,
    Dwarf_Bool       * loclists_base_address_present,
    Dwarf_Unsigned   * loclists_base_address,
    Dwarf_Bool       * loclists_debug_addr_base_present,
    Dwarf_Unsigned   * loclists_debug_addr_base,
    Dwarf_Unsigned   * offset_this_lle_area,
    Dwarf_Error      * error);
```

Used by dwarfdump to print basic data from the data generated to look at a specific loclist as returned by dwarf_loclists_index_get_lle_head() or dwarf_loclists_offset_get_lle_head(). Returns DW_DLV_OK or if there is some corrupted data, DW_DLV_ERROR or DW_DLV_NO_ENTRY.

6.10.5 dwarf_get_location_op_value_d()

```
int dwarf_get_location_op_value_d(Dwarf_Locdesc_c locdesc,
    Dwarf_Unsigned   index,
    Dwarf_Small      * atom_out,
    Dwarf_Unsigned   * operand1,
    Dwarf_Unsigned   * operand2,
    Dwarf_Unsigned   * operand3,
    Dwarf_Unsigned   * rawop1,
    Dwarf_Unsigned   * rawop2,
    Dwarf_Unsigned   * rawop3,
    Dwarf_Unsigned   * offset_for_branch,
    Dwarf_Error*     error);
```

On success The function dwarf_get_location_op_value_d() returns the information for the single operator number index from the location expression locdesc. It sets the following values.

atom_out is set to the applicable operator code, for example DW_OP_reg5.

operand1, operand2, and operand3 are set to the operator operands as applicable (see DWARF documents on the operands for each operator). All additions of base fields, if any, have been done already. operand3 is new as of DWARF5.

In some cases operand3 is actually a pointer into section data in memory and operand2 has the length of the data at operand3. Callers must extract the bytes and deal with endianness issues of the extracted value.

rawop1, rawop2, and rawop3 are set to the operator operands as applicable (see DWARF documents on the operands for each operator) before any base values were added in.. As for the previous, sometimes dealing with rawop3 means interpreting it as a pointer and doing a dereference.

More on the pointer values in Dwarf_Unsigned: When a DWARF operand is not of a size fixed by dwarf or whose type is unknown, or is possibly too large for a dwarf stack entry, libdwarf will insert a pointer (to memory in the dwarf data somewhere) as the operand value. DW_OP_implicit_value operand 2, DW_OP_[GNU_]entry_value operand 2, and DW_OP_[GNU_]const_type operand 3 are instances of this. The problem with the values is that libdwarf is unclear what the type of the value is so we pass the problem to you, the callers!

offset_for_branch is set to the offset (in bytes) in this expression of this operator. The value makes it possible for callers to implement the operator branch operators.

In case of an error, the function returns DW_DLV_ERROR and sets *error to an error value.

DW_DLV_NO_ENTRY is probably not a possible return value, but please test for it anyway.

6.10.6 dwarf_loclist_from_expr_c()

This is the recommended current interface. It uses the Dwarf_Loc_Head_c opaque struct pointer to hold the information for detailed printing using dwarf_get_locdesc_entry_d()

```
int dwarf_loclist_from_expr_c(Dwarf_Debug dbg,
    Dwarf_Ptr          expression_in,
    Dwarf_Unsigned      expression_length,
    Dwarf_Half          address_size,
    Dwarf_Half          offset_size,
    Dwarf_Small         dwarf_version,
    Dwarf_Loc_Head_c*   loc_head,
    Dwarf_Unsigned      * listlen,
    Dwarf_Error          * error);
```

Frame operators such as DW_CFA_def_cfa_expression have a location expression and the location_expression is accessed with this function.

On success it returns DW_DLV_OK and sets the two return arguments (explained a few

lines later here).

The `expression_in` argument must contain a valid pointer to location expression bytes. The `expression_length` argument must contain the length of that location expression in bytes.

The `address_size` argument must contain the size of an address on the target machine for this expression (normally 4 or 8). The `offset_size` argument must contain the size of an offset in the expression (normally 4, sometimes 8). The `dwarf_version` argument must contain the dwarf_version of the expression (2,3,4, or 5).

The returned value `*loc_head` is used to actually access the location expression details (see the example following).

The returned value `*listlen` is the number of location expressions (ie 1) in the location list (for uniformity of access we make it look like a single-entry location list).

On error the function returns `DW_DLV_ERROR` and sets `*error` to reflect the error.

A return of `DW_DLV_NO_ENTRY` is probably impossible, but callers should assume it is possible. No return arguments are set in this case.

```
void
example_locexpr(Dwarf_Debug dbg,Dwarf_Ptr expr_bytes,
    Dwarf_Unsigned expr_len,
    Dwarf_Half addr_size,
    Dwarf_Half offset_size,
    Dwarf_Half version)
{
    Dwarf_Loc_Head_c head = 0;
    Dwarf_Locdesc_c locentry = 0;
    int res2 = 0;
    Dwarf_Unsigned rawlopc = 0;
    Dwarf_Unsigned rawhipc = 0;
    Dwarf_Bool debug_addr_unavailable = FALSE;
    Dwarf_Unsigned lopc = 0;
    Dwarf_Unsigned hipc = 0;
    Dwarf_Unsigned ulistlen = 0;
    Dwarf_Unsigned ulocentry_count = 0;
    Dwarf_Unsigned section_offset = 0;
    Dwarf_Unsigned locdesc_offset = 0;
    Dwarf_Small lle_value = 0;
    Dwarf_Small loclist_source = 0;
    Dwarf_Unsigned i = 0;
    Dwarf_Error error = 0;

    res2 = dwarf_loclist_from_expr_c(dbg,
        expr_bytes,expr_len,
        addr_size,
        offset_size,
        version,
        &head,
        &ulistlen,
        &error);
    if(res2 == DW_DLV_NO_ENTRY) {
        return;
    }
    if(res2 == DW_DLV_ERROR) {
        return;
    }
    /* These are a location expression, not loclist.
       So we just need the 0th entry. */
    res2 = dwarf_get_locdesc_entry_d(head,
        0, /* Data from 0th LocDesc */
        &lle_value,
        &rawlopc,&rawhipc,
        &debug_addr_unavailable,
        &lopc, &hipc,
```

```
&ulocentry_count,
&locentry,
&loclist_source,
&section_offset,
&locdesc_offset,
&error);
if (res2 == DW_DLV_ERROR) {
    dwarf_loc_head_c_dealloc(head);
    return;
} else if (res2 == DW_DLV_NO_ENTRY) {
    dwarf_loc_head_c_dealloc(head);
    return;
}
/* ASSERT: ulistlen == 1 */
for (i = 0; i < ulocentry_count;++i) {
    Dwarf_Small op = 0;
    Dwarf_Unsigned opd1 = 0;
    Dwarf_Unsigned opd2 = 0;
    Dwarf_Unsigned opd3 = 0;
    Dwarf_Unsigned rawop1 = 0;
    Dwarf_Unsigned rawop2 = 0;
    Dwarf_Unsigned rawop3 = 0;
    Dwarf_Unsigned offsetforbranch = 0;

    res2 = dwarf_get_location_op_value_d(locentry,
        i, &op,&opd1,&opd2,&opd3,
        &rawop1,&rawop2,&rawop3,&offsetforbranch,
        &error);
    /* Do something with the expression operator and operands */
    if (res2 != DW_DLV_OK) {
        dwarf_loc_head_c_dealloc(head);
        return;
    }
}
dwarf_loc_head_c_dealloc(head);
}
```

6.10.7 dwarf_loc_head_c_dealloc()

```
void dwarf_loc_head_c_dealloc(Dwarf_Loc_Head_c loclist_head);
```

This function takes care of all the details so one does not have to `_dwarf_dealloc()` the pieces individually, though code that continues to do the pieces individually still works.

This function frees all the memory associated with the `loclist_head`. There is no return value. It's good practice to set `loclist_head` to zero immediately after the call, as the pointer is stale at that point.

6.11 Line Number Operations

These functions are concerned with accessing line number entries, mapping debugging information entry objects to their corresponding source lines, and providing a mechanism for obtaining information about line number entries. Although, the interface talks of "lines" what is really meant is "statements". In case there is more than one statement on the same line, there will be at least one descriptor per statement, all with the same line number. If column number is also being represented they will have the column numbers of the start of the statements also represented.

There can also be more than one Dwarf_Line per statement. For example, if a file is preprocessed by a language translator, this could result in translator output showing 2 or more sets of line numbers per translated line of output.

The current set of line functions is `dwarf_srclines_b()` with `dwarf_srclines_from_linecontext()` and `dwarf_srclines_dealloc_b()`. These functions provide for handling both DWARF2 through DWARF5 details and give access to line header information even if there are no lines in a particular compilation unit's line table.

6.11.1 Get A Set of Lines (including skeleton line tables)

This set of functions works on any DWARF version. DWARF2,3,4,5 and the DWARF4 based experimental two-level line tables are all supported.

The interfaces support reading GNU two-level line tables. The format of such tables is a topic beyond the scope of this document.

6.11.2 dwarf_srclines_b()

This is the

```
int dwarf_srclines_b(
    Dwarf_Die die,
    Dwarf_Unsigned *version_out,
    Dwarf_Small *table_count,
    Dwarf_Line_Context *context_out,
    Dwarf_Error *error)
```

`dwarf_srclines_b()` takes a single argument as input, a pointer to a compilation-unit (CU) DIE. The other arguments are used to return values to the caller. On success `DW_DLV_OK` is returned and values are returned through the pointers. If there is no line table `DW_DLV_NO_ENTRY` is returned and no values are returned through the pointers. If `DW_DLV_ERROR` is returned the involved is returned through the `error` pointer.

The values returned on success are:

`*version_out()` is set to the version number from the line table header for this CU. The experimental two-level line table value is 0xf006. Standard numbers are 2,3,4 and 5.

`*is_single_table()` is set to non-zero if the line table is an ordinary single line table. If the line table is anything else (either a line table header with no lines or an experimental two-level line table) it is set to zero.

`*context_out()` is set to an opaque pointer to a `Dwarf_Line_Context` record which in turn is used to get other data from this line table. See below.

See `*dwarf_srclines_dealloc_b()` for examples showing correct use.

6.11.3 `dwarf_get_line_section_name()`

```
int dwarf_get_line_section_name(  
    Dwarf_Debug dbg,  
    const char ** sec_name,  
    Dwarf_Error *error)
```

`*dwarf_get_line_section_name()` retrieves the object file section name of the applicable line section. Do not free the string whose pointer is returned.

If the section does not exist the function returns `DW_DLV_NO_ENTRY`.

If there is an internal error detected the function returns `DW_DLV_ERROR` and sets the `*error` pointer.

6.11.4 `dwarf_check_lineheader_b()`

```
int dwarf_check_lineheader_b(  
    Dwarf_Die die,  
    int *err_count_out,  
    Dwarf_Error *error)
```

The function checks for some line table errors on success reports a count of those noticed via `err_count_out`. This finds a subset of the errors `dwarfdump` reports on when `dwarfdump` prints or checks the line table(s).

If it completes normally it returns `DW_DLV_OK` even if it noted and counted errors.

In some circumstances it might return `DW_DLV_ERROR` and report that single error via the `error` argument.

No details of an errors found and recorded in `rr_count_out` will be available.

6.11.5 `dwarf_get_line_section_name_from_die()`

```
int dwarf_get_line_section_name_from_die(  
    Dwarf_Die die,  
    const char ** sec_name,  
    Dwarf_Error *error)
```

`*dwarf_get_line_section_name_from_die()` retrieves the object file section name of the applicable line section. This is useful for applications wanting to print the

name, but of course the object section name is not really a part of the DWARF information. Most applications will probably not call this function. It can be called at any time after the Dwarf_Debug initialization is done.

If the function succeeds, `*sec_name` is set to a pointer to a string with the object section name and the function returns `DW_DLV_OK`. Do not free the string whose pointer is returned. For non-Elf objects it is possible the string pointer returned will be NULL or will point to an empty string. It is up to the calling application to recognize this possibility and deal with it appropriately.

If the section does not exist the function returns `DW_DLV_NO_ENTRY`.

If there is an internal error detected the function returns `DW_DLV_ERROR` and sets the `*error` pointer.

6.11.6 dwarf_srclines_from_linecontext()

```
int dwarf_srclines_from_linecontext(  
    Dwarf_Line_Context line_context,  
    Dwarf_Line ** linebuf,  
    Dwarf_Signed *linecount,  
    Dwarf_Error *error)
```

`*dwarf_srclines_from_linecontext()` gives access to the line tables. On success it returns `DW_DLV_OK` and passes back line tables through the pointers.

Though `DW_DLV_OK` will not be returned callers should assume it is possible.

On error `DW_DLV_ERROR` is returned and the error code set through the `error` pointer.

On success:

`*linebuf` is set to an array of `Dwarf_Line` pointers.

`*linecount` is set to the number of pointers in the array.

6.11.7 dwarf_srclines_two_levelfrom_linecontext()

```
int dwarf_srclines_from_linecontext(  
    Dwarf_Line_Context line_context,  
    Dwarf_Line ** linebuf,  
    Dwarf_Signed *linecount,  
    Dwarf_Line ** linebuf_actuais,  
    Dwarf_Signed *linecount_actuais,  
    Dwarf_Error *error)
```

`*dwarf_srclines_two_levelfrom_linecontext()` gives access to the line tables. On success it returns `DW_DLV_OK` and passes back line tables through the pointers.

Though `DW_DLV_OK` will not be returned callers should assume it is possible.

On error DW_DLV_ERROR is returned and the error code set through the `error` pointer.

On success:

`*linebuf` is set to an array of `Dwarf_Line` pointers.

`*linecount` is set to the number of pointers in the array.

If one is not intending that the experimental two-level line tables are of interest then pass `NULL` for `*linebuf_actuais` and `*linecount_actuais`. The `NULL` pointers notify the library that the second table is not to be passed back.

If a line table is actually a two-level tables `*linebuf` is set to point to an array of Logicals lines. `*linecount` is set to the number of Logicals. `*linebuf_actuais` is set to point to an array of Actuals lines. `*linecount_actuais` is set to the number of Actuals.

6.11.8 dwarf_srclines_dealloc_b()

```
void dwarf_srclines_dealloc_b(  
    Dwarf_Line_Context line_context)
```

This does a complete deallocation of the memory of the `Dwarf_Line_Context` and the `Dwarf_Line` array (or arrays) that came from the `Dwarf_Line_Context`. On return you should set any local pointers to these buffers to `NULL` as a reminder that any use of the local pointers would be to stale memory.

Figure 18. Example of `dwarf_srclines_b()`

```
void examplec(Dwarf_Die cu_die)
{
    /* EXAMPLE: DWARF5 style access. */
    Dwarf_Line *linebuf = 0;
    Dwarf_Signed linecount = 0;
    Dwarf_Line *linebuf_actuais = 0;
    Dwarf_Signed linecount_actuais = 0;
    Dwarf_Line_Context line_context = 0;
    Dwarf_Signed linecount_total = 0;
    Dwarf_Small table_count = 0;
    Dwarf_Unsigned lineversion = 0;
    Dwarf_Error err = 0;
    int sres = 0;
    /* ... */
    /* we use 'return' here to signify we can do nothing more
       at this point in the code. */
    sres = dwarf_srclines_b(cu_die,&lineversion,
        &table_count,&line_context,&err);
    if (sres != DW_DLV_OK) {
        /* Handle the DW_DLV_NO_ENTRY or DW_DLV_ERROR
           No memory was allocated so there nothing
           to dealloc. */
        return;
    }
    if (table_count == 0) {
        /* A line table with no actual lines.
           This occurs in a DWARF5 or DWARF5
           DW_TAG_type_unit
           as such has no lines of code
           but needs data for
           DW_AT_decl_file attributes. */

        dwarf_srclines_dealloc_b(line_context);
        /* All the memory is released, the line_context
           and linebuf zeroed now
           as a reminder they are stale. */
        linebuf = 0;
        line_context = 0;
    } else if (table_count == 1) {
        Dwarf_Signed i = 0;
        Dwarf_Signed baseindex = 0;
        Dwarf_Signed file_count = 0;
        Dwarf_Signed endindex = 0;
        /* Standard dwarf 2,3,4, or 5 line table */
        /* Do something. */
    }
}
```



```
/* First let us index through all the files listed
   in the line table header. */
sres = dwarf_srclines_files_indexes(line_context,
    &baseindex,&file_count,&endindex,&err);
if (sres != DW_DLV_OK) {
    /* Something badly wrong! */
    return;
}
/* Works for DWARF2,3,4 (one-based index)
   and DWARF5 (zero-based index) */
for (i = baseindex; i < endindex; i++) {
    Dwarf_Unsigned dirindex = 0;
    Dwarf_Unsigned modtime = 0;
    Dwarf_Unsigned flength = 0;
    Dwarf_Form_Data16 *md5data = 0;
    int vres = 0;
    const char *name = 0;

    vres = dwarf_srclines_files_data_b(line_context,i,
        &name,&dirindex, &modtime,&flength,
        &md5data,&err);
    if (vres != DW_DLV_OK) {
        /* something very wrong. */
        return;
    }
    /* Do something. */
}

/* For this case where we have a line table we will likely
   wish to get the line details: */
sres = dwarf_srclines_from_linecontext(line_context,
    &linebuf,&linecount,
    &err);
if (sres != DW_DLV_OK) {
    /* Error. Clean up the context information. */
    dwarf_srclines_dealloc_b(line_context);
    return;
}
/* The lines are normal line table lines. */
for (i = 0; i < linecount; ++i) {
    /* use linebuf[i] */
}
dwarf_srclines_dealloc_b(line_context);
/* All the memory is released, the line_context
   and linebuf zeroed now as a reminder they are stale */
```

```
    linebuf = 0;
    line_context = 0;
    linecount = 0;
} else {
    Dwarf_Signed i = 0;
    /* ASSERT: table_count == 2,
       Experimental two-level line table. Version 0xf006
       We do not define the meaning of this non-standard
       set of tables here. */

    /* For 'something C' (two-level line tables)
       one codes something like this
       Note that we do not define the meaning
       or use of two-level line
       tables as these are experimental, not standard DWARF. */
    sres = dwarf_srclines_two_level_from_linecontext(
        line_context,
        &linebuf,&linecount,
        &linebuf_actuais,&linecount_actuais,
        &err);
    if (sres == DW_DLV_OK) {
        for (i = 0; i < linecount; ++i) {
            /* Use linebuf[i], these are
               the 'logicals' entries. */
        }
        for (i = 0; i < linecount_actuais; ++i) {
            /* Use linebuf_actuais[i],
               these are the actuals entries */
        }
        dwarf_srclines_dealloc_b(line_context);
        line_context = 0;
        linebuf = 0;
        linecount = 0;
        linebuf_actuais = 0;
        linecount_actuais = 0;
    } else if (sres == DW_DLV_NO_ENTRY) {
        /* This should be impossible, but do something.    */
        /* Then Free the line_context */
        dwarf_srclines_dealloc_b(line_context);
        line_context = 0;
        linebuf = 0;
        linecount = 0;
        linebuf_actuais = 0;
        linecount_actuais = 0;
    } else {
        /* ERROR, show the error or something.

```

```
        Free the line_context. */
        dwarf_srclines_dealloc_b(line_context);
        line_context = 0;
        linebuf = 0;
        linecount = 0;
        linebuf_actuais = 0;
        linecount_actuais = 0;
    }
}
}
```

6.12 Line Context Details (DWARF5 style)

New in October 2015. When a `Dwarf_Line_Context` has been returned by `dwarf_srclines_b()` that line context data's details can be retrieved with the following set of calls.

6.12.1 dwarf_srclines_table_offset()

```
int dwarf_srclines_table_offset(Dwarf_Line_Context line_context,
    Dwarf_Unsigned * offset,
    Dwarf_Error * error);
```

On success, this function returns the offset (in the object file line section) of the actual line data (i.e. after the line header for this compilation unit) through the `offset` pointer. The offset is probably only of interest when printing detailed information about a line table header.

In case of error, `DW_DLV_ERROR` is returned and the error is set through the `error` pointer. `DW_DLV_NO_ENTRY` will not be returned.

6.12.2 dwarf_srclines_version()

```
int dwarf_srclines_version(Dwarf_Line_Context line_context,
    Dwarf_Unsigned * version,
    Dwarf_Error * error);
```

On success `DW_DLV_OK` is returned and the line table version number is returned through the `version` pointer.

In case of error, `DW_DLV_ERROR` is returned and the error is set through the `error` pointer. `DW_DLV_NO_ENTRY` will not be returned.

6.12.3 dwarf_srclines_comp_dir()

```
int dwarf_srclines_comp_dir(Dwarf_Line_Context line_context,
    const char ** compilation_directory,
    Dwarf_Error * error);
```

On success this returns a pointer to the compilation directory string for this line table in `*compilation_directory`. That compilation string may be NULL or the empty string. The string pointer is valid until the `line_context` has been deallocated.

In case of error, `DW_DLV_ERROR` is returned and the error is set through the `error` pointer. `DW_DLV_NO_ENTRY` will not be returned.

6.12.4 dwarf_srclines_files_indexes()

```
int dwarf_srclines_files_indexes(Dwarf_Line_Context line_context,
    Dwarf_Signed * baseindex,
    Dwarf_Signed * count,
    Dwarf_Signed * endindex,
    Dwarf_Error * error);
```

With DWARF5 the base file number index in the line table changed from zero (DWARF2,3,4) to one (DWARF5). See Figure "Examplec dwarf_srclines_b()" above for use of this function in accessing file names.

The base index of files in the files list of a line table header will be returned through `baseindex`.

The number of files in the files list of a line table header will be returned through `count`.

The end index of files in the files list of a line table header will be returned through `endindex`.

In case of error, `DW_DLV_ERROR` is returned and the error is set through the `error` pointer. `DW_DLV_NO_ENTRY` will not be returned.

6.12.5 dwarf_srclines_files_data_b()

This supplants `dwarf_srclines_files_data()` as of March 2018 to allow access to the md5 value in DWARF5.

```
int dwarf_srclines_files_data_b(Dwarf_Line_Context line_context,
    Dwarf_Signed index,
    const char ** name,
    Dwarf_Unsigned * directory_index,
    Dwarf_Unsigned * last_mod_time,
    Dwarf_Unsigned * file_length,
    Dwarf_Form_Data16 ** md5_value,
    Dwarf_Error * error);
```

On success, data about a single file in the files list will be returned through the pointers. See DWARF documentation for the meaning of these fields. `count`. Valid `index`.

values are 1 through `count`, reflecting the way the table is defined by DWARF2,3,4. For a dwarf5 line table index values 0...count-1 are legal. This is certainly awkward.

If `md5_value` is non-null it is used to pass a back a pointer to a `Dwarf_Form_Data16` md5 value if the md5 value is present. Otherwise a zero value is passed back to indicate there was no such field. The 16-byte value pointed to is inside the `line_context`, so if you want to keep the value you should probably copy it to storage you control.

This returns the raw files data from the line table header.

In case of error, `DW_DLV_ERROR` is returned and the error is set through the `error` pointer. `DW_DLV_NO_ENTRY` will not be returned.

6.12.6 dwarf_srclines_include_dir_count()

```
int dwarf_srclines_include_dir_count(Dwarf_Line_Context
    line_context,
    Dwarf_Signed * count,
    Dwarf_Error * error);
```

On success, the number of files in the includes list of a line table header will be returned through `count`.

Valid index. values are 1 through `count`, reflecting the way the table is defined by DWARF 2,3 and 4. For a dwarf5 line table index values 0...count-1 are legal. This is certainly awkward.

In case of error, `DW_DLV_ERROR` is returned and the error is set through the `error` pointer. `DW_DLV_NO_ENTRY` will not be returned.

6.12.7 dwarf_srclines_include_dir_data()

```
int dwarf_srclines_include_dir_data(Dwarf_Line_Context line_context,
    Dwarf_Signed index,
    const char ** name,
    Dwarf_Error * error);
```

On success, data about a single file in the include files list will be returned through the pointers. See DWARF documentation for the meaning of these fields.

Valid index. values are 1 through `count`, reflecting the way the table is defined by DWARF.

In case of error, `DW_DLV_ERROR` is returned and the error is set through the `error` pointer. `DW_DLV_NO_ENTRY` will not be returned.

6.12.8 dwarf_srclines_subprog_count()

```
int dwarf_srclines_subprog_count(Dwarf_Line_Context
    line_context,
    Dwarf_Signed * count,
    Dwarf_Error * error);
```

This is only useful with experimental two-level

line tables.

6.12.9 dwarf_srclines_subprog_data()

```
int dwarf_srclines_subprog_data(Dwarf_Line_Context
line_context,
Dwarf_Signed index,
const char ** name,
Dwarf_Unsigned * decl_file,
Dwarf_Unsigned * decl_line,
Dwarf_Error * error);
```

This is only useful with experimental two-level line tables.

6.13 Get the set of Source File Names

The function returns the names of the source files that have contributed to the compilation-unit represented by the given DIE. Only the source files named in the statement program prologue (which in current DWARF standards is referred to as the Line Table Header) are returned.

6.13.1 dwarf_srcfiles()

This works for for all line tables. However indexing is different in DWARF5 than in other versions of dwarf. To understand the DWARF5 version look at the following which explains a contradiction in the DWARF5 document and how libdwarf (and at least some compilers) resolve it. Join the next two strings together with no spaces to recreate the web reference.

If the applicable file name in the line table Statement Program Prolog does not start with a '/' character the string in DW_AT_comp_dir (if applicable and present) and the applicable directory name from the line Statement Program Prolog is prepended to the file name in the line table Statement Program Prolog to make a full path.

For all versions of dwarf this function and dwarf_linesrc() prepend the value of DW_AT_co prepend the value of DW_AT_comp_dir to the name created from the line table header file names and directory names if the line table header name(s) are not full paths.mp_dir to the name created from the line table header file names and directory names if the line table header name(s) are not full paths.

http://wiki.dwarfstd.org/index.php?title=DWARF5_Line_Table_File_Numbers

It may help understand the file tables and dwarf_srcfiles() to use dwarfdump. The dwarfdump utility program now will print the dwarf_srcfiles() values in addition to the compilation unit DIE and the line table header details (and much more) if one does "dwarfdump -vvv -i -l <objfilename>" or "dwarfdump -vvv -a <objfilename>" for example. Since the output can be large, with your editor focus on lines beginning with "COMPILE_UNIT" (do not type the quotes) to quickly get to the CU die and the line table for that CU as those tend to be far apart in the output.

DWARF5: DW_MACRO_start_file, DW_LNS_set_file, DW_AT_decl_file, DW_AT_call_file, and the line table state machine file numbers begin at zero. To index srcfiles use the values directly with no subtraction.

DWARF2-4 and experimental line table: DW_MACINFO_start_file, DW_LNS_set_file, DW_AT_decl_file, and line table state machine file numbers begin at one. In all these the value of 0 means there is no source file or source file name. To index the srcfiles array subtract one from the DW_AT_decl_file (etc) file number.

```
int dwarf_srcfiles(  
    Dwarf_Die die,  
    char ***srcfiles,  
    Dwarf_Signed *srccount,  
    Dwarf_Error *error)
```

When it succeeds dwarf_srcfiles() returns DW_DLV_OK and puts the number of source files named in the statement program prologue indicated by the given die into *srccount. Source files defined in the statement program are ignored. The given die should have the tag DW_TAG_compile_unit, DW_TAG_partial_unit, or DW_TAG_type_unit. The location pointed to by srcfiles is set to point to a list of pointers to null-terminated strings that name the source files.

On a successful return from dwarf_srcfiles() each of the strings returned should be individually freed using dwarf_dealloc() with the allocation type DW_DLA_STRING when no longer of interest. This should be followed by free-ing the list using dwarf_dealloc() with the allocation type DW_DLA_LIST. It returns DW_DLV_ERROR on error. It returns DW_DLV_NO_ENTRY if there is no corresponding statement program (i.e., if there is no line information).

Figure 19. Exemplified dwarf_srcfiles()

```
void examplee(Dwarf_Debug dbg, Dwarf_Die somedie)  
{  
    Dwarf_Signed count = 0;  
    char ***srcfiles = 0;  
    Dwarf_Signed i = 0;  
    Dwarf_Error error = 0;  
    int res = 0;  
  
    res = dwarf_srcfiles(somedie, &srcfiles, &count, &error);  
    if (res == DW_DLV_OK) {  
        for (i = 0; i < count; ++i) {  
            /* use srcfiles[i] */  
            dwarf_dealloc(dbg, srcfiles[i], DW_DLA_STRING);  
        }  
        dwarf_dealloc(dbg, srcfiles, DW_DLA_LIST);  
    }  
}
```

6.14 Get Information About a Single Line Table Line

The following functions can be used on the `Dwarf_Line` descriptors returned by `dwarf_srclines_b()` or `dwarf_srclines_from_linecontext()` to obtain information about the source lines.

6.14.1 `dwarf_linebeginstatement()`

```
int dwarf_linebeginstatement(  
    Dwarf_Line line,  
    Dwarf_Bool *return_bool,  
    Dwarf_Error *error)
```

The function `dwarf_linebeginstatement()` returns `DW_DLV_OK` and sets `*return_bool` to *non-zero* (if `line` represents a line number entry that is marked as beginning a statement). or *zero* (if `line` represents a line number entry that is not marked as beginning a statement). It returns `DW_DLV_ERROR` on error. It never returns `DW_DLV_NO_ENTRY`.

6.14.2 `dwarf_lineendsequence()`

```
int dwarf_lineendsequence(  
    Dwarf_Line line,  
    Dwarf_Bool *return_bool,  
    Dwarf_Error *error)
```

The function `dwarf_lineendsequence()` returns `DW_DLV_OK` and sets `*return_bool` *non-zero* (in which case `line` represents a line number entry that is marked as ending a text sequence) or *zero* (in which case `line` represents a line number entry that is not marked as ending a text sequence). A line number entry that is marked as ending a text sequence is an entry with an address one beyond the highest address used by the current sequence of line table entries (that is, the table entry is a `DW_LNE_end_sequence` entry (see the DWARF specification)).

The function `dwarf_lineendsequence()` returns `DW_DLV_ERROR` on error. It never returns `DW_DLV_NO_ENTRY`.

6.14.3 `dwarf_lineno()`

```
int dwarf_lineno(  
    Dwarf_Line line,  
    Dwarf_Unsigned * returned_lineno,  
    Dwarf_Error * error)
```

The function `dwarf_lineno()` returns `DW_DLV_OK` and sets `*return_lineno` to the source statement line number corresponding to the descriptor `line`. It returns `DW_DLV_ERROR` on error. It never returns `DW_DLV_NO_ENTRY`.

6.14.4 dwarf_line_srcfileno()

```
int dwarf_line_srcfileno(  
    Dwarf_Line      line,  
    Dwarf_Unsigned * returned_fileno,  
    Dwarf_Error     * error)
```

The function `dwarf_line_srcfileno()` returns `DW_DLV_OK` and sets `*returned_fileno` to the source statement line number corresponding to the descriptor file number.

DWARF2-4 and experimental: When the number returned through `*returned_fileno` is zero it means the file name is unknown (see the DWARF2/3 line table specification). When the number returned through `*returned_fileno` is non-zero it is a file number: subtract 1 from this file number to get an index into the array of strings returned by `dwarf_srcfiles()` (verify the resulting index is in range for the array of strings before indexing into the array of strings). The file number may exceed the size of the array of strings returned by `dwarf_srcfiles()` because `dwarf_srcfiles()` does not return files names defined with the `DW_DLE_define_file` operator.

DWARF5: To index into the array of strings returned by `dwarf_srcfiles()` use the number returned through `*returned_fileno`.

The function `dwarf_line_srcfileno()` returns `DW_DLV_ERROR` on error. It never returns `DW_DLV_NO_ENTRY`.

6.14.5 dwarf_lineaddr()

```
int dwarf_lineaddr(  
    Dwarf_Line      line,  
    Dwarf_Addr      *return_lineaddr,  
    Dwarf_Error     *error)
```

The function `dwarf_lineaddr()` returns `DW_DLV_OK` and sets `*return_lineaddr` to the address associated with the descriptor line. It returns `DW_DLV_ERROR` on error. It never returns `DW_DLV_NO_ENTRY`.

6.14.6 dwarf_lineoff_b()

```
int dwarf_lineoff_b(  
    Dwarf_Line line,  
    Dwarf_Unsigned * return_lineoff,  
    Dwarf_Error *error)
```

The function `dwarf_lineoff_b()` returns the unsigned column number of the declaration within the line through the pointer `return_lineoff()`.

Per the standard (all versions) a column number of zero means column unknown. Actual columns start with 1 (one). Any non-zero value comes from the attribute

DW_AT_decl_column while zero could be from DW_AT_decl_column or could mean DW_AT_decl_column is missing (the attribute is very often missing).

It returns DW_DLV_OK unless the line or return_lineoff() field is NULL, in which case it returns DW_DLV_ERROR and sets the error DIE.

6.14.7 dwarf_linesrc()

```
int dwarf_linesrc(  
    Dwarf_Line line,  
    char ** return_linesrc,  
    Dwarf_Error *error)
```

The function dwarf_linesrc() returns DW_DLV_OK and sets *return_linesrc to a pointer to a null-terminated string of characters that represents the name of the source-file where line occurs. It returns DW_DLV_ERROR on error.

If the applicable file name in the line table Statement Program Prolog does not start with a '/' character the string in DW_AT_comp_dir (if applicable and present) or the applicable directory name from the line Statement Program Prolog is prepended to the file name in the line table Statement Program Prolog to make a full path.

The storage pointed to by a successful return of dwarf_linesrc() should be freed using dwarf_dealloc() with the allocation type DW_DLA_STRING when no longer of interest. It never returns DW_DLV_NO_ENTRY.

6.14.8 dwarf_lineblock()

```
int dwarf_lineblock(  
    Dwarf_Line line,  
    Dwarf_Bool *return_bool,  
    Dwarf_Error *error)
```

The function dwarf_lineblock() returns DW_DLV_OK and sets *return_linesrc to non-zero (i.e. true)(if the line is marked as beginning a basic block) or zero (i.e. false) (if the line is marked as not beginning a basic block). It returns DW_DLV_ERROR on error. It never returns DW_DLV_NO_ENTRY.

6.14.9 dwarf_line_is_addr_set()

```
int dwarf_line_is_addr_set(  
    Dwarf_Line line,  
    Dwarf_Bool *return_bool,  
    Dwarf_Error *error)
```

The function dwarf_line_is_addr_set() returns DW_DLV_OK and sets *return_bool to non-zero (i.e. true)(if the line is marked as being a DW_LNE_set_address operation) or zero (i.e. false) (if the line is marked as not being a DW_LNE_set_address operation). It returns DW_DLV_ERROR on error. It never returns

DW_DLV_NO_ENTRY.

This is intended to allow consumers to do a more useful job printing and analyzing DWARF data, it is not strictly necessary.

6.14.10 dwarf_prologue_end_etc()

```
int dwarf_prologue_end_etc(Dwarf_Line line,
    Dwarf_Bool * prologue_end,
    Dwarf_Bool * epilogue_begin,
    Dwarf_Unsigned * isa,
    Dwarf_Unsigned * discriminator,
    Dwarf_Error * error)
```

The function `dwarf_prologue_end_etc()` returns `DW_DLV_OK` and sets the returned fields to values currently set. While it is pretty safe to assume that the `isa` and `discriminator` values returned are very small integers, there is no restriction in the standard. It returns `DW_DLV_ERROR` on error. It never returns `DW_DLV_NO_ENTRY`.

This function is new in December 2011.

6.15 Accelerated Access By Name operations

These operations operate on the `.debug_pubnames` section as well as all the other sections with this specific format and purpose:

`.debug_pubtypes`,
`.debug_tynames`,
`.debug_varnames`,
`.debug_funcnames`,

and `.debug_weaknames`. The first in the list is generic DWARF 2,3,4. The second in the list is generic DWARF 3,4. The rest are SGI specific and rarely used.

The interface types are `Dwarf_Global`, `Dwarf_Type`, `Dwarf_Weak`, `Dwarf_Func`, and `Dwarf_Var`. Only `Dwarf_Global` is a real type. The others are opaque pointers with no actual definition or instantiation and can be converted to `Dwarf_Global` with a simple cast.

In hindsight it would have been simpler to write a single set of interfaces for Accelerated Access By Name.

6.15.1 Fine Tuning Accelerated Access

By default the various `dwarf_get*()` functions here return an array of pointers to opaque records with a `.debug_info` DIE offset and a string (the fields are accessible by function calls). While the actual `.debug_pubnames` (etc) section contains CU-local DIE offsets for the named things the accelerated access functions below return a `.debug_info` (or

.debug_types) global section offset.

6.15.1.1 dwarf_return_empty_pubnames

New March 2019. Mostly special for dwarfdump. If called with a flag value of one (1) it tells libdwarf, for any pubnames(etc) section list returned to add to the list an entry with a global-DIE-offset of zero (0) for any section Compilation Unit entry with no pubnames(etc) name(ie, an empty list for the Compilation Unit).

If called with a value of zero(0) (zero is the default set by any dwarf_init*() call) it causes such empty lists to be omitted from the array of pointers returned, which is the standard behavior of libdwarf since libdwarf was first written.

Since zero is never a valid DIE offset in .debug_info (or .debug_types) consumers requesting such can detect the special Dwarf_Global entries.

For example, calling

dwarf_global_name_offsets() on one of the special global records sets *die_offset to 0, *return_name to a pointer to an empty string, and *cu_offset to the offset of the compilation unit die in the .debug_info (or .debug_types if applicable) section.

```
int dwarf_return_empty_pubnames(Dwarf_Debug dbg,
                                int          flag ,
                                Dwarf_Error* error)
```

Callers should pass in one (1) or zero(0), no other value. On success it returns DW_DLV_OK. On failure it returns DW_DLV_ERROR;

The assumption is that programs calling this with value one (1) will be calling dwarf_get_globals_header() to retrieve the relevant pubnames(etc) section Compilation Unit header.

6.15.1.2 dwarf_get_globals_header

New February 2019. For more complete dwarfdump printing. For each CU represented in .debug_pubnames, etc, there is a .debug_pubnames header. For any given Dwarf_Global this returns the content of the applicable header.

This allows dwarfdump, or any DWARF dumper, to print pubnames(etc) specific CU header data.

```
int dwarf_get_globals_header(Dwarf_Global global,
    Dwarf_Off      * offset_pub_header,
    Dwarf_Unsigned * offset_size,
    Dwarf_Unsigned * length_pub,
    Dwarf_Unsigned * version,
    Dwarf_Unsigned * header_info_offset,
    Dwarf_Unsigned * info_length,
    Dwarf_Error*    error)
```

On success it returns DW_DLV_OK and it returns the header data (and calculated values) through the pointers. Casting Dwarf_Type (etc) to Dwarf_Global for a call to this function allows this to be used for any of these accelerated-access types.

6.15.2 Accelerated Access Pubnames

6.15.2.1 dwarf_get_globals()

This is .debug_pubnames and is standard DWARF2, DWARF3, and DWARF4.

```
int dwarf_get_globals(
    Dwarf_Debug dbg,
    Dwarf_Global **globals,
    Dwarf_Signed * return_count,
    Dwarf_Error *error)
```

The function dwarf_get_globals() returns DW_DLV_OK and sets *return_count to the count of pubnames represented in the section containing pubnames i.e. .debug_pubnames. It also stores at *globals, a pointer to a list of Dwarf_Global descriptors, one for each of the pubnames in the .debug_pubnames section. The returned results are for the entire section.

It returns DW_DLV_ERROR on error. It returns DW_DLV_NO_ENTRY if the .debug_pubnames section does not exist.

On a successful return from dwarf_get_globals(), the Dwarf_Global descriptors should be freed using dwarf_globals_dealloc(). dwarf_globals_dealloc() is new as of July 15, 2005 and is the preferred approach to freeing this memory..

Global names refer exclusively to names and offsets in the .debug_info section. See section 6.1.1 "Lookup by Name" in the dwarf standard.

Figure 20. Example of dwarf_get_globals()

```
void examplef(Dwarf_Debug dbg)
{
    Dwarf_Signed count = 0;
    Dwarf_Global *globs = 0;
    Dwarf_Signed i = 0;
    Dwarf_Error error = 0;
    int res = 0;

    res = dwarf_get_globals(dbg, &globs, &count, &error);
    if (res == DW_DLV_OK) {
        for (i = 0; i < count; ++i) {
            /* use globs[i] */
        }
        dwarf_globals_dealloc(dbg, globs, count);
    }
}
```

6.15.2.2 dwarf_globname()

```
int dwarf_globname(
    Dwarf_Global global,
    char **        return_name,
    Dwarf_Error *error)
```

The function `dwarf_globname()` returns `DW_DLV_OK` and sets `*return_name` to a pointer to a null-terminated string that names the pubname represented by the `Dwarf_Global` descriptor, `global`.

The string returned should not be freed.

It returns `DW_DLV_ERROR` on error. It never returns `DW_DLV_NO_ENTRY`.

6.15.2.3 dwarf_global_die_offset()

```
int dwarf_global_die_offset(
    Dwarf_Global global,
    Dwarf_Off    *return_offset,
    Dwarf_Error *error)
```

The function `dwarf_global_die_offset()` returns `DW_DLV_OK` and sets `*return_offset` to the offset in the section containing DIEs, i.e. `.debug_info`, of the DIE representing the pubname that is described by the `Dwarf_Global` descriptor, `glob`. It returns `DW_DLV_ERROR` on error. It never returns `DW_DLV_NO_ENTRY`.

6.15.2.4 dwarf_global_cu_offset()

```
int dwarf_global_cu_offset(  
    Dwarf_Global global,  
    Dwarf_Off *return_offset,  
    Dwarf_Error *error)
```

The function `dwarf_global_cu_offset()` returns `DW_DLV_OK` and sets `*return_offset` to the offset in the section containing DIEs, i.e. `.debug_info`, of the compilation-unit header of the compilation-unit that contains the pubname described by the `Dwarf_Global` descriptor, `global`. It returns `DW_DLV_ERROR` on error. It never returns `DW_DLV_NO_ENTRY`.

6.15.2.5 `dwarf_get_cu_die_offset_given_cu_header_offset_b()`

```
int dwarf_get_cu_die_offset_given_cu_header_offset_b(  
    Dwarf_Debug dbg,  
    Dwarf_Off in_cu_header_offset,  
    Dwarf_Bool is_info,  
    Dwarf_Off * out_cu_die_offset,  
    Dwarf_Error *error)
```

The function `dwarf_get_cu_die_offset_given_cu_header_offset()` returns `DW_DLV_OK` and sets `*out_cu_die_offset` to the offset of the compilation-unit DIE given the offset `in_cu_header_offset` of a compilation-unit header. It returns `DW_DLV_ERROR` on error. It never returns `DW_DLV_NO_ENTRY`.

If `is_info` is non-zero the `in_cu_header_offset` must refer to a `.debug_info` section offset. If `is_info` zero the `in_cu_header_offset` must refer to a `.debug_types` section offset. Chaos may result if the `is_info` flag is incorrect.

This effectively turns a compilation-unit-header offset into a compilation-unit DIE offset (by adding the size of the applicable CU header). This function is also sometimes useful with the `dwarf_weak_cu_offset()`, `dwarf_func_cu_offset()`, `dwarf_type_cu_offset()`, and `int dwarf_var_cu_offset()` functions, though for those functions the data is only in `.debug_info` by definition.

6.15.2.6 `dwarf_global_name_offsets()`

```
int dwarf_global_name_offsets(  
    Dwarf_Global global,  
    char **return_name,  
    Dwarf_Off *die_offset,  
    Dwarf_Off *cu_die_offset,  
    Dwarf_Error *error)
```

The function `dwarf_global_name_offsets()` returns `DW_DLV_OK` and sets `*return_name` to a pointer to a null-terminated string that gives the name of the pubname described by the `Dwarf_Global` descriptor `global`.

The string returned should not be freed.

It returns `DW_DLV_ERROR` on error. It never returns `DW_DLV_NO_ENTRY`. It also returns in the locations pointed to by `die_offset`, and `cu_offset`, the global offset of the DIE representing the pubname, and the offset of the DIE representing the compilation-unit containing the pubname, respectively.

If a portion of `.debug_pubnames` (or `.debug_types` etc) represents a compilation unit with no names there is a `.debug_pubnames` header there with no content. In that case a single `Dwarf_Global` record is created with the value of `*die_offset` zero and the name-pointer returned points to the empty string. A zero is never a valid DIE offset, so zero always means this is an uninteresting (`Dwarf_Global`).

6.15.3 Accelerated Access Pubtypes

Section ".debug_pubtypes" is in DWARF3 and DWARF4. The type in calls is `Dwarf_Type`. These functions operate on the `.debug_pubtypes` section of the debugging information. The `.debug_pubtypes` section contains the names of file-scope user-defined types, the offsets of the DIEs that represent the definitions of those types, and the offsets of the compilation-units that contain the definitions of those types.

6.15.3.1 dwarf_get_pubtypes()

This is standard DWARF3 and DWARF4.

```
int dwarf_get_pubtypes(  
    Dwarf_Debug dbg,  
    Dwarf_Type **types,  
    Dwarf_Signed *typecount,  
    Dwarf_Error *error)
```

The function operates as described in `dwarf_get_globals` `dwarf_get_globals` above.

Global type names refer exclusively to names and offsets in the `.debug_info` section. See section 6.1.1 "Lookup by Name" in the dwarf standard. The Descriptor should be freed using `dwarf_pubtypes_dealloc()`.

6.15.3.2 dwarf_pubtypename()

```
int dwarf_pubtypename(  
    Dwarf_Type type,  
    char **return_name,  
    Dwarf_Error *error)
```

The function operates as described in `dwarf_globalname()` above.

6.15.3.3 dwarf_pubtype_type_die_offset()


```
int dwarf_pubtype_type_die_offset(  
    Dwarf_Type type,  
    Dwarf_Off *return_offset,  
    Dwarf_Error *error)
```

The function operates as described in `dwarf_global_type_die_offset()` above.

6.15.3.4 dwarf_pubtype_cu_offset()

```
int dwarf_pubtype_cu_offset(  
    Dwarf_Type type,  
    Dwarf_Off *return_offset,  
    Dwarf_Error *error)
```

The function operates as described in `dwarf_global_cu_offset()` above.

6.15.3.5 dwarf_pubtype_name_offsets()

```
int dwarf_pubtype_name_offsets(  
    Dwarf_Type type,  
    char ** returned_name,  
    Dwarf_Off * die_offset,  
    Dwarf_Off * cu_offset,  
    Dwarf_Error *error)
```

The function operates as described in `dwarf_global_name_offsets()` above.

6.15.3.6 dwarf_pubtypes_dealloc()

```
void dwarf_pubtypes_dealloc(Dwarf_Type * type,  
    Dwarf_Signed number_of_types)
```

Deallocs (frees) all memory allocated by `dwarf_get_pubtypes()`.

6.15.4 Accelerated Access Weaknames

This section is SGI specific and is not part of standard DWARF.

These functions operate on the `.debug_varnames` section of the debugging information. The `.debug_varnames` section contains the names of file-scope static variables, the offsets of the DIEs that represent the definitions of those variables, and the offsets of the compilation-units that contain the definitions of those variables.

These operations operate on the `.debug_weaknames` section of the debugging information.

6.15.4.1 dwarf_get_weak()

```
int dwarf_get_weak(  
    Dwarf_Debug dbg,  
    Dwarf_Weak **weak,  
    Dwarf_Signed *weak_count,  
    Dwarf_Error *error)
```

The function operates as described in `dwarf_get_globals` above. Descriptors should be freed using `dwarf_weak_dealloc()`.

6.15.4.2 dwarf_weak_dealloc()

```
void dwarf_weak_dealloc(Dwarf_Type * weak,  
    Dwarf_Signed number_of_types)
```

Deallocs (frees) all memory allocated by `dwarf_get_weak()`.

6.15.4.3 dwarf_weakname()

```
int dwarf_weakname(  
    Dwarf_Weak weak,  
    char ** return_name,  
    Dwarf_Error *error)
```

The function operates as described in `dwarf_globalname` above.

6.15.4.4 dwarf_weak_die_offset()

```
int dwarf_weak_die_offset(  
    Dwarf_Weak weak,  
    Dwarf_Off *return_offset,  
    Dwarf_Error *error)
```

The function operates as described in `dwarf_global_die_offset` above.

6.15.4.5 dwarf_weak_cu_offset()

```
int dwarf_weak_cu_offset(  
    Dwarf_Weak weak,  
    Dwarf_Off *return_offset,  
    Dwarf_Error *error)
```

The function operates as described in `dwarf_global_cu_offset` above.

6.15.4.6 dwarf_weak_name_offsets()

```
int dwarf_weak_name_offsets(  
    Dwarf_Weak weak,  
    char ** weak_name,  
    Dwarf_Off *die_offset,  
    Dwarf_Off *cu_offset,  
    Dwarf_Error *error)
```

The function operates as described in `dwarf_global_name_offsets` above.

6.15.5

6.15.6 Accelerated Access Funcnames (static functions)

This section is SGI specific and is not part of standard DWARF.

These function operate on the `.debug_funcnames` section of the debugging information. The `.debug_funcnames` section contains the names of static functions defined in the object, the offsets of the DIEs that represent the definitions of the corresponding functions, and the offsets of the start of the compilation-units that contain the definitions of those functions.

6.15.6.1 dwarf_get_funcs()

```
int dwarf_get_funcs(  
    Dwarf_Debug dbg,  
    Dwarf_Func **funcs,  
    Dwarf_Signed *func_count,  
    Dwarf_Error *error)
```

The function operates as described in `dwarf_get_globals` above. Descriptors should be freed using `dwarf_funcs_dealloc()`.

6.15.6.2 dwarf_funcname()

```
int dwarf_funcname(  
    Dwarf_Func func,  
    char ** return_name,  
    Dwarf_Error *error)
```

The function operates as described in `dwarf_globalname` above.

6.15.6.3 dwarf_funcs_dealloc()

```
void dwarf_funcs_dealloc(Dwarf_Debug dbg,  
    Dwarf_Func *func,  
    Dwarf_Signed func_count,  
    Dwarf_Error *error)
```

This is the dealloc (free) function for the `Dwarf_Func *` array returned, on success, by `dwarf_get_funcs`

6.15.6.4 dwarf_func_die_offset()

```
int dwarf_func_die_offset(  
    Dwarf_Func func,  
    Dwarf_Off  *return_offset,  
    Dwarf_Error *error)
```

The function operates as described in dwarf_global_die_offset above.

6.15.6.5 dwarf_func_cu_offset()

```
int dwarf_func_cu_offset(  
    Dwarf_Func func,  
    Dwarf_Off  *return_offset,  
    Dwarf_Error *error)
```

The function operates as described in dwarf_global_cu_offset above.

6.15.6.6 dwarf_func_name_offsets()

```
int dwarf_func_name_offsets(  
    Dwarf_Func func,  
    char      **func_name,  
    Dwarf_Off *die_offset,  
    Dwarf_Off *cu_offset,  
    Dwarf_Error *error)
```

The function operates as described in dwarf_global_name_offsets above.

6.15.7 Accelerated Access Typenames

Section "debug_tynames" is SGI specific and is not part of standard DWARF. (However, an identical section is part of DWARF version 3 named ".debug_pubtypes", see dwarf_get_pubtypes() above.)

These functions operate on the .debug_tynames section of the debugging information. The .debug_tynames section contains the names of file-scope user-defined types, the offsets of the DIES that represent the definitions of those types, and the offsets of the compilation-units that contain the definitions of those types.

6.15.7.1 dwarf_get_types()

```
int dwarf_get_types(  
    Dwarf_Debug dbg,  
    Dwarf_Type **types,  
    Dwarf_Signed *typecount,  
    Dwarf_Error *error)
```

The function operates as described in dwarf_get_globals above. Descriptors should be freed using dwarf_types_dealloc().

6.15.7.2 dwarf_typename()

```
int dwarf_typename(  
    Dwarf_Type    type,  
    char          **return_name,  
    Dwarf_Error   *error)
```

The function operates as described in dwarf_globalname above.

6.15.7.3 dwarf_type_die_offset()

```
int dwarf_type_die_offset(  
    Dwarf_Type type,  
    Dwarf_Off  *return_offset,  
    Dwarf_Error *error)
```

The function operates as described in dwarf_global_die_offset above.

6.15.7.4 dwarf_type_cu_offset()

```
int dwarf_type_cu_offset(  
    Dwarf_Type type,  
    Dwarf_Off  *return_offset,  
    Dwarf_Error *error)
```

The function operates as described in dwarf_global_cu_offset above.

6.15.7.5 dwarf_type_name_offsets()

```
int dwarf_type_name_offsets(  
    Dwarf_Type    type,  
    char          ** returned_name,  
    Dwarf_Off *   die_offset,  
    Dwarf_Off *   cu_offset,  
    Dwarf_Error   *error)
```

The function operates as described in dwarf_global_name_offsets above.

6.15.7.6 dwarf_types_dealloc()

```
void dwarf_types_dealloc(Dwarf_Type *type,  
    Dwarf_Signed number_of_types)
```

Deallocs (frees) all memory allocated by dwarf_get_types().

6.15.8 Accelerated Access varnames

This section is SGI specific and is not part of standard DWARF.

These functions operate on the .debug_varnames section of the debugging information. The .debug_varnames section contains the names of file-scope static variables, the offsets of the DIEs that represent the definitions of those variables, and the offsets of the compilation-units that contain the definitions of those variables.

6.15.8.1 dwarf_get_vars()

```
int dwarf_get_vars(  
    Dwarf_Debug dbg,  
    Dwarf_Var **vars,  
    Dwarf_Signed *var_count,  
    Dwarf_Error *error)
```

The function operates as described in `dwarf_get_globals` above. Descriptors should be freed using `dwarf_vars_dealloc()`.

6.15.8.2 dwarf_vars_dealloc()

```
void dwarf_vars_dealloc(Dwarf_Var *vars,  
    Dwarf_Signed number_of_vars)
```

Deallocs (frees) all memory allocated by `dwarf_get_vars()`.

6.15.8.3 dwarf_varname()

```
int dwarf_varname(  
    Dwarf_Var var,  
    char **    returned_name,  
    Dwarf_Error *error)
```

The function operates as described in `dwarf_globalname` above.

6.15.8.4 dwarf_var_die_offset()

```
int dwarf_var_die_offset(  
    Dwarf_Var var,  
    Dwarf_Off *returned_offset,  
    Dwarf_Error *error)
```

The function operates as described in `dwarf_global_die_offset` above.

6.15.8.5 dwarf_var_cu_offset()

```
int dwarf_var_cu_offset(  
    Dwarf_Var var,  
    Dwarf_Off *returned_offset,  
    Dwarf_Error *error)
```

The function operates as described in `dwarf_global_cu_offset` above.

6.15.8.6 dwarf_var_name_offsets()

```
int dwarf_var_name_offsets(  
    Dwarf_Var var,  
    char      **returned_name,  
    Dwarf_Off *die_offset,  
    Dwarf_Off *cu_offset,  
    Dwarf_Error *error)
```

The function operates as described in `dwarf_global_name_offsets` above.

6.16 Names Fast Access (DWARF5) `.debug_names`

The section `.debug_names` section is new in DWARF5 so a new set of functions is defined to access this section. This section replaces `.debug_pubnames` and `.debug_pubtypes` as those older sections were not found to be useful in practice.

The intent is that many compilation units (likely that of an entire program or shared object) will be placed in a single name table that will be the entire content of `.debug_names`, nothing in the DWARF5 standard in sections 6.1 and 6.1.1 insists there is only one name table in the `.debug_names` section.

Within a particular name table, Each name encoded is a separate row.

A name table is a space-efficient encoding of a table of names with columns of

- The name (string) of the item (for the row).
- An optional hashed value of the name.
- The string offset (which leads to the name in `.debug_str`)
- An index to the entry pool
- The abbreviation code (always non-zero) and a zero-terminated array of abbreviation entries (the same format as in `.debug_abbrev`).

The field referred to below (`name_table_count_out`) restricts valid name table numbers to 0 to (`name_table_count_out-1`);

See also Names Fast Access `.debug_gnu_pubnames`

6.16.1 `dwarf_dnames_header()`

```
int dwarf_dnames_header(Dwarf_Debug dbg,  
    Dwarf_Off starting_offset,  
    Dwarf_Dnames_Head * dn_out,  
    Dwarf_Off * offset_of_next_table,  
    Dwarf_Error * error);
```

The function `dwarf_dnames_header()` allocates an opaque data structure used in all the other `dnames` calls and allows access to a single `.debug_names` table. Normally there is only one such table in the section, but there could be more than one.

To access all `.debug_names` tables in the section do

```
void examfuncdname(Dwarf_Debug dbg)
{
    Dwarf_Dnames_Head dn = 0;
    Dwarf_Off starting_offset = 0;
    Dwarf_Off next_offset = 0;
    Dwarf_Error error = 0;
    int res = DW_DLV_OK;

    while (res == DW_DLV_OK ) {
        res = dwarf_dnames_header(dbg,starting_offset,
            &dn,&next_offset,&error);
        if (res == DW_DLV_NO_ENTRY) {
            /* All processed. */
            return;
        }
        if (res == DW_DLV_ERROR) {
            /* corrupt data. give up, or do something
             with the error record. */
            return;
        }
        /* Use the dn record to do dwarf_dnames calls */
        /* clean up */
        dwarf_dealloc_dnames(dn);
        dn = 0;
        starting_offset = next_offset;
    }
    return;
}
```

On success the function returns DW_DLV_OK and returns a pointer to the Head structure through dn_out and returns the section offset of the next table.

It returns DW_DLV_NO_ENTRY if there is record with that offset in the .debug_names section.

It returns DW_DLV_ERROR if there is an internal error such as data corruption in the section and if a Dwarf_Error* is passed in returns information on the error through that pointer.

6.16.2 dwarf_dnames_sizes()


```
int dwarf_dnames_sizes(Dwarf_Dnames_Head dn,
/* The counts are entry counts, not byte sizes. */
Dwarf_Unsigned * comp_unit_count,
Dwarf_Unsigned * local_type_unit_count,
Dwarf_Unsigned * foreign_type_unit_count,
Dwarf_Unsigned * bucket_count,
/* name_count gives the size of
the string_offsets and entry_offsets arrays,
and if hashes present, the size of the
hash_table array. */
Dwarf_Unsigned * name_count,

/* The following are all counted in bytes.
indextable_overall_length is the
length of all the data in the
specific name table. */
Dwarf_Unsigned * indextable_overall_length,

Dwarf_Unsigned * entry_pool_size, /* aka abbrev table*/
Dwarf_Unsigned * augmentation_string_size,
char ** augmentation_string,
Dwarf_Insigned * section_size,
Dwarf_Half * table version,
Dwarf_Error * error*)
```

Given a properly created head dn this Allows access to fields in a .debug_names table.

We will not describe the fields in detail here. See the DWARF5 standard and dwarfdump for the motivation of this function.

6.16.3 dwarf_dnames_cu_entry()

```
int dwarf_dnames_cu_entry(Dwarf_Dnames_Head dn,
Dwarf_Unsigned cu_index_number,
Dwarf_Unsigned * offset_count,
Dwarf_Unsigned * offset,
Dwarf_Error * error)
```

Given a properly created head dn this Allows access to fields in name table entry for one or more compilation units in a single name_index_number name table.

We will not describe the fields in detail here. See the DWARF5 standard and dwarfdump for the motivation of this function.

6.16.4 dwarf_dnames_local_tu_entry()

```
int dwarf_dnames_local_tu_entry(Dwarf_Dnames_Head dn,
    Dwarf_Unsigned    name_table_number,
    Dwarf_Unsigned    offset_number,
    Dwarf_Unsigned    * offset_count,
    Dwarf_Unsigned    * offset,
    Dwarf_Error *      error)
```

The same as `dwarf_dnames_cu_entry()` but referencing type unit fields.

6.16.5 dwarf_dnames_foreign_tu_entry()

```
int dwarf_dnames_foreign_tu_entry(
    Dwarf_Dnames_Head dn,
    Dwarf_Unsigned    name_table_number,
    Dwarf_Unsigned    sig_number,
    Dwarf_Unsigned    * sig_minimum,
    Dwarf_Unsigned    * sig_count,
    Dwarf_Sig8        * signature,
    Dwarf_Error *      error)
```

Allows retrieving the data for foreign type-unit entries.

6.16.6 dwarf_dnames_bucket()

```
int dwarf_dnames_bucket(
    Dwarf_Dnames_Head dn,
    Dwarf_Unsigned    name_table_number,
    Dwarf_Unsigned    bucket_number,
    Dwarf_Unsigned    * bucket_count,
    Dwarf_Unsigned    * index_of_name_entry,
    Dwarf_Error *      error)
```

Allows retrieving the data for hash buckets.

6.16.7 dwarf_dnames_name()

```
int dwarf_dnames_name(
    Dwarf_Dnames_Head dn,
    Dwarf_Unsigned    index_number,
    Dwarf_Unsigned    name_entry,
    Dwarf_Unsigned    * names_count,
    Dwarf_Sig8        * signature,
    Dwarf_Unsigned    * offset_to_debug_str,
    Dwarf_Unsigned    * offset_in_entrypool,
    Dwarf_Error *      error)
```

Allows retrieving the data about names and signatures.

6.16.8 dwarf_dnames_abbrev_by_index()

```
int dwarf_dnames_abbrev_by_index(  
    Dwarf_Dnames_Head dn,  
    Dwarf_Unsigned      name_table_number,  
    Dwarf_Unsigned      abbrev_entry,  
    Dwarf_Unsigned      * abbrev_code,  
    Dwarf_Unsigned      * tag,  
    Dwarf_Unsigned      * number_of_abbrev,  
    Dwarf_Unsigned      * number_of_attr_form_entries,  
    Dwarf_Error *        error)
```

Allows retrieving the abbreviations from a portion of the section by index.

6.16.9 dwarf_dnames_abbrev_form_by_index()

```
int dwarf_dnames_abbrev_form_by_index(  
    Dwarf_Dnames_Head dn,  
    Dwarf_Unsigned      name_table_number,  
    Dwarf_Unsigned      abbrev_entry_index,  
    Dwarf_Unsigned      * name_index_attr,  
    Dwarf_Unsigned      * form,  
    Dwarf_Unsigned      * number_of_attr_form_entries,  
    Dwarf_Error *        error)
```

Allows retrieving the abbreviations from a portion of the section by index.

6.16.10 dwarf_dnames_abbrev_by_code()

```
int dwarf_dnames_abbrev_by_code(  
    Dwarf_Dnames_Head dn,  
    Dwarf_Unsigned      name_table_number,  
    Dwarf_Unsigned      abbrev_code,  
    Dwarf_Unsigned      * tag,  
    Dwarf_Unsigned      * index_of_abbrev,  
    Dwarf_Unsigned      * index_of_attr_form_entries,  
    Dwarf_Error *        error)
```

Allows retrieving the abbreviations from a portion of the section by abbrev-code.

6.16.11 dwarf_dnames_entrypool()

```
int dwarf_dnames_entrypool(  
    Dwarf_Dnames_Head dn,  
    Dwarf_Unsigned      name_table_number,  
    Dwarf_Unsigned      offset_in_entrypool,  
    Dwarf_Unsigned      * abbrev_code,  
    Dwarf_Unsigned      * tag,  
    Dwarf_Unsigned      * value_count,  
    Dwarf_Unsigned      * index_of_abbrev,  
    Dwarf_Unsigned      * offset_of_initial_value,  
    Dwarf_Error *        error)
```

Allows retrieving the data from a portion of the entrypool by index and offset.

6.16.12 dwarf_dnames_entrypool_values()

```
int dwarf_dnames_entrypool_values(  
    Dwarf_Dnames_Head dn,  
    Dwarf_Unsigned      name_table_number,  
    Dwarf_Unsigned      index_of_abbrev,  
    Dwarf_Unsigned      offset_in_entrypool_of_values,  
    Dwarf_Unsigned      * array_dw_idx_number,  
    Dwarf_Unsigned      * array_form,  
    Dwarf_Unsigned      * array_of_offsets,  
    Dwarf_Sig8          * array_of_signatures,  
    Dwarf_Error *        error)
```

Allows retrieving detailed data from a portion of the entrypool by index and offset.

6.16.13 dwarf_dnames_cu_table()

```
int dwarf_dnames_cu_table(  
    Dwarf_Dnames_Head dn,  
    const char *type, /* "cu" or "tu" */  
    Dwarf_Unsigned      index_number,  
    Dwarf_Unsigned      offset,  
    Dwarf_Sig8          *signature,  
    Dwarf_Error *        error)
```

The count limits mentioned here are returned by the function `dwarf_dnames_sizes()`.

The "tu" category spans both the local and foreign type units. The lower values of `index_number` (less than `local_type_unit_count`) are local type units (offset is returned) while the upper values (`index_number < (local_type_unit_count + foreign_type_unit_count)`) are foreign type units (signature is returned).

The "cu" category only returns an offset. `index_number` must be less than `comp_unit_count`.

If `index_number` is outside the valid range `DW_DLV_NO_ENTRY` is returned.

In case of error `DW_DLV_NO_ENTRY` is returned.

6.16.14 `dwarf_dnames_name()`

```
int dwarf_dnames_name(  
    Dwarf_Dnames_Head dn,  
    Dwarf_Unsigned      name_index UNUSEDARG,  
    Dwarf_Unsigned      * bucket_number UNUSEDARG,  
    Dwarf_Unsigned      * hash_value UNUSEDARG,  
    Dwarf_Unsigned      * offset_to_debug_str UNUSEDARG,  
    char *              * ptrtostr,  
    Dwarf_Unsigned      * offset_in_entrypool UNUSEDARG,  
    Dwarf_Unsigned      * abbrev_number UNUSEDARG,  
    Dwarf_Half          * abbrev_tag UNUSEDARG,  
    Dwarf_Unsigned      array_size,  
    Dwarf_Half          * attr_array,  
    Dwarf_Unsigned      * attr_count UNUSEDARG ,  
    Dwarf_Error *        error)
```

This is supposed to present each effective Name Table entry with essentially all its data. The implementation details of the table are hidden. The function is, as yet, incomplete. **FIXME** `dwarf_dnames_name()` Currently only the attribute array data is returned, meaning the function is unusable..

6.17 Names Fast Access `.debug_gnu_pubnames`

The sections `.debug_gnu_pubnames` and `.debug_gnu_pubtypes` are non-standard sections emitted by gcc and clang with DWARF5. Typically they will be in the skeleton executable and the split dwarf section `.debug_info.dwo` will have the actual DWARF the offsets refer to, These sections would normally be read once by a program wanting them and filed in an internal format and then the program would do the cleanup `dwarf_gnu_index_dealloc()`.

Each section is divided into what we term blocks here and within each block there is an array of entries. The functions below enable access.

6.17.1 `dwarf_get_gnu_index_head()`

```
int dwarf_get_gnu_index_head(  
    Dwarf_Debug dbg,  
    /* The following arg false to select gnu_pubtypes */  
    Dwarf_Bool      for_gdb_pubnames ,  
    Dwarf_Gnu_Index_Head * head,  
    Dwarf_Unsigned   * index_block_count,  
    Dwarf_Error * error);
```

This creates an open header to use in subsequent data access. Free the memory associated with this by calling `dwarf_gnu_index_dealloc(head)`.

The field `index_block_count` is set through the pointer to the number of blocks in the section. Call `dwarf_get_gnu_index_block()` and pass in valid block number (zero through `index_block_count-1`) to get block information.

If the section does not exist or is empty it returns `DW_DLV_NO_ENTRY` and does nothing else.

If there is data corruption or some serious error it returns `DW_DLV_ERROR` and sets the error pointer with information about the error.

6.17.2 dwarf_gnu_index_dealloc()

```
void dwarf_gnu_index_dealloc(  
    Dwarf_Gnu_Index_Head index_head);
```

This frees all data associated with the section.

6.17.3 dwarf_get_gnu_index_block()

```
int dwarf_get_gnu_index_block(  
    Dwarf_Gnu_Index_Head head,  
    Dwarf_Unsigned      blocknumber,  
    Dwarf_Unsigned * block_length,  
    Dwarf_Half * version ,  
    Dwarf_Unsigned * offset_into_debug_info,  
    Dwarf_Unsigned * size_of_debug_info_area,  
    Dwarf_Unsigned * count_of_index_entries,  
    Dwarf_Error * error);
```

On success this returns `DW_DLV_OK` and fills in the various fields through the pointers. If the pointer to a field is null the function ignores that field.

The field `block_length` has the byte length of the block (with its entries).

The field `version` has the version number. Currently it must be 2.

The field `offsetinto_debug_info` is the offset (in some `.debug_info` or `.debug_info.owo` section) of a Compilation Unit Header.

The field `size_of_debug_info_area` is the size of the referenced compilation unit.

The field `count_of_index_entries` is the number of entries attached to the block. See `dwarf_get_gnu_index_block_entry()`.

If the block number is outside the valid range (zero through `index_block_count - 1`) it returns `DW_DLV_NO_ENTRY` and does nothing.

If there is data corruption or some serious error it returns `DW_DLV_ERROR` and sets the error pointer with information about the error.

6.17.4 `dwarf_get_gnu_index_block_entry()`

```
int dwarf_get_gnu_index_block_entry(  
    Dwarf_Gnu_Index_Head head,  
    Dwarf_Unsigned      blocknumber,  
    Dwarf_Unsigned      entrynumber,  
    Dwarf_Unsigned      * offset_in_debug_info  
    const char          ** name,  
    unsigned char        * flagbyte,  
    unsigned char        * staticorglobal,  
    unsigned char        * typeofentry,  
    Dwarf_Error          * error);
```

If either `blocknumber` or `entrynumber` is outside the range of valid values it returns `DW_DLV_NO_ENTRY` and does nothing.

On success it returns `DW_DLV_OK` and sets information about each entry through the pointers. Any pointers passed in as `NULL` are ignored.

The field `offset_in_debug_info` has the offset of DIE in a `.debug_info` section.

The field `name` has a pointer to the name of the variable or function that the DIE refers to.

The field `flagbyte` has the entire 8 bits of a byte that has two useful fields. The next two fields are those useful fields.

The field `staticorglobal` has an integer 0 if the DIE involved describes a global (externally-visible) name. It has an integer 1 if the name refers to a static (file-local) DIE.

The field `typeofentry` has a small integer describing the type. Zero means the type is "none". One means the type is "type". Two means the type is "variable". Three means the type is "function". Four means the type is "other". Any other value has, apparently, no assigned meaning.

If there is data corruption or some serious error it returns `DW_DLV_ERROR` and sets the error pointer with information about the error.

6.18 Macro Information Operations (DWARF4, DWARF5)

This section refers to DWARF4 and later macro information from the `.debug_macro` section (for DWARF 4 some producers generated `.debug_macro` before its formal standardization in DWARF 5). While standard operations are supported there is as yet no support for implementation-defined extensions. Once someone has defined such things it will make sense to design an interface for extensions.

6.18.1 Getting access

The opaque struct pointer `Dwarf_Macro_Context` is allocated by either `dwarf_get_macro_context()` or `dwarf_get_macro_context_by_offset()` and once the context is no longer needed one frees up all its storage by `dwarf_dealloc_macro_context()`.

6.18.1.1 `dwarf_get_macro_context()`

```
int dwarf_get_macro_context(Dwarf_Die die,
    Dwarf_Unsigned      * version_out,
    Dwarf_Macro_Context * macro_context,
    Dwarf_Unsigned      * macro_unit_offset_out,
    Dwarf_Unsigned      * macro_ops_count_out,
    Dwarf_Unsigned      * macro_ops_data_length_out,
    Dwarf_Error          * error);
```

Given a Compilation Unit (CU) `die`, on success `dwarf_get_macro_context()` opens a `Dwarf_Macro_Context` and returns a pointer to it and some data from the macro unit for that CU. The `Dwarf_Macro_Context` is used to get at the details of the macros.

The value `version_out` is set to the DWARF version number of the macro data. Version 5 means DWARF5 version information. Version 4 means the DWARF5 format macro data is present as an extension of DWARF4.

The value `macro_unit_offset_out` is set to the offset in the `.debug_macro` section of the first byte of macro data for this CU.

Macro unit is defined in the DWARF5 standard, Section 6.3 Macro Information on page 165.

The value `macro_ops_count_out` is set to the number of macro entries in the macro data data for this CU. The count includes the final zero entry (which is not really a macro, it is a terminator, a zero byte ending the macro unit).

The value `macro_ops_data_length_out` is set to the number of bytes of data in the set of ops (not including macro_unit header bytes). See `dwarf_macro_context_total_length()` to get the macro unit total length.

If `DW_DLV_NO_ENTRY` is returned the CU has no macro data attribute or there is no `.debug_macro` section present.

On error `DW_DLV_ERROR` is returned and the error details are returned through the pointer `error`.

6.18.1.2 `dwarf_get_macro_context_by_offset()`

```
int dwarf_get_macro_context_by_offset(Dwarf_Die die,
    Dwarf_Unsigned      offset,
    Dwarf_Unsigned      * version_out,
    Dwarf_Macro_Context * macro_context,
    Dwarf_Unsigned      * macro_ops_count_out,
    Dwarf_Unsigned      * macro_ops_total_byte_len,
    Dwarf_Error          * error);
```

Given a Compilation Unit (CU) die and the offset of an imported macro unit `dwarf_get_macro_context_by_offset()` opens a `Dwarf_Macro_Context` and returns a pointer to it and some data from the macro unit for that CU on success.

On success the function produces the same output values as `dwarf_get_macro_context()`.

If `DW_DLV_NO_ENTRY` is returned there is no `.debug_macro` section present.

On error `DW_DLV_ERROR` is returned and the error details are returned through the pointer `error`.

6.18.1.3 `dwarf_macro_context_total_length()`

```
int dwarf_macro_context_total_length(
    Dwarf_Macro_Context macro_context,
    Dwarf_Unsigned      *total_length,
    Dwarf_Error          * error);
```

New in December, 2020, `dwarf_macro_context_total_length()` because callers of `dwarf_get_macro_context[_by_offset]()` sometimes want to know the length of macro ops plus the length of the DWARF5-style header.

On success function returns `DW_DLV_OK` and sets `*total_length` to the total length of the DWARF5-style macro unit.

It never returns `DW_DLV_NO_ENTRY`.

If the `macro_context` argument is `NULL` or invalid it returns `DW_DLV_ERROR`. and sets `*error` to an appropriate error value.

6.18.1.4 dwarf_dealloc_macro_context()

```
void dwarf_dealloc_macro_context (Dwarf_Macro_Context  
    macro_context) ;
```

The function `dwarf_dealloc_macro_context()` cleans up memory allocated by a successful call to `dwarf_get_macro_context()` or `dwarf_get_macro_context_by_offset()`.

Figure 21. Examplep5 `dwarf_dealloc_macro_context()`

```
/* This builds an list or some other data structure
   (not defined) to give an import somewhere to list
   the import offset and then later to enquire
   if the list has unexamined offsets.
   A candidate set of hypothetical functions that
   callers would write:
   has_unchecked_import_in_list()
   get_next_import_from_list()
   mark_this_offset_as_examined(macro_unit_offset);
   add_offset_to_list(offset);
*/
void examplep5(Dwarf_Debug dbg, Dwarf_Die cu_die)
{
    int lres = 0;
    Dwarf_Unsigned version = 0;
    Dwarf_Macro_Context macro_context = 0;
    Dwarf_Unsigned macro_unit_offset = 0;
    Dwarf_Unsigned number_of_ops = 0;
    Dwarf_Unsigned ops_total_byte_len = 0;
    Dwarf_Bool is_primary = TRUE;
    unsigned k = 0;
    Dwarf_Error err = 0;

    for(;;) {
        if (is_primary) {
            lres = dwarf_get_macro_context(cu_die,
                                           &version, &macro_context,
                                           &macro_unit_offset,
                                           &number_of_ops,
                                           &ops_total_byte_len,
                                           &err);
            is_primary = FALSE;
        } else {
            if (has_unchecked_import_in_list()) {
                macro_unit_offset = get_next_import_from_list();
            } else {
                /* We are done */
                break;
            }
            lres = dwarf_get_macro_context_by_offset(cu_die,
                                                    macro_unit_offset,
                                                    &version,
                                                    &macro_context,
                                                    &number_of_ops,
                                                    &ops_total_byte_len,
                                                    &err);
        }
    }
}
```

```
        mark_this_offset_as_examined(macro_unit_offset);
    }

    if (lres == DW_DLV_ERROR) {
        /* Something is wrong. */
        return;
    }
    if (lres == DW_DLV_NO_ENTRY) {
        /* We are done. */
        break;
    }
    /* lres == DW_DLV_OK) */
    for (k = 0; k < number_of_ops; ++k) {
        Dwarf_Unsigned section_offset = 0;
        Dwarf_Half      macro_operator = 0;
        Dwarf_Half      forms_count = 0;
        const Dwarf_Small *formcode_array = 0;
        Dwarf_Unsigned line_number = 0;
        Dwarf_Unsigned index = 0;
        Dwarf_Unsigned offset = 0;
        const char      *macro_string = 0;
        int lres = 0;

        lres = dwarf_get_macro_op(macro_context,
                                k, &section_offset, &macro_operator,
                                &forms_count, &formcode_array, &err);
        if (lres != DW_DLV_OK) {
            print_error(dbg,
                       "ERROR from dwarf_get_macro_op()",
                       lres, err);
            dwarf_dealloc_macro_context(macro_context);
            return;
        }
        switch(macro_operator) {
        case 0:
            /* Nothing to do. This
               signifies it is the end-marker,
               standing in for the 0 byte
               at the end of his macro group. */
            break;
        case DW_MACRO_end_file:
            /* Do something */
            break;
        case DW_MACRO_define:
        case DW_MACRO_undef:
        case DW_MACRO_define_strp:
```

```
case DW_MACRO_undef_strp:
case DW_MACRO_define_strx:
case DW_MACRO_undef_strx:
case DW_MACRO_define_sup:
case DW_MACRO_undef_sup: {
    lres = dwarf_get_macro_defundef (macro_context,
        k,
        &line_number,
        &index,
        &offset,
        &forms_count,
        &macro_string,
        &err);
    if (lres != DW_DLV_OK) {
        print_error (dbg,
            "ERROR from sup dwarf_get_macro_defundef()",
            lres, err);
        dwarf_dealloc_macro_context (macro_context);
        return;
    }
    /* do something */
}
break;
case DW_MACRO_start_file: {
    lres = dwarf_get_macro_startend_file (macro_context,
        k, &line_number,
        &index,
        &macro_string, &err);
    if (lres != DW_DLV_OK) {
        print_error (dbg,
            "ERROR from dwarf_get_macro_"
            "startend_file() (sup)",
            lres, err);
        dwarf_dealloc_macro_context (macro_context);
        return;
    }
    /* do something */
}
break;
case DW_MACRO_import: {
    lres = dwarf_get_macro_import (macro_context,
        k, &offset, &err);
    if (lres != DW_DLV_OK) {
        print_error (dbg,
            "ERROR from dwarf_get_macro_import() (sup)",
            lres, err);
    }
}
```

```
        dwarf_dealloc_macro_context (macro_context);
        return;
    }
    add_offset_to_list (offset);
    }
    break;
case DW_MACRO_import_sup: {
    lres = dwarf_get_macro_import (macro_context,
        k, &offset, &err);
    if (lres != DW_DLV_OK) {
        print_error (dbg,
            "ERROR from dwarf_get_macro_import() (sup)",
            lres, err);
        dwarf_dealloc_macro_context (macro_context);
        return;
    }
    /* do something */
    }
    break;
}
}
dwarf_dealloc_macro_context (macro_context);
macro_context = 0;
}
}
```

6.18.2 Getting Macro Unit Header Data

6.18.2.1 dwarf_macro_context_head()

```
int dwarf_macro_context_head (Dwarf_Macro_Context
    macro_context,
    Dwarf_Half      * version,
    Dwarf_Unsigned * mac_offset,
    Dwarf_Unsigned * mac_len,
    Dwarf_Unsigned * mac_header_len,
    unsigned        * flags,
    Dwarf_Bool      * has_line_offset,
    Dwarf_Unsigned * line_offset,
    Dwarf_Bool      * has_offset_size_64,
    Dwarf_Bool      * has_operands_table,
    Dwarf_Half      * opcode_count,
    Dwarf_Error      * error);
```

Given a Dwarf_Macro_Context pointer this function returns the basic fields of a

macro unit header (Macro Information Header) on success.

The value `version` is set to the DWARF version number of the macro unit header. Version 5 means DWARF5 version information. Version 4 means the DWARF5 format macro data is present as an extension of DWARF4.

The value `mac_offset` is set to the offset in the `.debug_macro` section of the first byte of macro data for this CU.

The value `mac_len` is set to the number of bytes of data in the macro unit, including the macro unit header.

The value `mac_header_len` is set to the number of bytes in the macro unit header (not a field that is generally useful).

The value `flags` is set to the value of the `flags` field of the macro unit header.

The value `has_line_offset` is set to non-zero if the `debug_line_offset_flag` bit is set in the `flags` field of the macro unit header. If `has_line_offset` is set then `line_offset` is set to the value of the `debug_line_offset` field in the macro unit header. If `has_line_offset` is not set there is no `debug_line_offset` field present in the macro unit header.

The value `has_offset_size_64` is set non-zero if the `offset_size_flag` bit is set in the `flags` field of the macro unit header and in this case offset fields in this macro unit are 64 bits. If `has_offset_size_64` is not set then offset fields in this macro unit are 32 bits.

The value `has_operands_table` is set to non-zero if the `opcode_operands_table_flag` bit is set in the `flags` field of the macro unit header.

If `has_operands_table` is set non-zero then The value `opcode_count` is set to the number of opcodes in the macro unit header `opcode_operands_table`. See `dwarf_get_macro_op()`.

`DW_DLV_NO_ENTRY` is not returned.

On error `DW_DLV_ERROR` is returned and the error details are returned through the pointer `error`.

6.18.2.2 dwarf_get_macro_section_name()

```
int dwarf_get_macro_section_name(Dwarf_Debug dbg,
    const char **sec_name_out,
    Dwarf_Error * error);
```

If a `.debug_macro` section has been noted by libdwarf this returns the name through the `sec_name_out` pointer and returns `DW_DLV_OK`.

It returns `DW_DLV_ERROR` on some serious error (null `dbg`, corrupt object file etc).

It returns `DW_DLV_NO_ENTRY` if the section is absent or empty.

6.18.2.3 dwarf_macro_operands_table()

```
int dwarf_macro_operands_table(Dwarf_Macro_Context
    macro_context,
    Dwarf_Half    index, /* 0 to opcode_count -1 */
    Dwarf_Half    * opcode_number,
    Dwarf_Half    * operand_count,
    const Dwarf_Small ** operand_array,
    Dwarf_Error * error);
```

`dwarf_macro_operands_table()` is used to index through the operands table in a macro unit header if the operands table exists in the macro unit header. The operands table provides the mechanism for implementations to add extensions to the macro operations while allowing clients to skip macro operations the client code does not recognize.

The `macro_context` field passed in identifies the macro unit involved. The `index` field passed in identifies which macro operand to look at. Valid index values are zero through the `opcode_count-1` (returned by `dwarf_macro_context_head()`).

The `opcode_number` value returned through the pointer is the the macro operation code. The operation code could be one of the standard codes or if there are user extensions there would be an extension code in the `DW_MACRO_lo_user` to `DW_MACRO_hi_user` range.

The `operand_count` returned is the number of form codes in the form codes array of unsigned bytes `operand_array`.

`DW_DLV_NO_ENTRY` is not returned.

On error `DW_DLV_ERROR` is returned and the error details are returned through the pointer `error`.

6.18.3 Getting Individual Macro Operations Data

6.18.3.1 dwarf_get_macro_op()

```
int dwarf_get_macro_op(Dwarf_Macro_Context macro_context,
    Dwarf_Unsigned op_number,
    Dwarf_Unsigned * op_start_section_offset,
    Dwarf_Half    * macro_operator,
    Dwarf_Half    * forms_count,
    const Dwarf_Small ** formcode_array,
    Dwarf_Error * error);
```

Use `dwarf_get_macro_op()` to access the macro operations of this macro unit.

The `macro_context` field passed in identifies the macro unit involved. The `op_number` field passed in identifies which macro operand to look at. Valid index

values are zero through `macro_ops_count_out-1` (field returned by `dwarf_get_macro_context()` or `dwarf_get_macro_context_by_offset()`)

On success the function returns values through the pointers.

If `macro_operator` returned is zero that means this is a placeholder for the null byte at the end of this array of macros. The other pointer values returned are also zero in this case.

The `op_start_section_offset` returned is useful for debugging but otherwise is not normally useful. It is the byte offset of the beginning of this macro operator's data.

The `macro_operator` returned is one of the defined macro operations such as `DW_MACRO_define`. This is the field you will use to choose what call to use to get the data for a macro operator. For example, for `DW_MACRO_undef` one would call `dwarf_get_macro_defundef()` (see below) to get the details about the undefine.

The `forms_count` returned is useful for debugging but otherwise is not normally useful. It is the number of bytes of form numbers in the `formcode_array` of this macro operator's applicable forms.

`DW_DLV_NO_ENTRY` is not returned.

On error `DW_DLV_ERROR` is returned and the error details are returned through the pointer `error`.

6.18.3.2 `dwarf_get_macro_defundef()`

```
int dwarf_get_macro_defundef(Dwarf_Macro_Context
    macro_context,
    Dwarf_Unsigned    op_number,
    Dwarf_Unsigned * line_number,
    Dwarf_Unsigned * index,
    Dwarf_Unsigned * offset,
    Dwarf_Half      * forms_count,
    const char      ** macro_string,
    Dwarf_Error      * error);
```

Call `dwarf_get_macro_defundef` for any of the macro define/undefine operators. Which fields are set through the pointers depends on the particular operator.

The `macro_context` field passed in identifies the macro unit involved. The `op_number` field passed in identifies which macro operand to look at. Valid index values are zero through `macro_ops_count_out-1` (field returned by `dwarf_get_macro_context()` or `dwarf_get_macro_context_by_offset()`).

The `line_number` field is set with the source line number of the macro.

The `index` field only set meaningfully if the macro operator is

DW_MACRO_define_strx or DW_MACRO_undef_strx. If set it is an index into an array of offsets in the .debug_str_offsets section.

The offset field only set meaningfully if the macro operator is DW_MACRO_define_strx, DW_MACRO_undef_strx, DW_MACRO_define_strp, or DW_MACRO_undef_strp. If set it is an offset of a string in the .debug_str section.

The forms_count is set to the number of forms that apply to the macro operator.

The macro_string pointer is used to return a pointer to the macro string. If the actual string cannot be found (as when section with the string is in a different object, see set_tied_dbg()) the string returned may be "<:No string available>" or "<.debug_str_offsets not available>" (without the quotes).

The function returns DW_DLV_NO_ENTRY if the macro operation is not one of the define/undef operations.

On error DW_DLV_ERROR is returned and the error details are returned through the pointer error.

6.18.3.3 dwarf_get_macro_startend_file()

```
int dwarf_get_macro_startend_file(Dwarf_Macro_Context
    macro_context,
    Dwarf_Unsigned op_number,
    Dwarf_Unsigned * line_number,
    Dwarf_Unsigned * name_index_to_line_tab,
    const char ** src_file_name,
    Dwarf_Error * error);
```

Call dwarf_get_macro_startend_file for operators DW_MACRO_start_file or DW_MACRO_end_file.

The macro_context field passed in identifies the macro unit involved.

The op_number field passed in identifies which macro operand to look at. Valid index values are zero through macro_ops_count_out-1 (field returned by dwarf_get_macro_context() or dwarf_get_macro_context_by_offset()).

For DW_MACRO_end_file none of the following fields are set on successful return, they are only set for DW_MACRO_start_file

The line_number field is set with the source line number of the macro.

The name_index_to_line_tab field is set with the index into the file name table of the line table section. For DWARF2, DWARF3, DWARF4 line tables the index value assumes DWARF2 line table header rules (identical to DWARF3, DWARF4 line table header rules). For DWARF5 the index value assumes DWARF5 line table header rules. The src_file_name is set with the source file name. If the index seems wrong or the line table is unavailable the name returned is "<no-source-file-name-available>");

The function returns DW_DLV_NO_ENTRY if the macro operation is not one of the start/end operations.

On error DW_DLV_ERROR is returned and the error details are returned through the pointer `error`.

6.18.3.4 dwarf_get_macro_import()

```
int dwarf_get_macro_import(Dwarf_Macro_Context macro_context,  
    Dwarf_Unsigned op_number,  
    Dwarf_Unsigned * target_offset,  
    Dwarf_Error * error);
```

Call `dwarf_get_macro_import` for operators `DW_MACRO_import` or `DW_MACRO_import_sup`.

The `macro_context` field passed in identifies the macro unit involved. The `op_number` field passed in identifies which macro operand to look at. Valid index values are zero through `macro_ops_count_out-1` (field returned by `dwarf_get_macro_context()` or `dwarf_get_macro_context_by_offset()`)

On success the `target_offset` field is set to the offset in the referenced section. For `DW_MACRO_import` the referenced section is the same section as the macro operation referenced here. For `DW_MACRO_import_sup` the referenced section is in a supplementary object.

The function returns DW_DLV_NO_ENTRY if the macro operation is not one of the import operations.

On error DW_DLV_ERROR is returned and the error details are returned through the pointer `error`.

6.19 Macro Information Operations (DWARF2, DWARF3, DWARF4)

This section refers to DWARF2,DWARF3,and DWARF4 macro information from the `.debug_macinfo` section. These do not apply to DWARF5 macro data.

6.19.1 General Macro Operations

6.19.1.1 dwarf_find_macro_value_start()

```
char *dwarf_find_macro_value_start(char * macro_string);
```

Given a macro string in the standard form defined in the DWARF document ("name <space> value" or "name(args)<space>value") this returns a pointer to the first byte of the macro value. It does not alter the string pointed to by `macro_string` or copy the string: it returns a pointer into the string whose address was passed in.

6.19.2 Debugger Interface Macro Operations

Macro information is accessed from the `.debug_info` section via the `DW_AT_macro_info` attribute (whose value is an offset into `.debug_macinfo`).

No Functions yet defined.

6.19.3 Low Level Macro Information Operations

6.19.3.1 `dwarf_get_macro_details()`

```
int dwarf_get_macro_details(Dwarf_Debug /*dbg*/,
    Dwarf_Off          macro_offset,
    Dwarf_Unsigned     maximum_count,
    Dwarf_Signed       * entry_count,
    Dwarf_Macro_Details ** details,
    Dwarf_Error *      err);
```

`dwarf_get_macro_details()` returns `DW_DLV_OK` and sets `entry_count` to the number of details records returned through the `details` pointer. The data returned through `details` should be freed by a call to `dwarf_dealloc()` with the allocation type `DW_DLA_STRING`. If `DW_DLV_OK` is returned, the `entry_count` will be at least 1, since a compilation unit with macro information but no macros will have at least one macro data byte of 0.

`dwarf_get_macro_details()` begins at the `macro_offset` offset you supply and ends at the end of a compilation unit or at `maximum_count` detail records (whichever comes first). If `maximum_count` is 0, it is treated as if it were the maximum possible unsigned integer.

`dwarf_get_macro_details()` attempts to set `dmd_fileindex` to the correct file in every `details` record. If it is unable to do so (or whenever the current file index is unknown, it sets `dmd_fileindex` to -1.

`dwarf_get_macro_details()` returns `DW_DLV_ERROR` on error. It returns `DW_DLV_NO_ENTRY` if there is no more macro information at that `macro_offset`. If `macro_offset` is passed in as 0, a `DW_DLV_NO_ENTRY` return means there is no macro information.

Figure 22. Examplep2 `dwarf_get_macro_details()`

```
void examplep2(Dwarf_Debug dbg, Dwarf_Off cur_off)
{
    Dwarf_Error error = 0;
    Dwarf_Signed count = 0;
    Dwarf_Macro_Details *maclist = 0;
    Dwarf_Signed i = 0;
    Dwarf_Unsigned max = 500000; /* sanity limit */
    int errv = 0;

    /* Given an offset from a compilation unit,
       start at that offset (from DW_AT_macroinfo)
       and get its macro details. */
    errv = dwarf_get_macro_details(dbg, cur_off, max,
                                   &count, &maclist, &error);
    if (errv == DW_DLV_OK) {
        for (i = 0; i < count; ++i) {
            Dwarf_Macro_Details * mentry = maclist + i;
            /* example of use */
            Dwarf_Signed lineno = mentry->dmd_lineno;
            functionusingsigned(lineno);
        }
        dwarf_dealloc(dbg, maclist, DW_DLA_STRING);
    }
    /* Loop through all the compilation units macro info from zero.
       This is not guaranteed to work because DWARF does not
       guarantee every byte in the section is meaningful:
       there can be garbage between the macro info
       for CUs. But this loop will sometimes work.
    */
    cur_off = 0;
    while((errv = dwarf_get_macro_details(dbg, cur_off, max,
                                           &count, &maclist, &error)) == DW_DLV_OK) {
        for (i = 0; i < count; ++i) {
            Dwarf_Macro_Details * mentry = maclist + i;
            /* example of use */
            Dwarf_Signed lineno = mentry->dmd_lineno;
            functionusingsigned(lineno);
        }
        cur_off = maclist[count-1].dmd_offset + 1;
        dwarf_dealloc(dbg, maclist, DW_DLA_STRING);
    }
}
```

6.20 Low Level Frame Operations

These functions provide information about stack frames to be used to perform stack traces. The information is an abstraction of a table with a row per instruction and a column per register and a column for the canonical frame address (CFA, which corresponds to the notion of a frame pointer), as well as a column for the return address.

We say that `DW_FRAME_CFA_COL3`, `DW_FRAME_UNDEFINED_VAL`, and `DW_FRAME_SAME_VAL` are synthetic column numbers, not columns in the actual tables. These columns may be user-chosen by calls of `dwarf_set_frame_cfa_value()`, `dwarf_set_frame_undefined_value()`, and `dwarf_set_frame_same_value()` respectively.

Each cell in the table contains one of the following:

1. A register + offset(a)(b)
2. A register(c)(d)
3. A marker (`DW_FRAME_UNDEFINED_VAL`) meaning *register value undefined*
4. A marker (`DW_FRAME_SAME_VAL`) meaning *register value same as in caller*

The CFA is separately accessible and not part of the table. The 'rule number' for the CFA is a number outside the table. So the CFA is a marker, not a register number. See `DW_FRAME_CFA_COL3` in `libdwarf.h` and `dwarf_get_fde_info_for_cfa_reg3_b()` and `dwarf_set_frame_rule_cfa_value()`.

(b) When the column is not `DW_FRAME_CFA_COL3`, the 'register' will and must be `DW_FRAME_CFA_COL3(COL)`, implying that to get the final location for the column one must add the offset here plus the `DW_FRAME_CFA_COL3` rule value.

(c) When the column is `DW_FRAME_CFA_COL3`, then the 'register' number is (must be) a real hardware register . (This paragraph does not apply to the April 2006 new interface). If it were `DW_FRAME_UNDEFINED_VAL` or `DW_FRAME_SAME_VAL` it would be a marker, not a register number.

(d) When the column is not `DW_FRAME_CFA_COL3`, the register may be a hardware register. It will not be `DW_FRAME_CFA_COL3`.

There is no 'column' for `DW_FRAME_UNDEFINED_VAL` or `DW_FRAME_SAME_VAL`. Nor for `DW_FRAME_CFA_COL3`.

Figure 23. Frame Information Special Values any architecture

The following table shows more general special cell values. These values mean that the cell register-number refers to the *cfa-register* or *undefined-value* or *same-value* respectively, rather than referring to a *register in the table*. The generality arises from

making DW_FRAME_CFA_COL3 be outside the set of registers and making the cfa rule accessible from outside the rule-table.

NAME	value	PURPOSE
DW_FRAME_UNDEFINED_VAL	1034	means undefined value. Not a column or register value
DW_FRAME_SAME_VAL	1035	means 'same value' as caller had. Not a column or register value
DW_FRAME_CFA_COL3	1436	means 'cfa register' is referred to, not a real register, not a column, but the cfa (the cfa does have a value, but in the DWARF3 libdwarf interface it does not have a 'real register number').

6.20.1 dwarf_get_frame_section_name()

```
int dwarf_get_frame_section_name(Dwarf_Debug dbg,
    const char ** sec_name,
    Dwarf_Error *error)
```

dwarf_get_string_section_name() lets consumers access the object string section name. This is useful for applications wanting to print the name, but of course the object section name is not really a part of the DWARF information. Most applications will probably not call this function. It can be called at any time after the Dwarf_Debug initialization is done. See also dwarf_get_frame_section_name_eh_gnu().

The function dwarf_get_frame_section_name() operates on the the .debug_frame section.

If the function succeeds, *sec_name is set to a pointer to a string with the object section name and the function returns DW_DLV_OK. Do not free the string whose pointer is returned. For non-Elf objects it is possible the string pointer returned will be NULL or will point to an empty string. It is up to the calling application to recognize this possibility and deal with it appropriately.

If the section does not exist the function returns DW_DLV_NO_ENTRY.

If there is an internal error detected the function returns DW_DLV_ERROR and sets the *error pointer.

6.20.2 dwarf_get_frame_section_name_eh_gnu()

```
int dwarf_get_frame_section_name_eh_gnu(Dwarf_Debug dbg
    const char ** sec_name,
    Dwarf_Error *error)
```

dwarf_get_frame_section_name_eh_gnu() lets consumers access the object string section name. This is useful for applications wanting to print the name, but of

course the object section name is not really a part of the DWARF information. Most applications will probably not call this function. It can be called at any time after the Dwarf_Debug initialization is done. See also dwarf_get_frame_section_name().

The function dwarf_get_frame_section_name_eh_gnu() operates on the the .eh_frame section.

If the function succeeds, *sec_name is set to a pointer to a string with the object section name and the function returns DW_DLV_OK. Do not free the string whose pointer is returned. For non-Elf objects it is possible the string pointer returned will be NULL or will point to an empty string. It is up to the calling application to recognize this possibility and deal with it appropriately.

If the section does not exist the function returns DW_DLV_NO_ENTRY.

If there is an internal error detected the function returns DW_DLV_ERROR and sets the *error pointer.

6.20.3 dwarf_get_fde_list()

```
int dwarf_get_fde_list(  
    Dwarf_Debug dbg,  
    Dwarf_Cie **cie_data,  
    Dwarf_Signed *cie_element_count,  
    Dwarf_Fde **fde_data,  
    Dwarf_Signed *fde_element_count,  
    Dwarf_Error *error);
```

dwarf_get_fde_list() stores a pointer to a list of Dwarf_Cie descriptors in *cie_data, and the count of the number of descriptors in *cie_element_count. There is a descriptor for each CIE in the .debug_frame section. Similarly, it stores a pointer to a list of Dwarf_Fde descriptors in *fde_data, and the count of the number of descriptors in *fde_element_count. There is one descriptor per FDE in the .debug_frame section. dwarf_get_fde_list() returns DW_DLV_ERROR on error. It returns DW_DLV_NO_ENTRY if it cannot find frame entries. It returns DW_DLV_OK on a successful return.

On successful return, structures pointed to by a descriptor should be freed using dwarf_dealloc_fde_cie_list(). This dealloc approach is new as of July 15, 2005.

Figure 24. Example of dwarf_get_fde_list()


```
void exampleq(Dwarf_Debug dbg)
{
    Dwarf_Cie *cie_data = 0;
    Dwarf_Signed cie_count = 0;
    Dwarf_Fde *fde_data = 0;
    Dwarf_Signed fde_count = 0;
    Dwarf_Error error = 0;
    int fres = 0;

    fres = dwarf_get_fde_list(dbg, &cie_data, &cie_count,
                             &fde_data, &fde_count, &error);
    if (fres == DW_DLV_OK) {
        dwarf_dealloc_fde_cie_list(dbg, cie_data, cie_count,
                                   fde_data, fde_count);
    }
}
```

6.20.4 dwarf_dealloc_fde_cie_list()

```
void dwarf_dealloc_fde_cie_list(
    Dwarf_Debug dbg,
    Dwarf_Cie *cie_data,
    Dwarf_Signed cie_element_count,
    Dwarf_Fde *fde_data,
    Dwarf_Signed fde_element_count);
```

dwarf_dealloc_fde_cie_list() frees memory allocated by a call to dwarf_get_fde_list_eh() or dwarf_get_fde_list().

6.20.5 dwarf_get_fde_list_eh()

```
int dwarf_get_fde_list_eh(
    Dwarf_Debug dbg,
    Dwarf_Cie **cie_data,
    Dwarf_Signed *cie_element_count,
    Dwarf_Fde **fde_data,
    Dwarf_Signed *fde_element_count,
    Dwarf_Error *error);
```

dwarf_get_fde_list_eh() is identical to dwarf_get_fde_list() except that dwarf_get_fde_list_eh() reads the GNU gcc section named .eh_frame (C++ exception handling information).

dwarf_get_fde_list_eh() stores a pointer to a list of Dwarf_Cie descriptors in *cie_data, and the count of the number of descriptors in *cie_element_count.

There is a descriptor for each CIE in the `.debug_frame` section. Similarly, it stores a pointer to a list of `Dwarf_Fde` descriptors in `*fde_data`, and the count of the number of descriptors in `*fde_element_count`. There is one descriptor per FDE in the `.debug_frame` section. `dwarf_get_fde_list()` returns `DW_DLV_ERROR` on error. It returns `DW_DLV_NO_ENTRY` if it cannot find exception handling entries. It returns `DW_DLV_OK` on a successful return.

On successful return, structures pointed to by a descriptor should be freed using `dwarf_dealloc_fde_cie_list()`. This dealloc approach is new as of July 15, 2005.

Figure 25. Exemplar `dwarf_get_fde_list_eh()`

```
void exemplar(Dwarf_Debug dbg,Dwarf_Addr mypcval)
{
    /*  Given a pc value
        for a function find the FDE and CIE data for
        the function.
        Example shows basic access to FDE/CIE plus
        one way to access details given a PC value.
        dwarf_get_fde_n() allows accessing all FDE/CIE
        data so one could build up an application-specific
        table of information if that is more useful.  */
    Dwarf_Signed count = 0;
    Dwarf_Cie *cie_data = 0;
    Dwarf_Signed cie_count = 0;
    Dwarf_Fde *fde_data = 0;
    Dwarf_Signed fde_count = 0;
    Dwarf_Error error = 0;
    int fres = 0;

    fres = dwarf_get_fde_list_eh(dbg,&cie_data,&cie_count,
                                &fde_data,&fde_count,&error);
    if (fres == DW_DLV_OK) {
        Dwarf_Fde myfde = 0;
        Dwarf_Addr low_pc = 0;
        Dwarf_Addr high_pc = 0;
        fres = dwarf_get_fde_at_pc(fde_data,mypcval,
                                &myfde,&low_pc,&high_pc,
                                &error);
        if (fres == DW_DLV_OK) {
            Dwarf_Cie mycie = 0;
            fres = dwarf_get_cie_of_fde(myfde,&mycie,&error);
            if (fres == DW_DLV_OK) {
                /*  Now we can access a range of information
                    about the fde and cie applicable.  */
            }
        }
        dwarf_dealloc_fde_cie_list(dbg, cie_data, cie_count,
                                fde_data,fde_count);
    }
    /* ERROR or NO ENTRY. Do something */
}
```

6.20.6 dwarf_get_cie_augmentation_data()

```
int dwarf_get_cie_augmentation_data(Dwarf_Cie cie,  
    Dwarf_Small ** /* augdata */,  
    Dwarf_Unsigned * /* augdata_len */,  
    Dwarf_Error *error);
```

This only works with GNU .eh_frame, not with .debug_frame.

6.20.7 dwarf_get_fde_augmentation_data()

```
int dwarf_get_fde_augmentation_data(Dwarf_Fde fde,  
    Dwarf_Small ** /* augdata */,  
    Dwarf_Unsigned * /* augdata_len */,  
    Dwarf_Error *error);
```

This only works with GNU .eh_frame, not with .debug_frame.

6.20.8 dwarf_get_cie_of_fde()

```
int dwarf_get_cie_of_fde(Dwarf_Fde fde,  
    Dwarf_Cie *cie_returned,  
    Dwarf_Error *error);
```

dwarf_get_cie_of_fde() stores a Dwarf_Cie into the Dwarf_Cie that cie_returned points at.

If one has called dwarf_get_fde_list() must avoid dwarf_dealloc-ing the FDEs and the CIEs for those FDEs individually (see its documentation here). Failing to observe this restriction will cause the FDE(s) not dealloc'd to become invalid: an FDE contains (hidden in it) a CIE pointer which will be be invalid (stale, pointing to freed memory) if the CIE is dealloc'd. The invalid CIE pointer internal to the FDE cannot be detected as invalid by libdwarf. If one later passes an FDE with a stale internal CIE pointer to one of the routines taking an FDE as input the result will be failure of the call (returning DW_DLV_ERROR) at best and it is possible a coredump or worse will happen (eventually).

dwarf_get_cie_of_fde() returns DW_DLV_OK if it is successful (it will be unless fde is the NULL pointer). It returns DW_DLV_ERROR if the fde is invalid (NULL).

Each Dwarf_Fde descriptor describes information about the frame for a particular subroutine or function.

int dwarf_get_fde_for_die is SGI/MIPS specific.

6.20.9 dwarf_get_fde_for_die()

```
int dwarf_get_fde_for_die(  
    Dwarf_Debug dbg,  
    Dwarf_Die die,  
    Dwarf_Fde * return_fde,  
    Dwarf_Error *error)
```

When it succeeds, `dwarf_get_fde_for_die()` returns `DW_DLV_OK` and sets `*return_fde` to a `Dwarf_Fde` descriptor representing frame information for the given die. It looks for the `DW_AT_MIPS_fde` attribute in the given die. If it finds it, it uses the value of the attribute as the offset in the `.debug_frame` section where the FDE begins. If there is no `DW_AT_MIPS_fde` it returns `DW_DLV_NO_ENTRY`. If there is an error it returns `DW_DLV_ERROR`.

6.20.10 dwarf_get_fde_range()

```
int dwarf_get_fde_range(  
    Dwarf_Fde fde,  
    Dwarf_Addr *low_pc,  
    Dwarf_Unsigned *func_length,  
    Dwarf_Ptr *fde_bytes,  
    Dwarf_Unsigned *fde_byte_length,  
    Dwarf_Off *cie_offset,  
    Dwarf_Signed *cie_index,  
    Dwarf_Off *fde_offset,  
    Dwarf_Error *error);
```

On success, `dwarf_get_fde_range()` returns `DW_DLV_OK`.

The location pointed to by `low_pc` is set to the low pc value for this function.

The location pointed to by `func_length` is set to the length of the function in bytes. This is essentially the length of the text section for the function.

The location pointed to by `fde_bytes` is set to the address where the FDE begins in the `.debug_frame` section.

The location pointed to by `fde_byte_length` is set to the length in bytes of the portion of `.debug_frame` for this FDE. This is the same as the value returned by `dwarf_get_fde_range`.

The location pointed to by `cie_offset` is set to the offset in the `.debug_frame` section of the CIE used by this FDE.

The location pointed to by `cie_index` is set to the index of the CIE used by this FDE. The index is the index of the CIE in the list pointed to by `cie_data` as set by the

function `dwarf_get_fde_list()`. However, if the function `dwarf_get_fde_for_die()` was used to obtain the given fde, this index may not be correct.

The location pointed to by `fde_offset` is set to the offset of the start of this FDE in the `.debug_frame` section.

`dwarf_get_fde_range()` returns `DW_DLV_ERROR` on error.

6.20.11 dwarf_get_cie_info_b()

```
int dwarf_get_cie_info_b(  
    Dwarf_Cie      cie,  
    Dwarf_Unsigned *bytes_in_cie,  
    Dwarf_Small    *version,  
    char           **augmenter,  
    Dwarf_Unsigned *code_alignment_factor,  
    Dwarf_Signed  *data_alignment_factor,  
    Dwarf_Half    *return_address_register_rule,  
    Dwarf_Ptr      *initial_instructions,  
    Dwarf_Unsigned *initial_instructions_length,  
    Dwarf_Half     *offset_size,  
    Dwarf_Error    *error);
```

`dwarf_get_cie_info_b()` is primarily for Internal-level Interface consumers. If successful, it returns `DW_DLV_OK` and sets `*bytes_in_cie` to the number of bytes in the portion of the frames section for the CIE represented by the given `Dwarf_Cie` descriptor, `cie`. The other fields are directly taken from the `cie` and returned, via the pointers to the caller. It returns `DW_DLV_ERROR` on error.

6.20.12 dwarf_get_cie_index()

```
int dwarf_get_cie_index(  
    Dwarf_Cie cie,  
    Dwarf_Signed *cie_index,  
    Dwarf_Error *error);
```

On success, `dwarf_get_cie_index()` returns `DW_DLV_OK`. On error this function returns `DW_DLV_ERROR`.

The location pointed to by `cie_index` is set to the index of the CIE of this FDE. The index is the index of the CIE in the list pointed to by `cie_data` as set by the function `dwarf_get_fde_list()`.

So one must have used `dwarf_get_fde_list()` or `dwarf_get_fde_list_eh()` to get a cie list before this is meaningful.

This function is occasionally useful, but is little used.

6.20.13 dwarf_get_fde_instr_bytes()

```
int dwarf_get_fde_instr_bytes(  
    Dwarf_Fde fde,  
    Dwarf_Ptr *outinstrs,  
    Dwarf_Unsigned *outlen,  
    Dwarf_Error *error);
```

`dwarf_get_fde_instr_bytes()` returns `DW_DLV_OK` and sets `*outinstrs` to a pointer to a set of bytes which are the actual frame instructions for this fde. It also sets `*outlen` to the length, in bytes, of the frame instructions. It returns `DW_DLV_ERROR` on error. It never returns `DW_DLV_NO_ENTRY`. The intent is to allow low-level consumers like a dwarf-dumper to print the bytes in some fashion. The memory pointed to by `outinstrs` must not be changed and there is nothing to free.

6.20.14 dwarf_fde_section_offset()

```
int dwarf_fde_section_offset(  
    Dwarf_Debug /*dbg*/,  
    Dwarf_Fde /*in_fde*/,  
    Dwarf_Off * /*fde_off*/,  
    Dwarf_Off * /*cie_off*/,  
    Dwarf_Error *error);
```

On success `dwarf_fde_section_offset()` returns the `.dwarf_line` section offset of the fde passed in and also the offset of its CIE.

It returns `DW_DLV_ERROR` if there is an error.

It returns `DW_DLV_ERROR` if there is an error.

It is intended to be used by applications like `dwarfdump` when such want to print the offsets of CIEs and FDEs.

6.20.15 dwarf_cie_section_offset()

```
int dwarf_cie_section_offset(  
    Dwarf_Debug /*dbg*/,  
    Dwarf_Cie /*in_cie*/,  
    Dwarf_Off * /*cie_off*/,  
    Dwarf_Error * /*err*/);  
Dwarf_Error *error);
```

On success `dwarf_cie_section_offset()` returns the `.dwarf_line` section offset of the cie passed in.

It returns `DW_DLV_ERROR` if there is an error.

It is intended to be used by applications like dwarfdump when such want to print the offsets of CIEs.

6.20.16 dwarf_set_frame_rule_table_size()

This allows consumers to set the size of the (internal to libdwarf) rule table when using the 'reg3' interfaces (these interfaces are strongly preferred over the older 'reg' interfaces). It should be at least as large as the number of real registers in the ABI which is to be read in for the dwarf_get_fde_info_for_reg3_b() or dwarf_get_fde_info_for_all_regs3() functions to work properly.

The frame rule table size must be less than the marker values DW_FRAME_UNDEFINED_VAL, DW_FRAME_SAME_VAL, DW_FRAME_CFA_COL3 (dwarf_set_frame_rule_undefined_value() dwarf_set_frame_same_value() dwarf_set_frame_cfa_value() effectively set these markers so the frame rule table size can actually be any value regardless of the macro values in libdwarf.h as long as the table size does not overlap these markers).

```
Dwarf_Half
dwarf_set_frame_rule_table_size(Dwarf_Debug dbg,
                                Dwarf_Half value);
```

dwarf_set_frame_rule_table_size() sets the value value as the size of libdwarf-internal rules tables of dbg.

The function returns the previous value of the rules table size setting (taken from the dbg structure).

6.20.17 dwarf_set_frame_rule_initial_value()

This allows consumers to set the initial value for rows in the frame tables. By default it is taken from libdwarf.h and is DW_FRAME_REG_INITIAL_VALUE. The MIPS/IRIX default is DW_FRAME_SAME_VAL. Consumer code should set this appropriately and for many architectures (but probably not MIPS) DW_FRAME_UNDEFINED_VAL is an appropriate setting.

```
Dwarf_Half
dwarf_set_frame_rule_initial_value(Dwarf_Debug dbg,
                                   Dwarf_Half value);
```

dwarf_set_frame_rule_initial_value() sets the value value as the initial value for this dbg when initializing rules tables.

The function returns the previous value of initial value (taken from the dbg structure).

It is important that the value is higher than any register number appearing in DWARF.

6.20.18 dwarf_set_frame_same_value()

This allows consumers to set the 'same value' for rows in the frame tables. By default it is taken from libdwarf.h and is DW_FRAME_SAME_VAL. The MIPS/IRIX default is DW_FRAME_SAME_VAL. Consumer code should set this appropriately and for many architectures (but probably not MIPS) DW_FRAME_UNDEFINED_VAL is an appropriate setting.

```
Dwarf_Half  
dwarf_set_frame_same_value(Dwarf_Debug dbg,  
                           Dwarf_Half value);
```

It is important that the value is higher than any register number appearing in DWARF.

The function returns the previous value of initial value (taken from the dbg structure).

6.20.19 dwarf_set_frame_rule_undefined_value()

This allows consumers to set the initial value for rows in the frame tables. By default it is DW_FRAME_UNDEFINED_VAL.

```
Dwarf_Half  
dwarf_set_frame_undefined_value(Dwarf_Debug dbg,  
                                Dwarf_Half value);
```

It is important that the value is higher than any register number appearing in DWARF.

The function returns the previous value of initial value (taken from the dbg structure).

6.20.20 dwarf_set_default_address_size()

This allows consumers to set a default address size. When one has an object where the default address_size does not match the frame address size where there is no debug_info available to get a frame-specific address-size, this function is useful. For example, if an Elf64 object has a .debug_frame whose real address_size is 4 (32 bits). This is a very rare situation.

```
Dwarf_Small  
dwarf_set_default_address_size(Dwarf_Debug dbg,  
                               Dwarf_Small value);
```

dwarf_set_default_address_size() sets the value value as the default address size for this activation of the reader, but only if value is greater than zero (otherwise the default address size is not changed).

The function returns the previous value of the default address size (taken from the dbg structure).

6.20.21 dwarf_get_fde_info_for_reg3_b()

This interface is suitable for DWARF2 and later. It returns the values for a particular real register (Not for the CFA virtual register, see dwarf_get_fde_info_for_cfa_reg3_b() below). If the application is going to retrieve the value for more than a few table_column values at this pc_requested (by calling this function multiple times) it is much more efficient to call dwarf_get_fde_info_for_all_regs3() (in spite of the additional setup that requires of the caller).

```
int dwarf_get_fde_info_for_reg3_b(  
    Dwarf_Fde fde,  
    Dwarf_Half table_column,  
    Dwarf_Addr pc_requested,  
    Dwarf_Small *value_type,  
    Dwarf_Unsigned *offset_relevant,  
    Dwarf_Unsigned *register_num,  
    Dwarf_Unsigned *offset,  
    Dwarf_Block *block_content,  
    Dwarf_Addr *row_pc,  
    Dwarf_Bool *has_more_rows,  
    Dwarf_Addr *subsequent_pc,  
    Dwarf_Error *error);
```

if *value_type has the value DW_EXPR_OFFSET (0) then:

It sets *offset_relevant to non-zero if the offset is relevant for the row specified by pc_requested and column specified by table_column or, for the FDE specified by fde. In this case the *register_num will be set to DW_FRAME_CFA_COL3 (. This is an offset(N) rule as specified in the DWARF3/2 documents.

Adding the value of *offset to the value of the CFA register gives the address of a location holding the previous value of register table_column.

If offset is not relevant for this rule, *offset_relevant is set to zero. *register_num will be set to the number of the real register holding the value of the table_column register. This is the register(R) rule as specified in DWARF3/2 documents.

The intent is to return the rule for the given pc value and register. The location pointed to by register_num is set to the register value for the rule. The location pointed to by offset is set to the offset value for the rule. Since more than one pc value will have rows with identical entries, the user may want to know the earliest pc value after which the rules for all the columns remained unchanged. Recall that in the virtual table that the frame information represents there may be one or more table rows with identical data (each such table row at a different pc value). Given a pc_requested which refers to a pc in such a group of identical rows, the location pointed to by row_pc is set to the lowest pc value within the group of identical rows.

If `*value_type` has the value `DW_EXPR_VAL_OFFSET` (1) then:

This will be a `val_offset(N)` rule as specified in the DWARF3/2 documents so `*offset_relevant` will be non zero.

The calculation is identical to the `DW_EXPR_OFFSET` (0) calculation with `*offset_relevant` non-zero, but the value resulting is the actual `table_column` value (rather than the address where the value may be found).

If `*value_type` has the value `DW_EXPR_EXPRESSION` (1) then:

`*block` is set contain the to the length in bytes of a block of memory with a DWARF expression in the block and a pointer to the block of memory.. The consumer code should evaluate the block as a DWARF-expression. The result is the address where the previous value of the register may be found. This is a DWARF3/2 `expression(E)` rule.

If `*value_type` has the value `DW_EXPR_VAL_EXPRESSION` (1) then:

The calculation is exactly as for `DW_EXPR_EXPRESSION` (1) but the result of the DWARF-expression evaluation is the value of the `table_column` (not the address of the value). This is a DWARF3/2 `val_expression(E)` rule.

Arguments `has_more_rows` and `subsequent_pc` which allow the caller to know if there are more rows in the frame table and what the next pc value in the frame table for this fde is. The two new arguments may be passed in as `NULL` if their values are not needed by the caller.

6.20.22 `dwarf_get_fde_info_for_cfa_reg3_b()`

```
int dwarf_get_fde_info_for_cfa_reg3_b(Dwarf_Fde fde,
Dwarf_Addr      pc_requested,
Dwarf_Small *   value_type,
Dwarf_Unsigned* offset_relevant,
Dwarf_Unsigned* register_num,
Dwarf_Unsigned* offset,
Dwarf_Block *   block ,
Dwarf_Addr *    row_pc_out,
Dwarf_Bool *    has_more_rows,
Dwarf_Addr *    subsequent_pc,
Dwarf_Error *   error)
```

For a tool just wanting the frame information for a single `pc_value` this interface is no more useful or efficient than `dwarf_get_fde_info_for_cfa_reg3_b()`.

The essential difference is that when using `dwarf_get_fde_info_for_cfa_reg3_b()` for all pc values for a function the caller has no idea what is the next pc value that might have new frame data and iterating through pc values (calling `dwarf_get_fde_info_for_cfa_reg3_b()` on each)

is a waste of cpu cycles. With `dwarf_get_fde_info_for_cfa_reg3_b()` the `has_more_rows` and `subsequent_pc` arguments let the caller know whether there are further rows and if so at what pc value.

If `has_more_rows` is non-null then 1 is returned through the pointer if, for the `pc_requested` there is frame data for addresses after `pc_requested` in the frame. And if there are no more rows in the frame data then 0 is set through the `has_more_rows` pointer.

If `subsequent_pc` is non-null then the pc-value which has the next frame operator is returned through the pointer. If no more rows are present zero is returned through the pointer, but please use `has_more_rows` to determine if there are more rows.

6.20.23 dwarf_get_fde_info_for_all_regs3()

```
int dwarf_get_fde_info_for_all_regs3(  
    Dwarf_Fde fde,  
    Dwarf_Addr pc_requested,  
    Dwarf_Regtable3 *reg_table,  
    Dwarf_Addr *row_pc,  
    Dwarf_Error *error)
```

`dwarf_get_fde_info_for_all_regs3()` returns `DW_DLV_OK` and sets `*reg_table` for the row specified by `pc_requested` for the FDE specified by `fde`. The intent is to return the rules for decoding all the registers, given a pc value. `reg_table` is an array of rules, the array size specified by the caller. plus a rule for the CFA. The rule for the cfa returned in `*reg_table` defines the CFA value at `pc_requested`. The rule for each register contains several values that enable the consumer to determine the previous value of the register (see the earlier documentation of `Dwarf_Regtable3`). `dwarf_get_fde_info_for_reg3()` and the `Dwarf_Regtable3` documentation above for a description of the values for each row.

`dwarf_get_fde_info_for_all_regs3` returns `DW_DLV_ERROR` if there is an error.

It is up to the caller to allocate space for `*reg_table` and initialize it properly.

6.20.24 dwarf_get_fde_n()

```
int dwarf_get_fde_n(  
    Dwarf_Fde *fde_data,  
    Dwarf_Unsigned fde_index,  
    Dwarf_Fde *returned_fde  
    Dwarf_Error *error)
```

`dwarf_get_fde_n()` returns `DW_DLV_OK` and sets `returned_fde` to the `Dwarf_Fde` descriptor whose index is `fde_index` in the table of `Dwarf_Fde` descriptors pointed to by `fde_data`. The index starts with 0. The table pointed to by `fde_data` is required to contain at least one entry. If the table has no entries at all the error checks may refer to uninitialized memory. Returns `DW_DLV_NO_ENTRY` if the index does not exist in the table of `Dwarf_Fde` descriptors. Returns `DW_DLV_ERROR` if there is an error. This function cannot be used unless the block of `Dwarf_Fde` descriptors has been created by a call to `dwarf_get_fde_list()`.

6.20.25 dwarf_get_fde_at_pc()

```
int dwarf_get_fde_at_pc(  
    Dwarf_Fde *fde_data,  
    Dwarf_Addr pc_of_interest,  
    Dwarf_Fde *returned_fde,  
    Dwarf_Addr *lopc,  
    Dwarf_Addr *hipc,  
    Dwarf_Error *error)
```

`dwarf_get_fde_at_pc()` returns `DW_DLV_OK` and sets `returned_fde` to a `Dwarf_Fde` descriptor for a function which contains the `pc` value specified by `pc_of_interest`. In addition, it sets the locations pointed to by `lopc` and `hipc` to the low address and the high address covered by this FDE, respectively. The table pointed to by `fde_data` is required to contain at least one entry. If the table has no entries at all the error checks may refer to uninitialized memory. It returns `DW_DLV_ERROR` on error. It returns `DW_DLV_NO_ENTRY` if `pc_of_interest` is not in any of the FDEs represented by the block of `Dwarf_Fde` descriptors pointed to by `fde_data`. This function cannot be used unless the block of `Dwarf_Fde` descriptors has been created by a call to `dwarf_get_fde_list()`.

6.20.26 dwarf_expand_frame_instructions()

```
int dwarf_expand_frame_instructions(  
    Dwarf_Cie cie,  
    Dwarf_Ptr instruction,  
    Dwarf_Unsigned i_length,  
    Dwarf_Frame_Instr_Head * /*head*/,  
    Dwarf_Unsigned * /*instr_count*/,  
    Dwarf_Error *error);
```

`dwarf_expand_frame_instructions()` is a High-level interface function which

expands a frame instruction byte stream into internal data attached to the `head` pointer passed back.

On error it returns `DW_DLV_ERROR`.

To indicate success, it returns `DW_DLV_OK`.

It does not return `DW_DLV_NO_ENTRY`.

Figure 26. Examples `dwarf_expand_frame_instructions()`

```
void examples(Dwarf_Cie cie,
              Dwarf_Ptr instruction, Dwarf_Unsigned len)
{
    Dwarf_Frame_Instr_Head head = 0;
    Dwarf_Unsigned count = 0;
    Dwarf_Error error = 0;
    int res = 0;

    res = dwarf_expand_frame_instructions(cie, instruction, len,
                                         &head, &count, &error);
    if (res == DW_DLV_OK) {
        Dwarf_Unsigned i = 0;

        for (i = 0; i < count; ++i) {
            Dwarf_Unsigned instr_offset_in_instrs = 0;
            Dwarf_Small cfa_operation = 0;
            const char *fields_description = 0;
            Dwarf_Unsigned u0 = 0;
            Dwarf_Unsigned u1 = 0;
            Dwarf_Signed s0 = 0;
            Dwarf_Signed s1 = 0;
            Dwarf_Unsigned code_alignment_factor = 0;
            Dwarf_Signed data_alignment_factor = 0;
            Dwarf_Block expression_block;
            const char * op_name = 0;

            memset(&expression_block, 0, sizeof(expression_block));
            res = dwarf_get_frame_instruction(head, i,
                                             &instr_offset_in_instrs, &cfa_operation,
                                             &fields_description, &u0, &u1,
                                             &s0, &s1,
                                             &code_alignment_factor,
                                             &data_alignment_factor,
                                             &expression_block, &error);
            if (res == DW_DLV_OK) {
                res = dwarf_get_CFA_name(cfa_operation,
                                         &op_name);
                if (res != DW_DLV_OK) {
                    op_name = "unknown op";
                }
                printf("Instr %2lu %-22s %s0,
                      (unsigned long)i,
                      op_name,
                      fields_description);
                /* do something with the various data
                   as guided by the fields_description. */
            }
        }
    }
}
```

```
        }  
    }  
    dwarf_dealloc_frame_instr_head(head);  
}  
}
```

6.20.27 dwarf_get_frame_instruction()

```
int dwarf_get_frame_instruction(  
    Dwarf_Frame_Instr_Head head,  
    Dwarf_Unsigned    instr_index,  
    Dwarf_Unsigned    * instr_offset_in_instrs,  
    Dwarf_Small        * cfa_operation,  
    const char        ** fields,  
    Dwarf_Unsigned    * u0,  
    Dwarf_Unsigned    * u1,  
    Dwarf_Signed       * s0,  
    Dwarf_Signed       * s1,  
    Dwarf_Unsigned    * code_alignment_factor,  
    Dwarf_Signed       * data_alignment_factor,  
    Dwarf_Block        * expression_block,  
    Dwarf_Error        * error)
```

This function reports the details of a single DW_CFA_ instruction. The `instr_index` input must be less than `returned_instr_count` which was reported by the call to `dwarf_expand_frame_instructions()` which created `head`.

If `instr_index` is `>= returned_instr_count` the function returns `DW_DLV_NO_ENTRY`.

On error it returns `DW_DLV_ERROR` and returns error details in `*error`.

With the details presented one can fully understand what the instructions mean, though to reproduce the calculations of a runtime evaluation in some cases there may be augmentation data that affects the interpretation. Such augmentation data is not Standard DWARF and is not further mentioned here.

See the DWARF5 standard for details on doing the calculations. See also `src/bin/dwarfexample/frame1.c` and `src/bin/dwarfdump/print_frames.c`

The `fields` pointer returned is the key to understand what the following fields contain. This approach was chosen as there are quite a few CFA instructions, but only eleven different formats. So several of the keys apply to multiple DW_CFA instruction codes.

fields	return fields set
" "	No fields in the instruction
"b"	b=expression_block
"r"	u0=the register number
"rb"	u0=register number, b=expression_block
"rr"	u0 and u1, register numbers
"rsd"	u1=register, s1 value, data_alignment_factor.
"ru"	u0=register u1=value
"rud"	u0=register, u1=value, data_alignment_factor.
"sd"	s0=value, data_alignment_factor
"u"	u0=value
"uc"	u0=value, code_alignment_factor

See dwarf_expand_frame_instructions() above for an example of use.

6.20.28 dwarf_dealloc_frame_instr_head()

```
void dealloc_frame_instr_head( Dwarf_Frame_Instr_Head head);
```

This deallocs(frees) all space associated with head] fP.

6.20.29 dwarf_get_fde_exception_info()

```
int dwarf_get_fde_exception_info(  
    Dwarf_Fde fde,  
    Dwarf_Signed * offset_into_exception_tables,  
    Dwarf_Error * error);
```

dwarf_get_fde_exception_info() is an IRIX specific function which returns an exception table signed offset through offset_into_exception_tables. The function never returns DW_DLV_NO_ENTRY. If DW_DLV_NO_ENTRY is NULL the function returns DW_DLV_ERROR. For non-IRIX objects the offset returned will always be zero. For non-C++ objects the offset returned will always be zero. The meaning of the offset and the content of the tables is not defined in this document. The applicable CIE augmentation string (see above) determines whether the value returned has meaning.

6.21 Location Expression Evaluation

An "interpreter" which evaluates a location expression is required in any debugger. There is no interface defined here at this time.

One problem with defining an interface is that operations are machine dependent: they depend on the interpretation of register numbers and the methods of getting values from the environment the expression is applied to.

It would be desirable to specify an interface.

6.22 Abbreviations access

These are Internal-level Interface functions. Debuggers can ignore this.

6.22.1 dwarf_get_abbrev()

```
int dwarf_get_abbrev(  
    Dwarf_Debug dbg,  
    Dwarf_Unsigned offset,  
    Dwarf_Abbrev *returned_abbrev,  
    Dwarf_Unsigned *length,  
    Dwarf_Unsigned *attr_count,  
    Dwarf_Error *error)
```

The function `dwarf_get_abbrev()` returns `DW_DLV_OK` and sets `*returned_abbrev` to `Dwarf_Abbrev`, a descriptor for the abbreviation that begins at offset `*offset` in the abbreviations section (i.e. `.debug_abbrev`) on success. The user is responsible for making sure that a valid abbreviation begins at `offset` in the abbreviations section. The location pointed to by `length` is set to the length in bytes of the abbreviation set in the abbreviations section. The location pointed to by `attr_count` is set to the number of attributes in the abbreviation. An abbreviation entry with a length of 1 is the 0 byte of the last abbreviation entry of a compilation unit.

`dwarf_get_abbrev()` returns `DW_DLV_NO_ENTRY` if the `.debug_abbrev` section is missing or if the offset passed in is past the end of the section.

`dwarf_get_abbrev()` returns `DW_DLV_ERROR` on error. If the call succeeds, the storage pointed to by `*returned_abbrev` should be freed, using `dwarf_dealloc()` with the allocation type `DW_DLA_ABBREV` when no longer needed.

6.22.2 dwarf_get_abbrev_tag()

```
int dwarf_get_abbrev_tag(  
    Dwarf_Abbrev abbrev,  
    Dwarf_Half *return_tag,  
    Dwarf_Error *error);
```

If successful, `dwarf_get_abbrev_tag()` returns `DW_DLV_OK` and sets `*return_tag` to the *tag* of the given abbreviation. It returns `DW_DLV_ERROR` on error. It never returns `DW_DLV_NO_ENTRY`.

6.22.3 dwarf_get_abbrev_code()

```
int dwarf_get_abbrev_code(  
    Dwarf_Abbrev    abbrev,  
    Dwarf_Unsigned  *return_code,  
    Dwarf_Error     *error);
```

If successful, `dwarf_get_abbrev_code()` returns `DW_DLV_OK` and sets `*return_code` to the abbreviation code of the given abbreviation. It returns `DW_DLV_ERROR` on error. It never returns `DW_DLV_NO_ENTRY`.

6.22.4 dwarf_get_abbrev_children_flag()

```
int dwarf_get_abbrev_children_flag(  
    Dwarf_Abbrev abbrev,  
    Dwarf_Signed  *returned_flag,  
    Dwarf_Error  *error)
```

The function `dwarf_get_abbrev_children_flag()` returns `DW_DLV_OK` and sets `returned_flag` to `DW_children_no` (if the given abbreviation indicates that a die with that abbreviation has no children) or `DW_children_yes` (if the given abbreviation indicates that a die with that abbreviation has a child). It returns `DW_DLV_ERROR` on error.

6.22.5 dwarf_get_abbrev_entry_b()

```
int dwarf_get_abbrev_entry_b(Dwarf_Abbrev abbrev,  
    Dwarf_Unsigned index,  
    Dwarf_Bool     filter_outliers,  
    Dwarf_Unsigned * returned_attr_num,  
    Dwarf_Unsigned * returned_form,  
    Dwarf_Signed   * returned_implicit_const,  
    Dwarf_Off      * offset,  
    Dwarf_Error    * error)
```

`dwarf_get_abbrev_entry_b()` is new in August 2019. It should be used in place of `dwarf_get_abbrev_entry()` as `dwarf_get_abbrev_entry()` cannot return the DWARF5 implicit const value and `dwarf_get_abbrev_entry()` can hide some instances of corrupt uleb abbreviation values.

While the `returned_attr_num` and `returned_form` are only correct if they each fit in a `Dwarf_Half` value, we return larger values in certain cases (see next paragraph).

If `filter_outliers` is passed in zero then erroneous `returned_attr_num` or `returned_form` are returned whether their values are sensible or not and `DW_DLV_OK` is the returned value. This is useful for `dwarfdump` as `dwarfdump` checks abbreviation values quite thoroughly and reports errors in detail (`dwarfdump -kb`).

If `filter_outliers` is passed in non-zero then `DW_DLV_OK` is returned only if `returned_attr_num` and `returned_form` are both legitimate values.

If successful, `dwarf_get_abbrev_entry_b()` returns `DW_DLV_OK` and sets `*attr_num` to the attribute code of the attribute whose index is specified by `index` in the given abbreviation.

The index starts at 0.

The location pointed to by `returned_attr_num` is set to the attribute number (example: `DW_AT_name`). The location pointed to by `returned_form` is set to the form of the attribute (example: `DW_FORM_string`). The location pointed to by `returned_implicit_const` is set to the implicit const value if and only if the FORM returned is `DW_FORM_implicit_const`.

The location pointed to by `offset` is set to the byte offset of the attribute in the abbreviations section.

The function returns `DW_DLV_NO_ENTRY` if the index specified is outside the range of attributes in this abbreviation.

The function returns `DW_DLV_ERROR` on error and sets `*error` to an error value instance.

6.23 String Section Operations

The `.debug_str` section contains only strings. Debuggers need never use this interface: it is only for debugging problems with the string section itself.

6.23.1 `dwarf_get_string_section_name()`

```
int dwarf_get_string_section_name(Dwarf_Debug dbg,
    const char ** sec_name,
    Dwarf_Error *error)
```

`dwarf_get_string_section_name()` lets consumers access the object string section name. This is useful for applications wanting to print the name, but of course the object section name is not really a part of the DWARF information. Most applications will probably not call this function. It can be called at any time after the `Dwarf_Debug` initialization is done. See also `dwarf_get_die_section_name_b()`.

The function `dwarf_get_string_section_name()` operates on the the `.debug_string[.dwo]` section.

If the function succeeds, `*sec_name` is set to a pointer to a string with the object section name and the function returns `DW_DLV_OK`. Do not free the string whose pointer is returned. For non-Elf objects it is possible the string pointer returned will be `NULL` or will point to an empty string. It is up to the calling application to recognize this possibility and deal with it appropriately.

If the section does not exist the function returns `DW_DLV_NO_ENTRY`.

If there is an internal error detected the function returns `DW_DLV_ERROR` and sets the `*error` pointer.

6.23.2 dwarf_get_str()

```
int dwarf_get_str(  
    Dwarf_Debug    dbg,  
    Dwarf_Off      offset,  
    char           **string,  
    Dwarf_Signed   *returned_str_len,  
    Dwarf_Error    *error)
```

The function `dwarf_get_str()` returns `DW_DLV_OK` and sets `*returned_str_len` to the length of the string, not counting the null terminator, that begins at the offset specified by `offset` in the `.debug_str` section. The location pointed to by `string` is set to a pointer to this string. The next string in the `.debug_str` section begins at the previous `offset + 1 + *returned_str_len`. A zero-length string is NOT the end of the section. If there is no `.debug_str` section, `DW_DLV_NO_ENTRY` is returned. If there is an error, `DW_DLV_ERROR` is returned. If we are at the end of the section (that is, `offset` is one past the end of the section) `DW_DLV_NO_ENTRY` is returned. If the `offset` is some other too-large value then `DW_DLV_ERROR` is returned.

6.24 String Offsets Section Operations

The `.debug_str_offsets` section contains only table arrays (with headers) and Debuggers should never need to use this interface. The normal string access functions use the section tables transparently. The functions here are only intended to allow `dwarfdump` (or the like) print the section completely and to help compiler developers look for bugs in the section.

Figure 27. `examplestringoffsets dwarf_open_str_offsets_table_access()` etc

```
void examplestringoffsets(Dwarf_Debug dbg)
{
    int res = 0;
    Dwarf_Str_Offsets_Table sot = 0;
    Dwarf_Unsigned wasted_byte_count = 0;
    Dwarf_Unsigned table_count = 0;
    Dwarf_Error error = 0;

    res = dwarf_open_str_offsets_table_access(dbg, &sot, &error);
    if(res == DW_DLV_NO_ENTRY) {
        /* No such table */
        return;
    }
    if(res == DW_DLV_ERROR) {
        /* Something is very wrong. Print the error? */
        return;
    }
    for(;;) {
        Dwarf_Unsigned unit_length = 0;
        Dwarf_Unsigned unit_length_offset = 0;
        Dwarf_Unsigned table_start_offset = 0;
        Dwarf_Half entry_size = 0;
        Dwarf_Half version = 0;
        Dwarf_Half padding = 0;
        Dwarf_Unsigned table_value_count = 0;
        Dwarf_Unsigned i = 0;
        Dwarf_Unsigned table_entry_value = 0;

        res = dwarf_next_str_offsets_table(sot,
            &unit_length, &unit_length_offset,
            &table_start_offset,
            &entry_size, &version, &padding,
            &table_value_count, &error);
        if (res == DW_DLV_NO_ENTRY) {
            /* We have dealt with all tables */
            break;
        }
        if (res == DW_DLV_ERROR) {
            /* Something badly wrong. Do something. */
            return;
        }
        /* One could call dwarf_str_offsets_statistics to
           get the wasted bytes so far, but we do not do that
           in this example. */
        /* Possibly print the various table-related values
           returned just above. */
    }
}
```

```
    for (i=0; i < table_value_count; ++i) {
        res = dwarf_str_offsets_value_by_index(sot,i,
            &table_entry_value,&error);
        if (res != DW_DLV_OK) {
            /* Something is badly wrong. Do something. */
            return;
        }
        /* Do something with the table_entry_value
           at this index. Maybe just print it.
           It is an offset in .debug_str. */
    }
}
res = dwarf_str_offsets_statistics(sot,&wasted_byte_count,
    &table_count,&error);
if (res == DW_DLV_OK) {
    /* The wasted byte count is set. Print it or something.
       One hopes zero bytes are wasted.
       Print the table count if one is interested. */
}
res = dwarf_close_str_offsets_table_access(sot,&error);
/* There is little point in checking the return value
   as little can be done about any error. */
sot = 0;
}
```

6.24.1 dwarf_open_str_offsets_table_access()

```
int dwarf_open_str_offsets_table_access(
    Dwarf_Debug dbg,
    Dwarf_Str_Offsets_Table * table_data,
    Dwarf_Error * error);
```

dwarf_open_str_offsets_table_access() creates an opaque struct and returns a pointer to it on success. That struct pointer is used in all subsequent operations on the table. Through the function dwarf_next_str_offsets_table() the caller can iterate through each of the per-CU offset tables.

If there is no such section, or if the section is empty the function returns DW_DLV_NO_ENTRY.

If there is an error (such as out-of-memory) the function returns DW_DLV_ERROR and sets an error value through the error pointer.

6.24.2 dwarf_close_str_offsets_table_access()

```
int
dwarf_close_str_offsets_table_access(
    Dwarf_Str_Offsets_Table  table_data,
    Dwarf_Error               * error);
```

On success, `dwarf_close_str_offsets_table_access()` frees any allocated data associated with the struct pointed to by `table_data` and returns `DW_DLV_OK`. It is up to the caller to set the `table_data` pointer to `NULL` if desired. The pointer is unusable at that point and any other calls to `libdwarf` using that pointer will fail.

It returns `DW_DLV_OK` on error. Any error suggests there is memory corruption or an error in the call. Something serious happened.

It never returns `DW_DLV_NO_ENTRY`, but if it did there would be nothing the caller could do anyway..

If one forgets to call this function the memory allocated will be freed automatically by to call to `dwarf_finish()`, as is true of all other data allocated by `libdwarf`.

6.24.3 dwarf_next_str_offsets_table()

```
int dwarf_next_str_offsets_table(
    Dwarf_Str_Offsets_Table table,
    Dwarf_Unsigned *unit_length_out,
    Dwarf_Unsigned *unit_length_offset_out,
    Dwarf_Unsigned *table_start_offset_out,
    Dwarf_Half     *entry_size_out,
    Dwarf_Half     *version_out,
    Dwarf_Half     *padding_out,
    Dwarf_Unsigned *table_value_count_out,
    Dwarf_Error    * error);
```

Each call to `dwarf_next_str_offsets_table()` returns the next String Offsets table in the `.debug_str_offsets` section. Typically there would be one such table for each CU in `.debug_info[dwo]` contributing to `.debug_str_offsets`. The table contains (internally, hidden) the section offset of the next table.

On success it returns `DW_DLV_OK` and sets various fields representing data about the current table (fields described below).

If there are no more tables it returns `DW_DLV_NO_ENTRY`.

On error it returns `DW_DLV_ERROR` and passes back error details through the `error` pointer.

The returned values are intended to let the caller understand the table header and the table in detail. These pointers are only used if the call returned `DW_DLV_OK`.

`unit_length_out` is set to the `unit_length` of a String Offsets Table Header. Which means it gives the length, in bytes, of the data following the length value that belongs to this table.

`unit_length_offset_out` is set to the section offset of the table header.

`table_start_offset_out` is set to the section offset of the array of offsets in this table.

`entry_size_out` is set to the size of a table entry. Which is 4 for 32-bit offsets in this table and 8 for 64-bit offsets in this table.

`version_out` is set to the version number in the table header. The only current valid value is 5.

`padding_out` is set to the 16-bit padding value in the table header. In a correct table header the value is zero.

`table_value_count_out` is set to the number of entries in the array of offsets in this table. Each entry is `entry_size_out` bytes long. Use this value in calling `dwarf_str_offsets_value_by_index()`.

6.24.4 `dwarf_str_offsets_value_by_index()`

```
int dwarf_str_offsets_value_by_index(  
    Dwarf_Str_Offsets_Table sot,  
    Dwarf_Unsigned index,  
    Dwarf_Unsigned *stroffset,  
    Dwarf_Error *error);
```

On success, `dwarf_str_offsets_value_by_index()` returns `DW_DLV_OK` and sets the offset from the array of string offsets in the current table at the input `index`.

Valid index values are zero through `table_value_count_out - 1`

A function is used instead of simply letting callers use pointers as `libdwarf` correctly handles endianness differences (between the system running `libdwarf` and the object file being inspected) so offsets can be reported properly.

`DW_DLV_ERROR` is returned on error.

`DW_DLV_NO_ENTRY` is never returned.

6.24.5 `dwarf_str_offsets_statistics()`

```
int dwarf_str_offsets_statistics(  
    Dwarf_Str_Offsets_Table table_data,  
    Dwarf_Unsigned *wasted_byte_count,  
    Dwarf_Unsigned *table_count,  
    Dwarf_Error *error);
```

Normally called after all tables have been inspected to return (through a pointer) the count of apparently-wasted bytes in the section. It can be called at any point that the `Dwarf_Str_Offsets_Table` pointer is valid.

On error it returns `DW_DLV_ERROR` and sets an error value through the pointer.

`DW_DLV_NO_ENTRY` is never returned.

On success it returns DW_DLV_OK and sets values through the two pointers. Calling just after each table is accessed by `dwarf_next_str_offsets_table()` will reveal the sum of all wasted bytes at that point in iterating through the section.

`table_count` is the count of table headers encountered so far.

By wasted bytes we mean bytes in between tables. `libdwarf` has no idea whether any apparently-valid table data is in fact useless.

6.25 Address Range Operations

These functions provide information about address ranges. The content is in the `.debug_aranges` section. Address ranges map ranges of pc values to the corresponding compilation-unit die that covers the address range. In the DWARF2,3,4 Standards this is described under "Accelerated Access" "Lookup by Address".

6.25.1 dwarf_get_aranges_section_name()

```
int dwarf_get_aranges_section_name(Dwarf_Debug dbg,
    const char ** sec_name,
    Dwarf_Error *error)
```

`*dwarf_get_aranges_section_name()` retrieves the object file section name of the applicable aranges section. This is useful for applications wanting to print the name, but of course the object section name is not really a part of the DWARF information. Most applications will probably not call this function. It can be called at any time after the `Dwarf_Debug` initialization is done.

If the function succeeds, `*sec_name` is set to a pointer to a string with the object section name and the function returns DW_DLV_OK. Do not free the string whose pointer is returned. For non-Elf objects it is possible the string pointer returned will be NULL or will point to an empty string. It is up to the calling application to recognize this possibility and deal with it appropriately.

If the section does not exist the function returns DW_DLV_NO_ENTRY.

If there is an internal error detected the function returns DW_DLV_ERROR and sets the `*error` pointer.

6.25.2 dwarf_get_aranges()

```
int dwarf_get_aranges(
    Dwarf_Debug dbg,
    Dwarf_Arange **aranges,
    Dwarf_Signed * returned_arange_count,
    Dwarf_Error *error)
```

The function `dwarf_get_aranges()` returns `DW_DLV_OK` and sets `*returned_arange_count` to the count of the number of address ranges in the `.debug_aranges` section (for all compilation units). It sets `*aranges` to point to a block of `Dwarf_Arange` descriptors, one for each address range. It returns `DW_DLV_ERROR` on error. It returns `DW_DLV_NO_ENTRY` if there is no `.debug_aranges` section.

This not only reads all the ranges, it also reads the per-compilation-unit headers in `.debug_aranges` and verifies they make sense.

Figure 28. Example `void dwarf_get_aranges()`

```
void exampleu(Dwarf_Debug dbg)
{
    Dwarf_Signed count = 0;
    Dwarf_Arange *arang = 0;
    int res = 0;
    Dwarf_Error error = 0;

    res = dwarf_get_aranges(dbg, &arang, &count, &error);
    if (res == DW_DLV_OK) {
        Dwarf_Signed i = 0;

        for (i = 0; i < count; ++i) {
            /* use arang[i] */
            dwarf_dealloc(dbg, arang[i], DW_DLA_ARANGE);
        }
        dwarf_dealloc(dbg, arang, DW_DLA_LIST);
    }
}
```

6.25.3 `dwarf_get_arange()`

```
int dwarf_get_arange(
    Dwarf_Arange *aranges,
    Dwarf_Unsigned arange_count,
    Dwarf_Addr address,
    Dwarf_Arange *returned_arange,
    Dwarf_Error *error);
```

The function `dwarf_get_arange()` takes as input a pointer to a block of `Dwarf_Arange` pointers, and a count of the number of descriptors in the block. It then searches for the descriptor that covers the given address. If it finds one, it returns `DW_DLV_OK` and sets `*returned_arange` to the descriptor. It returns `DW_DLV_ERROR` on error. It returns `DW_DLV_NO_ENTRY` if there is no `.debug_aranges` entry covering that address.

6.25.4 dwarf_get_cu_die_offset()

```
int dwarf_get_cu_die_offset(  
    Dwarf_Arange arange,  
    Dwarf_Off *returned_cu_die_offset,  
    Dwarf_Error *error);
```

The function `dwarf_get_cu_die_offset()` takes a `Dwarf_Arange` descriptor as input, and if successful returns `DW_DLV_OK` and sets `*returned_cu_die_offset` to the offset in the `.debug_info` section of the compilation-unit DIE for the compilation-unit represented by the given address range. It returns `DW_DLV_ERROR` on error.

6.25.5 dwarf_get_arange_cu_header_offset()

```
int dwarf_get_arange_cu_header_offset(  
    Dwarf_Arange arange,  
    Dwarf_Off *returned_cu_header_offset,  
    Dwarf_Error *error)
```

The function `dwarf_get_arange_cu_header_offset()` takes a `Dwarf_Arange` descriptor as input, and if successful returns `DW_DLV_OK` and sets `*returned_cu_header_offset` to the offset in the `.debug_info` section of the compilation-unit header for the compilation-unit represented by the given address range. It returns `DW_DLV_ERROR` on error.

This function added Rev 1.45, June, 2001.

This function is declared as 'optional' in `libdwarf.h` on IRIX systems so the `_MIPS_SYMBOL_PRESENT` predicate may be used at run time to determine if the version of `libdwarf` linked into an application has this function.

6.25.6 dwarf_get_arange_info_b()

```
int dwarf_get_arange_info_b(  
    Dwarf_Arange arange,  
    Dwarf_Unsigned *segment,  
    Dwarf_Unsigned *segment_entry_size,  
    Dwarf_Addr *start,  
    Dwarf_Unsigned *length,  
    Dwarf_Off *cu_die_offset,  
    Dwarf_Error *error)
```

The function `dwarf_get_arange_info_b()` returns `DW_DLV_OK` and returns detailed information on the address range through the pointers.

segment is the segment number for segmented address spaces and it is only meaningful if segment_entry_size is non-zero.

It puts the starting value of the address range in the location pointed to by start, and the length of the address range in the location pointed to by length.

It sets the cu_die_offset. in the .debug_info, section of the compilation-unit DIE for the compilation-unit represented by the address range.

It returns DW_DLV_ERROR on error. and sets error,

6.26 General Low Level Operations

This function is low-level and intended for use only by programs such as dwarfdump.

6.26.1 dwarf_get_offset_size()

```
int dwarf_get_offset_size(Dwarf_Debug dbg,
    Dwarf_Half *offset_size,
    Dwarf_Error *error)
```

The function dwarf_get_offset_size() returns DW_DLV_OK on success and sets the *offset_size to the size in bytes of an offset. In case of error, it returns DW_DLV_ERROR and does not set *offset_size.

The offset size returned is the overall address size, which can be misleading if different compilation units have different address sizes. Many ABIs have only a single address size per executable, but differing address sizes are becoming more common.

6.26.2 dwarf_get_address_size()

```
int dwarf_get_address_size(Dwarf_Debug dbg,
    Dwarf_Half *addr_size,
    Dwarf_Error *error)
```

The function dwarf_get_address_size() returns DW_DLV_OK on success and sets the *addr_size to the size in bytes of an address. In case of error, it returns DW_DLV_ERROR and does not set *addr_size.

The address size returned is the overall address size, which can be misleading if different compilation units have different address sizes. Many ABIs have only a single address size per executable, but differing address sizes are becoming more common.

Use dwarf_get_die_address_size() instead whenever possible.

6.26.3 dwarf_get_die_address_size()

```
int dwarf_get_die_address_size(Dwarf_Die die,
    Dwarf_Half *addr_size,
    Dwarf_Error *error)
```

The function `dwarf_get_die_address_size()` returns `DW_DLV_OK` on success and sets the `*addr_size` to the size in bytes of an address. In case of error, it returns `DW_DLV_ERROR` and does not set `*addr_size`.

The address size returned is the address size of the compilation unit owning the `die`

This is the preferred way to get address size when the `Dwarf_Die` is known.

6.26.4 `dwarf_decode_leb128()`

See the DWARF5 standard Section 7.6 for a general description of LEB encoded values.

```
int dwarf_decode_leb128(char* leb,
    Dwarf_Unsigned* leblen,
    Dwarf_Unsigned* outval,
    char* endptr)
```

In December 2020 this makes library decoding visible to library users for the first time.

The user should pass in `leb` with a pointer to the initial byte of the leb number. and pass in `endptr` with a pointer at least one-past the content of the leb value. Typically `endptr` points at an end of section (if reading object sections) or some other value representing the end of memory the function should be allowed to read.

On success the function returns `DW_DLV_OK` and sets `leblen` (if `leblen` passed in non-null) to the number of bytes read in decoding. It sets `outval` to the unsigned value decoded.

If the function detects it has read to the `endptr` it returns `DW_DLV_ERROR`.

If the function reads too many bytes without reaching a terminator or `endptr` it returns `DW_DLV_ERROR` on the assumption that nobody would intentionally produce wastefully long LEB data, so something is wrong.

Only the argument `leblen` may be passed in as `NULL`, the others must be valid non-null values.

There is no way for the library to determine whether the value is signed or unsigned. The caller must know and call the the correct function.

6.26.5 `dwarf_decode_signed_leb128()`

See the DWARF5 standard Section 7.6 for a general description of LEB encoded values.

```
int dwarf_decode_signed_leb128(char* leb,  
    Dwarf_Unsigned* leblen,  
    Dwarf_Signed* outval,  
    char* endptr)
```

In December 2020 this makes library decoding visible to library users for the first time.

The user should pass in `leb` with a pointer to the initial byte of the leb number. and pass in `endptr` with a pointer at least one-past the content of the leb value. Typically `endptr` points at an end of section (if reading object sections) or some other value representing the end of memory the function should be allowed to read.

On success the function returns `DW_DLV_OK` and sets `leblen` (if `leblen` passed in non-null) to the number of bytes read in decoding. It sets `outval` to the signed value decoded.

If the function detects it has read to the `endptr` it returns `DW_DLV_ERROR`.

If the function reads too many bytes without reaching a terminator or `endptr` it returns `DW_DLV_ERROR` on the assumption that nobody would intentionally produce wastefully long LEB data, so something is wrong.

Only the argument `leblen` may be passed in as `NULL`, the others must be valid non-null values.

There is no way for the library to determine whether the value is signed or unsigned. The caller must know and call the the correct function.

6.27 Ranges Operations DWARF5 (.debug_rnglists)

These functions provide information about the address ranges indicated by a `DW_AT_ranges` attribute of a DIE. The ranges are recorded in the `.debug_rnglists` section.

The section requires that each group of ranges has a header and the compilation unit may have a `DW_AT_ranges_base` attribute that must be added to the `DW_AT_ranges` attribute value to get the true ranges offset.

(A compiler generating `DW_AT_ranges_base` will add a relocation for that attribute value but will not have to make the `DW_AT_ranges` attributes relocatable and will thus save space in the object (ie, .o) file and save link time.)

See DWARF5 Section 2.17.3 Non-Contiguous Address Ranges and Section 7.28 Range List Table.

Section 7.28 describes the header fields for a Range List Table. There will usually be many such tables, in some sequence, in the `.debug_rnglists` section. Here we call each header `Dwarf_Rnglists_Head` (a pointer to an opaque struct).

6.27.1 Getting rnglists data for a DIE

This set of interfaces provides access to the DWARF5 `.debug_rnglists` entries for a particular DIE. Here is an example using the functions described below:

Figure 29. Example .debug_rnglist for attribute

```
int example_rnglist_for_attribute(Dwarf_Attribute attr,
Dwarf_Unsigned attrvalue, Dwarf_Error *error)
{
    /* attrvalue must be the DW_AT_ranges
       DW_FORM_rnglistx or DW_FORM_sec_offset value
       extracted from attr. */
    int res = 0;
    Dwarf_Half theform = 0;
    Dwarf_Unsigned entries_count;
    Dwarf_Unsigned global_offset_of_rle_set;
    Dwarf_Rnglists_Head rnglhead = 0;
    Dwarf_Unsigned i = 0;

    res = dwarf_rnglists_get_rle_head(attr,
        theform,
        attrvalue,
        &rnglhead,
        &entries_count,
        &global_offset_of_rle_set,
        error);
    if (res != DW_DLV_OK) {
        return res;
    }
    for (i = 0; i < entries_count; ++i) {
        unsigned entrylen = 0;
        unsigned code = 0;
        Dwarf_Unsigned rawlowpc = 0;
        Dwarf_Unsigned rawhighpc = 0;
        Dwarf_Unsigned lowpc = 0;
        Dwarf_Unsigned highpc = 0;
        Dwarf_Bool debug_addr_unavailable = FALSE;

        /* Actual addresses are most likely what one
           wants to know, not the lengths/offsets
           recorded in .debug_rnglists. */
        res = dwarf_get_rnglists_entry_fields_a(rnglhead,
            i, &entrylen, &code,
            &rawlowpc, &rawhighpc,
            &debug_addr_unavailable,
            &lowpc, &highpc, error);
        if (res != DW_DLV_OK) {
            dwarf_dealloc_rnglists_head(rnglhead);
            return res;
        }
        if (code == DW_RLE_end_of_list) {
```

```
        /* we are done */
        break;
    }
    if (code == DW_RLE_base_addressx ||
        code == DW_RLE_base_address) {
        /* We do not need to use these, they
           have been accounted for already. */
        continue;
    }
    if (debug_addr_unavailable) {
        /* lowpc and highpc are not real addresses */
        continue;
    }
    /* Here do something with lowpc and highpc, these
       are real addresses */
}
dwarf_dealloc_rnglists_head(rnglhead);
return DW_DLV_OK;
}
```

6.27.1.1 dwarf_rnglists_get_rle_head()

This function is used to enable access to the specific set of rnglist entries applying to a specific DW_AT_ranges attribute.

```
int dwarf_rnglists_get_rle_head( Dwarf_Attribute attr,
    Dwarf_Half theform,
    Dwarf_Unsigned attr_val,
    Dwarf_Rnglists_Head *head_out,
    Dwarf_Unsigned *entries_count_out,
    Dwarf_Unsigned *global_offset_of_rle_set,
    Dwarf_Error *error);
```

Given a DW_AT_ranges Dwarf_Attribute, the FORM from that attribute, and the value of the the attribute (which might be an index from DW_FORM_rnglistx or a section offset from DW_FORM_sec_offset the function determines which Dwarf_Rnglists_Head applies and returns the pointer on success (meaning it returned . DW_DLV_OK). And on success it also returns the global offset of a set of rnglist entries within that particular Dwarf_Rnglists_Head (not needed except to show it to users) as well as the count of entries in that set (which is crucial to iterate through the rnglist entries applicable).

If not successful none of the pointers head_out, entries_count_out, global_offset will not be touched by the function.

If there is some problem with the section it will return DW_DLV_ERROR and return the

error information through. `*error`.

There is, currently, no situation in which it will return `DW_DLV_NO_ENTRY`.

See `dwarf_dealloc_rnglists_head()` below to release the storage allocated by a successful call here.

6.27.1.2 dwarf_get_rnglist_head_basics()

```
int dwarf_get_rnglist_head_basics(  
    Dwarf_Rnglists_Head head,  
    Dwarf_Unsigned * rle_count,  
    Dwarf_Unsigned * rle_version,  
    Dwarf_Unsigned * rnglists_index_returned,  
    Dwarf_Unsigned * bytes_total_in_rle,  
    unsigned * offset_size,  
    unsigned * address_size,  
    unsigned * segment_selector_size,  
    Dwarf_Unsigned * overall_offset_of_this_context,  
    Dwarf_Unsigned * total_length_of_this_context,  
    Dwarf_Bool * rnglists_base_present,  
    Dwarf_Unsigned * rnglists_base,  
    Dwarf_Bool * rnglists_base_address_present,  
    Dwarf_Unsigned * rnglists_base_address,  
    Dwarf_Bool * rnglists_debug_addr_base_present,  
    Dwarf_Unsigned * rnglists_debug_addr_base,  
    Dwarf_Error *error)
```

The function `dwarf_get_rnglist_head_basics()` allows caller to print or display the fields of the `Dwarf_Rnglists_Head` that might be of interest for understanding the section data for that `Dwarf_Rnglists_Head`.

It is not needed to access the rangelist data. It currently returns only `DW_DLV_OK`.

6.27.1.3 dwarf_get_rnglists_entry_fields_a()

```
int dwarf_get_rnglists_entry_fields_a(  
    Dwarf_Rnglists_Head head,  
    Dwarf_Unsigned entrynum,  
    unsigned *entrylen,  
    unsigned *code,  
    Dwarf_Unsigned *raw1,  
    Dwarf_Unsigned *raw2,  
    Dwarf_Bool      *debug_addr_unavailable,  
    Dwarf_Unsigned *cooked1,  
    Dwarf_Unsigned *cooked2,  
    Dwarf_Error      *err)
```

This is the function to access the rnglist entries for this Dwarf_Rnglists_Head. Call this with entrynum in the normal iteration "i = 0; i < entries_count; ++i" where entries_count was returned by dwarf_rnglists_get_rle_head() through a pointer.

On success DW_DLV_OK is returned and the following fields are set through the pointers.

The entrylen value returned is the length, in bytes, of the single entry's length.

The code value returned is the type of entry, DW_RLE_startx_endx (see dwarf.h).

The raw1 and raw2 values returned are the actual values in the rangelist entry (address, length, or index depending). For basename entries both values are set to the single value in the entry (an address or index). For end of list entries neither value is set.

If debug_addr_unavailable is returns non-zero then the cooked1 and cooked2 values are not set usefully and should be ignored. The issue arises because with dwp/dwo object files the .debug_addr section will be in the executable and if the dwarf_set_tied_dbg() function was not called to enable access to .debug_addr the 'cooked' fields cannot be calculated.

The cooked1 cooked2 values returned are the actual addresses in the rangelist entry, after any necessary translation of indexes and offsets and lengths. For non-basename entries these two values are the start and end addresses of the rnglist entry. If and only if debug_addr_unavailable returns zero. For basename entries these two values are both the basename address. For end-of-list entries neither value means anything.

If the entrynum is out of range, DW_DLV_NO_ENTRY is returned.

At present DW_DLV_ERROR is never returned, but callers should not assume that will always be true.

6.27.1.4 dwarf_dealloc_rnglists_head()

```
int dwarf_dealloc_rnglists_head(Dwarf_Rnglists_Head /*head*/);
```

This frees the storage allocated by the dwarf_rnglists_get_rle_head() call

that created the `Dwarf_Rnglists_Head` pointer.

It only returns `DW_DLV_OK`.

6.27.2 Getting raw `.debug_rnglists` entries

This set of interfaces is to read the (entire) `.debug_rnglists` section without reference to any DIE. As such these can only present the raw data from the file. There is no way in these interfaces to get actual addresses. These might be of interest if you want to know exactly what the compiler output in the `.debug_rnglists` section. "dwarfdump ---print-raw-rnglists" (try adding `-v` or `-vvv`) makes these calls.

Here is an example using all the following calls.

example_rngl

Figure 30. Examplev dwarf_rnglists)

```
int example_raw_rnglist(Dwarf_Debug dbg,Dwarf_Error *error)
{
    Dwarf_Unsigned count = 0;
    int res = 0;
    Dwarf_Unsigned i = 0;

    res = dwarf_load_rnglists(dbg,&count,error);
    if (res != DW_DLV_OK) {
        return res;
    }
    for(i=0 ; i < count ; ++i) {
        Dwarf_Unsigned header_offset = 0;
        Dwarf_Small    offset_size = 0;
        Dwarf_Small    extension_size = 0;
        unsigned        version = 0; /* 5 */
        Dwarf_Small    address_size = 0;
        Dwarf_Small    segment_selector_size = 0;
        Dwarf_Unsigned offset_entry_count = 0;
        Dwarf_Unsigned offset_of_offset_array = 0;
        Dwarf_Unsigned offset_of_first_rangeentry = 0;
        Dwarf_Unsigned offset_past_last_rangeentry = 0;

        res = dwarf_get_rnglist_context_basics(dbg,i,
            &header_offset,&offset_size,&extension_size,
            &version,&address_size,&segment_selector_size,
            &offset_entry_count,&offset_of_offset_array,
            &offset_of_first_rangeentry,
            &offset_past_last_rangeentry,error);
        if (res != DW_DLV_OK) {
            return res;
        }
        {
            Dwarf_Unsigned e = 0;
            unsigned colmax = 4;
            unsigned col = 0;
            Dwarf_Unsigned global_offset_of_value = 0;

            for ( ; e < offset_entry_count; ++e) {
                Dwarf_Unsigned value = 0;
                int resc = 0;

                resc = dwarf_get_rnglist_offset_index_value(dbg,
                    i,e,&value,
                    &global_offset_of_value,error);
                if (resc != DW_DLV_OK) {
                    return resc;
                }
            }
        }
    }
}
```

```
    }
    /* Do something */
    col++;
    if (col == colmax) {
        col = 0;
    }
}

}
{
    Dwarf_Unsigned curoffset = offset_of_first_rangeentry;
    Dwarf_Unsigned endoffset = offset_past_last_rangeentry;
    int rese = 0;
    Dwarf_Unsigned ct = 0;

    for ( ; curoffset < endoffset; ++ct ) {
        unsigned entrylen = 0;
        unsigned code = 0;
        Dwarf_Unsigned v1 = 0;
        Dwarf_Unsigned v2 = 0;
        rese = dwarf_get_rnglist_rle(dbg,i,
                                     curoffset,endoffset,
                                     &entrylen,
                                     &code,&v1,&v2,error);
        if (rese != DW_DLV_OK) {
            return rese;
        }
        curoffset += entrylen;
        if (curoffset > endoffset) {
            return DW_DLV_ERROR;
        }
    }
}
}
return DW_DLV_OK;
}
```

6.27.2.1 dwarf_load_rnglists()

```
int dwarf_load_rnglists(
    Dwarf_Debug dbg,
    Dwarf_Unsigned *rnglists_count,
    Dwarf_Error *error)
```

On a successful call to `dwarf_load_rnglists()` the function returns `DW_DLV_OK`,

sets `*rnglists_count` (if and only if `rnglists_count` is non-null) to the number of distinct section contents that exist. A small amount of data for each Range Line Table is recorded in `dbg` as a side effect. Normally `libdwarf` will have already called this, but if an application never requests any `.debug_info` data the section might not be loaded. If the section is loaded this returns very quickly and will set `*rnglists_count` just as described in this paragraph.

If there is no `.debug_rnglists` section in the object file this function returns `DW_DLV_NO_ENTRY`.

If something is malformed it returns `DW_DLV_ERROR` and sets `*error` to the applicable error pointer describing the problem.

There is no `dealloc` call. Calling `dwarf_finish()` releases the modest amount of memory recorded for this section as a side effect.

6.27.2.2 `dwarf_get_rnglist_context_basics()`

```
int dwarf_get_rnglist_context_basics(Dwarf_Debug dbg,
    Dwarf_Unsigned context_index,
    Dwarf_Unsigned * header_offset,
    Dwarf_Small    * offset_size,
    Dwarf_Small    * extension_size,
    unsigned       * version, /* 5 */
    Dwarf_Small    * address_size,
    Dwarf_Small    * segment_selector_size,
    Dwarf_Unsigned * offset_entry_count,
    Dwarf_Unsigned * offset_of_offset_array,
    Dwarf_Unsigned * offset_of_first_rangeentry,
    Dwarf_Unsigned * offset_past_last_rangeentry,
    Dwarf_Error *   /*err*/);
```

On success this returns `DW_DLV_OK` and returns values through the pointer arguments (other than `dbg` or `error`)

A call to `dwarf_load_rnglists()` that succeeds gets you the count of contexts and `dwarf_get_rnglist_context_basics()` for any "`i` ≥ 0 and `i` $<$ count" gets you the context values relevant to `.debug_rnglists`.

Any of the pointer-arguments for returning context values can be passed in as 0 (in which case they will be skipped).

You will want `*offset_entry_count` so you can call `dwarf_get_rnglist_offset_index_value()` usefully.

If the `context_index` passed in is out of range the function returns `DW_DLV_NO_ENTRY`

At the present time `DW_DLV_ERROR` is never returned.

6.27.2.3 dwarf_get_rnglist_offset_index_value()

```
int dwarf_get_rnglist_offset_index_value(Dwarf_Debug dbg,
    Dwarf_Unsigned context_index,
    Dwarf_Unsigned offsetentry_index,
    Dwarf_Unsigned * offset_value_out,
    Dwarf_Unsigned * global_offset_value_out,
    Dwarf_Error *error)
```

On success `dwarf_get_rnglist_offset_index_value()` returns `DW_DLV_OK`, sets `* offset_value_out` to the value in the Range List Table offset array, and sets `* global_offset_value_out` to the section offset (in `.debug_addr`) of the offset value.

Pass in `context_index` exactly as the same field passed to `dwarf_get_rnglist_context_basics()`.

Pass in `offset_entry_index` based on the return field `offset_entry_count` from `dwarf_get_rnglist_context_basics()`, meaning for that `context_index` an `offset_entry_index` ≥ 0 and $< \text{offset_entry_count}$.

Pass in `offset_entry_count` exactly as the same field passed to `dwarf_get_rnglist_context_basics()`.

If one of the indexes passed in is out of range `DW_DLV_NO_ENTRY` will be returned and no return arguments touched.

If there is some corruption of DWARF5 data then `DW_DLV_ERROR` might be returned and `*error` set to the error details.

6.27.2.4 dwarf_get_rnglist_rle()

```
int dwarf_get_rnglist_rle(
    Dwarf_Debug dbg,
    Dwarf_Unsigned contextnumber,
    Dwarf_Unsigned entry_offset,
    Dwarf_Unsigned endoffset,
    unsigned *entrylen,
    unsigned *entry_kind,
    Dwarf_Unsigned *entry_operand1,
    Dwarf_Unsigned *entry_operand2,
    Dwarf_Error *error)
```

On success it returns a single `DW_RLE*` record (see `dwarf.h`) fields.

`contextnumber` is the number of the current rnglist context.

`entry_offset` is the section offset (section-global offset) of the next record.

`endoffset` is one past the last entry in this rle context.

`*entrylen` returns the length in the `.debug_rnglists` section of the particular record returned. It's used to increment to the next record within this `rnglist` context.

`*entrykind` returns is the `DW_RLE*` number.

Some record kinds have 1 or 0 operands, most have two operands (the records describing ranges).

If the `contextnumber` is out of range it will return `DW_DLV_NO_ENTRY`.

If the `.debug_rnglists` section is malformed or the `entry_offset` is incorrect it may return `DW_DLV_ERROR`.

6.28 Ranges Operations DWARF3,4 (`.debug_ranges`)

These functions provide information about the address ranges indicated by a `DW_AT_ranges` attribute (the ranges are recorded in the `.debug_ranges` section) of a DIE. These functions apply to DWARF3 and DWARF4. Each call of `dwarf_get_ranges_a()` or `dwarf_get_ranges()` returns a an array of `Dwarf_Ranges` structs, each of which represents a single ranges entry. The struct is defined in `libdwarf.h`.

New in DWARF3, for DWARF3, and DWARF4 the section contains just ranges. The ranges are referenced by `DW_AT_ranges` attributes in various DIEs.

For DWARF5 the section requires that each group of ranges has a header and the compilation unit may have a `DW_AT_ranges_base` attribute that must be added to the `DW_AT_ranges` attribute value to get the true ranges offset.

(A compiler generating `DW_AT_ranges_base` will add a relocation for that attribute value but will not have to make the `DW_AT_ranges` attributes relocatable and will thus save space in the object (ie, `.o`) file and link time.)

6.28.1 `dwarf_get_ranges_section_name()`

```
int dwarf_get_ranges_section_name(Dwarf_Debug dbg,
    const char ** sec_name,
    Dwarf_Error *error)
```

`*dwarf_get_ranges_section_name()` retrieves the object file section name of the applicable ranges section. This is useful for applications wanting to print the name, but of course the object section name is not really a part of the DWARF information. Most applications will probably not call this function. It can be called at any time after the `Dwarf_Debug` initialization is done.

If the function succeeds, `*sec_name` is set to a pointer to a string with the object section name and the function returns `DW_DLV_OK`. Do not free the string whose pointer is returned. For non-Elf objects it is possible the string pointer returned will be `NULL` or will point to an empty string. It is up to the calling application to recognize this

possibility and deal with it appropriately.

If the section does not exist the function returns DW_DLV_NO_ENTRY.

If there is an internal error detected the function returns DW_DLV_ERROR and sets the *error pointer.

6.28.2 dwarf_get_ranges_b()

```
int dwarf_get_ranges_b(  
    Dwarf_Debug dbg,  
    Dwarf_Off  offset,  
    Dwarf_Die  die,  
    Dwarf_Off  *finaloffset,  
    Dwarf_Ranges **ranges,  
    Dwarf_Signed * returned_ranges_count,  
    Dwarf_Unsigned * returned_byte_count,  
    Dwarf_Error *error)
```

The function dwarf_get_ranges_b() returns DW_DLV_OK and sets *returned_ranges_count to the count of the number of address ranges in the group of ranges in the .debug_ranges section where the DW_AT_ranges attribute gives offset offset. This function is new as of 10 September 2020.

DWARF4 GNU split-dwarf extension ONLY: With a .dwp object and the tied (executable,a.out) involved the actual .debug_ranges offset is determined from the DW_AT_GNU_ranges_base from the tied file and the offset from DW_AT_ranges in the .dwp object and returned through the finaloffset pointer. If finaloffset pointer is null the function ignores it.

If there is no use of the GNU split-dwarf extension to DWARF4 the finaloffset value returned is identical to the offset passed in. If the pointer is null it is ignored by the function.

This function is normally used when one has a DIE with the DW_AT_ranges attribute (whose value is the offset needed). The ranges thus apply to the DIE involved. If no DIE is available or possible pass in 0 (NULL) as the DIE pointer.

See also dwarf_get_aranges(),

The offset argument should be the value of a DW_AT_ranges attribute of a Debugging Information Entry.

The die argument should be the value of a Dwarf_Die pointer of a Dwarf_Die with the attribute containing this range set offset. Because each compilation unit has its own address_size field this argument is necessary to to correctly read ranges. (Most executables have the same address_size in every compilation unit, but some ABIs allow multiple address sized in an executable). If a NULL pointer is passed in libdwarf assumes a single address_size is appropriate for all ranges records and that TIED files are not involved or available.

On success, The call sets `*ranges` to point to a block of `Dwarf_Ranges` structs, one for each address range. If the `*returned_byte_count` pointer is passed as non-NULL the number of bytes that the returned ranges were taken from is returned through the pointer (for example if the `returned_ranges_count` is 2 and the pointer-size is 4, then `returned_byte_count` will be 8). If the `*returned_byte_count` pointer is passed as NULL the parameter is ignored. The `*returned_byte_count` is only of use to certain dumper applications, most applications will not use it. The `finaloffset` pointer is only of use to certain dumper applications, and if null is passed the function ignores the argument.

On error the function returns `DW_DLV_ERROR`.

It returns `DW_DLV_NO_ENTRY` if there is no `.debug_ranges` section or if offset is past the end of the `.debug_ranges` section.

Figure 31. Example `dwarf_get_ranges_b()`

```
void examplev(Dwarf_Debug dbg,Dwarf_Unsigned offset,Dwarf_Die die)
{
    Dwarf_Signed count = 0;
    Dwarf_Ranges *ranges = 0;
    Dwarf_Unsigned bytes = 0;
    Dwarf_Error error = 0;
    Dwarf_Off finaloffset = 0;
    int res = 0;
    res = dwarf_get_ranges_b(dbg,offset,die,
        &finaloffset, &ranges,&count,&bytes,&error);
    if (res == DW_DLV_OK) {
        Dwarf_Signed i;
        for( i = 0; i < count; ++i ) {
            Dwarf_Ranges *cur = ranges+i;
            /* Use cur. */
            functionusingrange(cur);
        }
        dwarf_dealloc_ranges(dbg,ranges,count);
    }
}
```

6.28.3 `dwarf_dealloc_ranges()`

```
int dwarf_dealloc_ranges(
    Dwarf_Debug dbg,
    Dwarf_Ranges *ranges,
    Dwarf_Signed range_count,
);
```

The function `dwarf_ranges_dealloc()` takes as input a pointer to a block of `Dwarf_Ranges` array and the number of structures in the block. It frees all the data in the array of structures.

6.29 Gdb Index operations

These functions get access to the fast lookup tables defined by gdb and gcc and stored in the `.gdb_index` section. The section is of sufficient complexity that a number of function interfaces are needed. For additional information see "[https://sourceware.org/gdb/onlinedocs/gdb/\"Index-Section-Format.html#Index-Section-Format](https://sourceware.org/gdb/onlinedocs/gdb/\)". (We split the url to two pieces so it can fit on the printed page join the pieces to make a usable url).

6.29.1 dwarf_gdbindex_header()

```
int dwarf_gdbindex_header(Dwarf_Debug dbg,
    Dwarf_Gdbindex * gdbindexptr,
    Dwarf_Unsigned * version,
    Dwarf_Unsigned * cu_list_offset,
    Dwarf_Unsigned * types_cu_list_offset,
    Dwarf_Unsigned * address_area_offset,
    Dwarf_Unsigned * symbol_table_offset,
    Dwarf_Unsigned * constant_pool_offset,
    Dwarf_Unsigned * section_size,
    Dwarf_Unsigned * unused_reserved,
    const char ** section_name,
    Dwarf_Error * error);
```

The function `dwarf_gdbindex_header()` takes as input a pointer to a `Dwarf_Debug` structure and returns fields through various pointers.

If the function returns `DW_DLV_NO_ENTRY` there is no `.gdb_index` section and none of the return-pointer argument values are set.

If the function returns `DW_DLV_ERROR` `error` is set to indicate the specific error, but no other return-pointer arguments are touched.

If successful, the function returns `DW_DLV_OK` and other values are set. The other values are set as follows:

The field `*gdbindexptr` is set to an opaque pointer to a `libdwarf_internal` structure used as an argument to other `gdbindex` functions below.

The remaining fields are set to values that are mostly of interest to a pretty-printer application. See the detailed layout specification for specifics. The values returned are recorded in the `Dwarf_Gdbindex` opaque structure for the other `gdbindex` functions documented below.

The field `*version` is set to the version of the gdb index header (2)..

The field `*cu_list_offset` is set to the offset (in the `.gdb_index` section) of the cu-list.

The field `*types_cu_list_offset` is set to the offset (in the `.gdb_index` section) of the types-list.

The field `*address_area_offset` is set to the offset (in the `.gdb_index` section) of the address area.

The field `*symbol_table_offset` is set to the offset (in the `.gdb_index` section) of the symbol table.

The field `*constant_pool_offset` is set to the offset (in the `.gdb_index` section) of the constant pool.

The field `*section_size` is set to the length of the `.gdb_index` section.

The field `*unused_reserved` is set to zero.

The field `*section_name` is set to the Elf object file section name (`.gdb_index`). If a non-Elf object file has such a section the value set might be `NULL` or might point to an empty string (NUL terminated), so code to account for `NULL` or empty.

The field `*error` is not set.

Here we show a use of the set of cu_list functions (using all the functions in one example makes it rather too long).

Figure 32. Examplew dwarf_get_gdbindex_header()

```
void examplew(Dwarf_Debug dbg)
{
    Dwarf_Gdbindex gindexptr = 0;
    Dwarf_Unsigned version = 0;
    Dwarf_Unsigned cu_list_offset = 0;
    Dwarf_Unsigned types_cu_list_offset = 0;
    Dwarf_Unsigned address_area_offset = 0;
    Dwarf_Unsigned symbol_table_offset = 0;
    Dwarf_Unsigned constant_pool_offset = 0;
    Dwarf_Unsigned section_size = 0;
    Dwarf_Unsigned reserved = 0;
    Dwarf_Error error = 0;
    const char * section_name = 0;
    int res = 0;
    res = dwarf_gdbindex_header(dbg, &gindexptr,
                                &version, &cu_list_offset, &types_cu_list_offset,
                                &address_area_offset, &symbol_table_offset,
                                &constant_pool_offset, &section_size,
                                &reserved, &section_name, &error);
    if (res == DW_DLV_NO_ENTRY) {
        return;
    } else if (res == DW_DLV_ERROR) {
        return;
    }
    {
        /* do something with the data */
        Dwarf_Unsigned length = 0;
        Dwarf_Unsigned typeslength = 0;
        Dwarf_Unsigned i = 0;
        res = dwarf_gdbindex_culist_array(gindexptr,
                                          &length, &error);
        /* Example actions. */
        if (res == DW_DLV_OK) {
            for(i = 0; i < length; ++i) {
                Dwarf_Unsigned cuoffset = 0;
                res = dwarf_gdbindex_culist_entry(gindexptr,
                                                  i, &cuoffset, &culength, &error);
                if (res == DW_DLV_OK) {
                    /* Do something with cuoffset, culength */
                }
            }
        }
        res = dwarf_gdbindex_types_culist_array(gindexptr,
                                                  &typeslength, &error);
        if (res == DW_DLV_OK) {
            for(i = 0; i < typeslength; ++i) {
```

```
        Dwarf_Unsigned cuoffset = 0;
        Dwarf_Unsigned tuoffset = 0;
        Dwarf_Unsigned culength = 0;
        Dwarf_Unsigned type_signature = 0;
        res = dwarf_gdbindex_types_culist_entry(gindexptr,
            i, &cuoffset, &tuoffset, &type_signature, &error);
        if (res == DW_DLV_OK) {
            /* Do something with cuoffset etc. */
        }
    }
}
dwarf_gdbindex_free(gindexptr);
}
```

6.29.2 dwarf_gdbindex_culist_array()

```
int dwarf_gdbindex_culist_array(Dwarf_Gdbindex gdbindexptr,
    Dwarf_Unsigned * list_length,
    Dwarf_Error * error);
```

The function takes as input valid Dwarf_Gdbindex pointer.

While currently only DW_DLV_OK is returned one should test for DW_DLV_NO_ENTRY and DW_DLV_ERROR and do something sensible if either is returned.

If successful, the function returns DW_DLV_OK and returns the number of entries in the culist through the `list_length` pointer.

6.29.3 dwarf_gdbindex_culist_entry()

```
int dwarf_gdbindex_culist_entry(Dwarf_Gdbindex gdbindexptr,
    Dwarf_Unsigned entryindex,
    Dwarf_Unsigned * cu_offset,
    Dwarf_Unsigned * cu_length,
    Dwarf_Error * error);
```

The function takes as input valid Dwarf_Gdbindex pointer and an index into the culist array. Valid indexes are 0 through `list_length - 1`.

If it returns DW_DLV_NO_ENTRY there is a coding error. If it returns DW_DLV_ERROR there is an error of some kind and the error is indicated by the value returned through the `error` pointer.

On success it returns DW_DLV_OK and returns the `cu_offset` (the section global offset of the CU in `.debug_info`) and `cu_length` (the length of the CU in `.debug_info`) values through the pointers.

6.29.4 dwarf_gdbindex_types_culist_array()

```
int dwarf_gdbindex_types_culist_array(Dwarf_Gdbindex
/*gdbindexptr*/,
Dwarf_Unsigned      /*types_list_length*/,
Dwarf_Error         /*error*/);
```

The function takes as input valid Dwarf_Gdbindex pointer.

While currently only DW_DLV_OK is returned one should test for DW_DLV_NO_ENTRY and DW_DLV_ERROR and do something sensible if either is returned.

If successful, the function returns DW_DLV_OK and returns the number of entries in the types culist through the `list_length`

6.29.5 dwarf_gdbindex_types_culist_entry()

```
int dwarf_gdbindex_types_culist_entry(
Dwarf_Gdbindex  gdbindexptr,
Dwarf_Unsigned  entryindex,
Dwarf_Unsigned * cu_offset,
Dwarf_Unsigned * tu_offset,
Dwarf_Unsigned * type_signature,
Dwarf_Error    * error);
```

The function takes as input valid Dwarf_Gdbindex pointer and an index into the types culist array. Valid indexes are 0 through `types_list_length - 1`.

If it returns DW_DLV_NO_ENTRY there is a coding error. If it returns DW_DLV_ERROR there is an error of some kind. and the error is indicated by the value returned through the `error` pointer.

On success it returns DW_DLV_OK and returns the `tu_offset` (the section global offset of the CU in `.debug_types`) and `tu_length` (the length of the CU in `.debug_types`) values through the pointers. It also returns the type signature (a 64bit value) through the `type_signature` pointer.

6.29.6 dwarf_gdbindex_addressarea()

```
int dwarf_gdbindex_addressarea(Dwarf_Gdbindex /*gdbindexptr*/,
Dwarf_Unsigned      /*addressarea_list_length*/,
Dwarf_Error         /*error*/);
```

The function takes as input valid Dwarf_Gdbindex pointer and returns the length of the address area through `addressarea_list_length`.

If it returns `DW_DLV_NO_ENTRY` there is a coding error. If it returns `DW_DLV_ERROR` there is an error of some kind. and the error is indicated by the value returned through the `error` pointer.

If successful, the function returns `DW_DLV_OK` and returns the number of entries in the address area through the `addressarea_list_length` pointer.

6.29.7 dwarf_gdbindex_addressarea_entry()

```
int dwarf_gdbindex_addressarea_entry(  
    Dwarf_Gdbindex gdbindexptr,  
    Dwarf_Unsigned entryindex,  
    Dwarf_Unsigned * low_address,  
    Dwarf_Unsigned * high_address,  
    Dwarf_Unsigned * cu_index,  
    Dwarf_Error * error);
```

The function takes as input valid Dwarf_Gdbindex pointer and an index into the address area (valid indexes are zero through `addressarea_list_length - 1`).

If it returns `DW_DLV_NO_ENTRY` there is a coding error. If it returns `DW_DLV_ERROR` there is an error of some kind. and the error is indicated by the value returned through the `error` pointer.

If successful, the function returns `DW_DLV_OK` and returns The `low_address` `high_address` and `cu_index` through the pointers.

Given an open Dwarf_Gdbindex one uses the function as follows:

Figure 33. Examplewgdindex dwarf_gdindex_addressarea()

```
void examplewgdindex(Dwarf_Gdindex gdindex)
{
    Dwarf_Unsigned list_len = 0;
    Dwarf_Unsigned i = 0;
    int res = 0;
    Dwarf_Error err = 0;

    res = dwarf_gdindex_addressarea(gdindex, &list_len,&err);
    if (res != DW_DLV_OK) {
        /* Something wrong, ignore the addressarea */
    }
    /* Iterate through the address area. */
    for( i = 0; i < list_len; i++) {
        Dwarf_Unsigned lowpc = 0;
        Dwarf_Unsigned highpc = 0;
        Dwarf_Unsigned cu_index = 0;
        res = dwarf_gdindex_addressarea_entry(gdindex,i,
            &lowpc,&highpc,
            &cu_index,
            &err);
        if (res != DW_DLV_OK) {
            /* Something wrong, ignore the addressarea */
            return;
        }
        /* We have a valid address area entry, do something
           with it. */
    }
}
```

6.29.8 dwarf_gdindex_symboltable_array()

```
int dwarf_gdindex_symboltable_array(Dwarf_Gdindex gdindexptr,
    Dwarf_Unsigned * symtab_list_length,
    Dwarf_Error * error);
```

One can look at the symboltable as a two-level table (with The outer level indexes through symbol names and the inner level indexes through all the compilation units that define that symbol (each symbol having a different number of compilation units, this is not a simple rectangular table).

The function takes as input valid Dwarf_Gdindex pointer.

If it returns DW_DLV_NO_ENTRY there is a coding error. If it returns DW_DLV_ERROR there is an error of some kind. and the error is indicated by the value returned through the error pointer.

If successful, the function returns `DW_DLV_OK` and returns The `symtab_list_length` through the pointer.

Given a valid `Dwarf_Gdbindex` pointer, one can access the entire symbol table as follows (using 'return' here to indicate we are giving up due to a problem while keeping the example code fairly short):

Figure 34. Example `dwarf_gdbindex_symboltable_array()`

```
void examplex(Dwarf_Gdbindex gdbindex)
{
    Dwarf_Unsigned symtab_list_length = 0;
    Dwarf_Unsigned i = 0;
    Dwarf_Error err = 0;
    int res = 0;

    res = dwarf_gdbindex_symboltable_array(gdbindex,
        &symtab_list_length, &err);
    if (res != DW_DLV_OK) {
        return;
    }
    for( i = 0; i < symtab_list_length; i++) {
        Dwarf_Unsigned symnameoffset = 0;
        Dwarf_Unsigned cuvecoffset = 0;
        Dwarf_Unsigned cuvec_len = 0;
        Dwarf_Unsigned ii = 0;
        const char *name = 0;
        res = dwarf_gdbindex_symboltable_entry(gdbindex, i,
            &symnameoffset, &cuvecoffset,
            &err);
        if (res != DW_DLV_OK) {
            return;
        }
        res = dwarf_gdbindex_string_by_offset(gdbindex,
            symnameoffset, &name, &err);
        if(res != DW_DLV_OK) {
            return;
        }
        res = dwarf_gdbindex_cuvector_length(gdbindex,
            cuvecoffset, &cuvec_len, &err);
        if( res != DW_DLV_OK) {
            return;
        }
        for(ii = 0; ii < cuvec_len; ++ii ) {
            Dwarf_Unsigned attributes = 0;
            Dwarf_Unsigned cu_index = 0;
            Dwarf_Unsigned reserved1 = 0;
            Dwarf_Unsigned symbol_kind = 0;
            Dwarf_Unsigned is_static = 0;

            res = dwarf_gdbindex_cuvector_inner_attributes(
                gdbindex, cuvecoffset, ii,
                &attributes, &err);
            if( res != DW_DLV_OK) {
```

```
        return;
    }
    /* 'attributes' is a value with various internal
       fields so we expand the fields. */
    res = dwarf_gdbindex_cuvector_instance_expand_value(gdbindex,
        attributes, &cu_index,&reserved1,&symbol_kind, &is_static,
        &err);
    if( res != DW_DLV_OK) {
        return;
    }
    /* Do something with the attributes. */
}
}
```

6.29.9 dwarf_gdbindex_symboltable_entry()

```
int dwarf_gdbindex_symboltable_entry(
    Dwarf_Gdbindex  gdbindexptr,
    Dwarf_Unsigned  entryindex,
    Dwarf_Unsigned * string_offset,
    Dwarf_Unsigned * cu_vector_offset,
    Dwarf_Error    * error);
```

The function takes as input valid Dwarf_Gdbindex pointer and an entry index(valid index values being zero through `syntab_list_length -1`).

If it returns `DW_DLV_NO_ENTRY` there is a coding error. If it returns `DW_DLV_ERROR` there is an error of some kind. and the error is indicated by the value returned through the `error` pointer.

If successful, the function returns `DW_DLV_OK` and returns The `string_offset` and `cu_vector_offset` through the pointers. See the example above which uses this function.

6.29.10 dwarf_gdbindex_cuvector_length()

```
int dwarf_gdbindex_cuvector_length(
    Dwarf_Gdbindex  gdbindex,
    Dwarf_Unsigned  cuvector_offset,
    Dwarf_Unsigned * innercount,
    Dwarf_Error    * error);
```

The function takes as input valid Dwarf_Gdbindex pointer and an a cu vector offset.

If it returns `DW_DLV_NO_ENTRY` there is a coding error. If it returns `DW_DLV_ERROR` there is an error of some kind. and the error is indicated by the value

returned through the `error` pointer.

If successful, the function returns `DW_DLV_OK` and returns the `inner_count` through the pointer. The `inner_count` is the number of compilation unit vectors for this array of vectors. See the example above which uses this function.

6.29.11 `dwarf_gdbindex_cuvector_inner_attributes()`

```
int dwarf_gdbindex_cuvector_inner_attributes(  
    Dwarf_Gdbindex gdbindex,  
    Dwarf_Unsigned cuvector_offset,  
    Dwarf_Unsigned innerindex,  
    /* The attr_value is a field of bits. For expanded version  
       use dwarf_gdbindex_cuvector_expand_value() */  
    Dwarf_Unsigned * attr_value,  
    Dwarf_Error * error);
```

The function takes as input valid `Dwarf_Gdbindex` pointer and an a cu vector offset and a `inner_index` (valid `inner_index` values are zero through `inner_count - 1`).

If it returns `DW_DLV_NO_ENTRY` there is a coding error. If it returns `DW_DLV_ERROR` there is an error of some kind. and the error is indicated by the value returned through the `error` pointer.

If successful, the function returns `DW_DLV_OK` and returns The `attr_value` through the pointer. The `attr_value` is actually composed of several fields, see the next function which expands the value. See the example above which uses this function.

6.29.12 `dwarf_gdbindex_cuvector_instance_expand_value()`

```
int dwarf_gdbindex_cuvector_instance_expand_value(  
    Dwarf_Gdbindex gdbindex,  
    Dwarf_Unsigned attr_value,  
    Dwarf_Unsigned * cu_index,  
    Dwarf_Unsigned * reserved1,  
    Dwarf_Unsigned * symbol_kind,  
    Dwarf_Unsigned * is_static,  
    Dwarf_Error * error);
```

The function takes as input valid `Dwarf_Gdbindex` pointer and an `attr_value`.

If it returns `DW_DLV_NO_ENTRY` there is a coding error. If it returns `DW_DLV_ERROR` there is an error of some kind. and the error is indicated by the value returned through the `error` pointer.

If successful, the function returns `DW_DLV_OK` and returns the following values

through the pointers:

The `cu_index` field is the index in the applicable CU list of a compilation unit. For the purpose of indexing the CU list and the types CU list form a single array so the `cu_index` can be indicating either list.

The `symbol_kind` field is a small integer with the symbol kind(zero is reserved, one is a type, 2 is a variable or enum value, etc).

The `reserved1` field should have the value zero and is the value of a bit field defined as reserved for future use.

The `is_static` field is zero if the CU indexed is global and one if the CU indexed is static.

See the example above which uses this function.

6.29.13 `dwarf_gdbindex_string_by_offset()`

```
int dwarf_gdbindex_string_by_offset(  
    Dwarf_Gdbindex    gdbindexptr,  
    Dwarf_Unsigned    stringoffset,  
    const char        ** string_ptr,  
    Dwarf_Error        *   error);
```

The function takes as input valid `Dwarf_Gdbindex` pointer and a `stringoffset`. If it returns `DW_DLV_NO_ENTRY` there is a coding error. If it returns `DW_DLV_ERROR` there is an error of some kind. and the error is indicated by the value returned through the `error` pointer.

If it succeeds, the call returns a pointer to a string from the 'constant pool' through the `string_ptr`. The string pointed to must never be free()'d.

See the example above which uses this function.

6.30 GNU linking (`.gnu_debuglink`, `.note.gnu.build-id`) operations

This section deals with the way GNU tools allow creation of DWARF separated from the executable file involved. See <https://sourceware.org/gdb/onlinedocs/gdb/Separate-Debug-Files.html> for more information. The function here is new in September 2019, revised in October 2020. An example of use follows the description of arguments.

These functions are concerned with finding DWARF data in a companion file. There is no Split-Dwarf involved, this is a different way of splitting DWARF out of an executable or shared object.. It never applies to simple `.o` object files, only to executable objects (or shared libraries).

6.30.1 dwarf_gnu_debuglink()

```
int dwarf_gnu_debuglink(Dwarf_Debug dbg,
    char      **debuglink_path_returned,
    unsigned char **crc_returned,
    char      **debuglink_fullpath_returned,
    unsigned *buildid_type returned,
    char      **buildid_returned,
    unsigned *buildid_length_returned,
    char      ***paths_returned,
    unsigned *paths_count_returned,
    Dwarf_Error* error);
```

This returns DW_DLV_NO_ENTRY if there is neither a .gnu_debuglink object-file section nor a .note.gnu.build-id section in the object file.

If there is an error it returns DW_DLV_ERROR and sets *error to point to the error value.

On success it returns DW_DLV_OK and sets the fields through the pointers as described below. Two fields must be free()d to avoid a memory leak. None of the other fields should be freed.

If there is a .gnu_debuglink section the first four fields will be set.

*debuglink_path_returned points to the null-terminated string in the section. Do not free this. The bytes are in the object itself and the pointer is invalid once dwarf_finish() is run on the dbg.

*crc_returned points to a 4-byte CRC value. The bytes pointed to are not a string.

*debuglink_fullpath_returned points to a full pathname derived from the *debuglink_fullpath_returned string. And then *debuglink_fullpath_strlen is set to the length of *debuglink_fullpath_returned just as strlen() would count the length. Callers must free() *debuglink_fullpath_returned.

If there is a .note.gnu.build-id section the buildid fields will be set through the pointers.

*buildid_type_returned will be set to the value 3.

*buildid_owner_name_returned will be set to point to the null-terminated string which will be "GNU". Do not free() this. The bytes are in the object itself and the pointer is invalid once dwarf_finish() is run on the dbg.

*buildid_returned will be set to point to the group of bytes of length *buildid_length_returned. This is not a string and is not null-terminated. It is normally a 20-byte field to be used in its ascii-hex form. Do not free() this. The bytes are in the object itself and the pointer is invalid once dwarf_finish() is run on the dbg.

If *paths_returned is passed as NULL then no paths calculation will be made and

`*paths_count_returned` is not referenced by `libdwarf`.

If `*paths_returned` is passed in non-NULL then `*paths_returned` and `*paths_count_returned` provide an array of pointers-to-strings (with the actual strings following the array) and the count of the pointers in the array. When the strings are no longer needed `free()` `*paths_returned`. The number of paths returned will depend on which (of the two) sections exist and on how many global paths have been set by `dwarf_add_debuglink_global_path()`. and defined by the rules described in the web page mentioned above. The default global path is `"/usr/lib/debug"` and that is set by `libdwarf` as `paths_returned[0]`.

An example of calling this function follows

Figure 35. Example debuglink ()

```
void exampledebuglink(Dwarf_Debug dbg)
{
    int      res = 0;
    char      *debuglink_path = 0;
    unsigned char *crc = 0;
    char      *debuglink_fullpath = 0;
    unsigned debuglink_fullpath_strlen = 0;
    unsigned buildid_type = 0;
    char *      buildidowner_name = 0;
    unsigned char *buildid_itself = 0;
    unsigned buildid_length = 0;
    char **      paths = 0;
    unsigned paths_count = 0;
    Dwarf_Error error = 0;
    unsigned i = 0;

    /* This is just an example if one knows
       of another place full-DWARF objects
       may be. "/usr/lib/debug" is automatically
       set. */
    res = dwarf_add_debuglink_global_path(dbg,
        "/some/path/debug",&error);
    if (res != DW_DLV_OK) {
        /* Something is wrong, but we'll ignore
           that. */
    }

    res = dwarf_gnu_debuglink(dbg,
        &debuglink_path,
        &crc,
        &debuglink_fullpath,
        &debuglink_fullpath_strlen,
        &buildid_type,
        &buildidowner_name,
        &buildid_itself,
        &buildid_length,
        &paths,
        &paths_count,
        &error);
    if (res == DW_DLV_ERROR) {
        /* Do something with the error */
        return;
    }
    if (res == DW_DLV_NO_ENTRY) {
        /* No such sections as .note.gnu.build-id
```

```
        or .gnu_debuglink */
    return;
}
if (debuglink_fullpath_strlen) {
    printf("debuglink      path: %s\n", debuglink_path);
    printf("crc length      : %u  crc: ", 4);
    for (i = 0; i < 4; ++i) {
        printf("%02x", crc[i]);
    }
    printf("\n");
    printf("debuglink fullpath: %s\n", debuglink_fullpath);
}
if (builddid_length) {
    printf("builddid type      : %u\n", builddid_type);
    printf("Builddid owner       : %s\n", builddidowner_name);
    printf("builddid byte count: %u\n", builddid_length);
    printf(" ");
    /*    builddid_length should be 20. */
    for (i = 0; i < builddid_length; ++i) {
        printf("%02x", builddid_itself[i]);
    }
    printf("\n");
}
printf("Possible paths count %u\n", paths_count);
for ( ; i < paths_count; ++i) {
    printf("%2u: %s\n", i, paths[i]);
}
free(debuglink_fullpath);
free(paths);
return;
}
```

6.30.2 dwarf_add_debuglink_global_path()

```
int dwarf_add_debuglink_global_path(Dwarf_Debug dbg,
    const char * path,
    Dwarf_Error* error);
```

This is unlikely to return DW_DLV_ERROR unless one passes in a NULL instead of an open Dwarf_Debug. It cannot return DW_DLV_NO_ENTRY.

On success it returns DW_DLV_OK after adding the path to the global list recorded in the Dwarf_Debug.

6.30.3 dwarf_crc32()

```
int dwarf_crc32(Dwarf_Debug dbg,
               unsigned char * crc_buf,
               Dwarf_Error* error);
```

The caller must pass the address of a 4 byte array of unsigned char in `crc_buf`. And the `Dwarf_Debug` must have been opened with `dwarf_init_path()` to be useful. If the executable is named `executable` the file containing most of the f(CWDWARF data would often be `executable.debug`. This is normally called from `libdwarf` code on opening `executable` and `libdwarf` may call this function on `executable.debug`. Library users could would likely never call it.

On success it returns `DW_DLV_OK` and sets the 4 bytes pointed to by `crc_buf` to the calculated CRC value.

If it returns `DW_DLV_NO_ENTRY` or `DW_DLV_ERROR` something went wrong and `crc_buf` is not touched.

The function was added October 2020.

6.30.4 dwarf_basic_crc32()

```
unsigned int dwarf_basic_crc32(const unsigned char *buf,
                              int len,
                              unsigned int init);
```

This computes the crc on `buf` of length `len` with initial value `init`. See `libdwarf` source for the details of calling this. It is not likely useful for library uses to call this directly.

The function was added October 2020.

6.31 DWARF5 .debug_sup section access

The `.debug_sup` section is new in DWARF5 and this function returns all the data in that section. The section enables splitting off some DWARF5 information to a separate file, enabling a debugger to find the file, and ensuring the file found actually matches. See the DWARF5 standard.

6.31.1 dwarf_get_debug_sup()

```
int dwarf_get_debug_sup(Dwarf_Debug dbg,
    Dwarf_Half      * version,
    Dwarf_Small     * is_supplementary,
    char            ** filename,
    Dwarf_Unsigned  * checksum_len,
    Dwarf_Small     ** checksum,
    Dwarf_Error* error);
```

On success it returns DW_DLV_OK and sets values through the pointer fields (other than error). If any of the pointer fields are NULL those pointers are ignored. There is nothing resulting from this call to free or dealloc.

The pointer values are as follows:

version is defined to be 2, and any other value is an error (libdwarf does not indicate an error).

is_supplementary is a flag and only 0 or 1 should be present. and any other value is an error, though libdwarf does not indicate an error.

filename is a null-terminated string.

checksum_len is the length, in bytes, of the data checksum points to.

If there is no .debug_sup section or if that is empty DW_DLV_NO_ENTRY is returned.

On error (for example, if a field runs off the end of the section due to data corruption) DW_DLV_ERROR is returned and *error returns the error information as is standard in libdwarf.

6.32 Debug Fission (.debug_tu_index, .debug_cu_index) operations

We name things "xu" as these sections have the same format so we let "x" stand for either section. The DWARF5 standard refers to Split Dwarf while libdwarf tends to refer to this as "Fission".

These functions get access to the index functions needed to access and print the contents of an object file which is an aggregate of .dwo objects. These sections are implemented in gcc/gdb and are DWARF5. The idea is that much debug information can be separated off into individual .dwo Elf objects and then aggregated simply into a single .dwp object so the executable need not have the complete debug information in it at runtime yet allow good debugging.

For additional information, see ["https://gcc.gnu.org/wiki/DebugFissionDWP"](https://gcc.gnu.org/wiki/DebugFissionDWP), ["https://gcc.gnu.org/wiki/DebugFission"](https://gcc.gnu.org/wiki/DebugFission), and ["http://www.bayarea.net/~cary/dwarf/Accelerated%20Access%20Diagram.png"](http://www.bayarea.net/~cary/dwarf/Accelerated%20Access%20Diagram.png) and as of 17 February 2017, the DWARF5 standard.

There are FORM access functions related to Debug Fission (Split Dwarf). See dwarf_formaddr() and dwarf_get_debug_addr_index() and dwarf_get_debug_str_index().

The FORM with the hash value (for a reference to a type unit) is DW_FORM_ref_sig8.

In a compilation unit of Debug Fission object (or a .dwp Package File) DW_AT_dwo_id the hash is expected to be DW_FORM_data8.

The DWARF5 standard defines the hash as an 8 byte value which we could use Dwarf_Unsigned. Instead (and mostly for type safety) we define the value as a structure whose type name is Dwarf_Sig8.

To look up a name in the hash (to find which CU(s) it exists in). use dwarf_get_debugfission_for_key(), defined below.

The second group of interfaces here beginning with dwarf_get_xu_index_header() are useful if one wants to print a .debug_tu_index or .debug_cu_index section.

To access DIE, macro, etc information the support is built into DIE, Macro, etc operations so applications usually won't need to use these operations at all.

6.32.1 Dwarf_Debug_Fission_Per_CU

```
#define DW_FFISSION_SECT_COUNT 12
struct Dwarf_Debug_Fission_Per_CU_s {
    /* Do not free the string. It contains "cu" or "tu". */
    /* If this is not set (ie, not a CU/TU in DWP Package File)
       then pcu_type will be NULL. */
    const char * pcu_type;
    /* pcu_index is the index (range 1 to N )
       into the tu/cu table of offsets and the table
       of sizes. 1 to N as the zero index is reserved
       for special purposes. Not a value one
       actually needs. */
    Dwarf_Unsigned pcu_index;
    Dwarf_Sig8 pcu_hash; /* 8 byte */
    /* [0] has offset and size 0.
       [1]-[8] are DW_SECT_* indexes and the
       values are the offset and size
       of the respective section contribution
       of a single .dwo object. When pcu_size[n] is
       zero the corresponding section is not present. */
    Dwarf_Unsigned pcu_offset[DW_FFISSION_SECT_COUNT];
    Dwarf_Unsigned pcu_size[DW_FFISSION_SECT_COUNT];
    Dwarf_Unsigned unused1;
    Dwarf_Unsigned unused2;
};
```

The structure is used to return data to callers with the data from either .debug_tu_index or

.debug_cu_index that is applicable to a single compilation unit or type unit.

Callers to the applicable functions (see below) should allocate the structure and zero all the bytes in it. The structure has a few fields that are presently unused. These are reserved for future use since it is impossible to alter the structure without breaking binary compatibility.

6.32.2 dwarf_die_from_hash_signature()

```
int dwarf_die_from_hash_signature(Dwarf_Debug dbg,  
    Dwarf_Sig8 *   hash_sig,  
    const char *   sig_type,  
    Dwarf_Die*     returned_die,  
    Dwarf_Error*   error);
```

The function is the most direct way to go from the hash data from a DW_FORM_ref_sig8 or a DW_AT_dwo_id (from DW_FORM_data8) to a DIE from a .dwp package file or a .dwo object file (.dwo access not supported yet).

The caller passes in dbg which should be Dwarf_Debug open/initialized on a .dwp package file (or a .dwo object file).

The caller also passes in hash_sig, a pointer to the hash signature for which the caller wishes to find a DIE.

The caller also passes in sig_type which must contain either "tu" (identifying the hash referring to a type unit) or "cu" (identifying the hash as referring to a compilation unit).

On success the function returns DW_DLV_OK and sets *returned_die to be a pointer to a valid DIE for the compilation unit or type unit. If the type is "tu" the DIE returned is the specific type DIE that the hash refers to. If the type is "cu" the DIE returned is the compilation unit DIE of the compilation unit referred to.

When appropriate the caller should free the space of the returned DIE by a call something like

```
dwarf_dealloc(dbg,die,DW_DLA_DIE);
```

If there is no DWP Package File section or the hash cannot be found the function returns DW_DLV_NO_ENTRY and leaves returned_die untouched. Only .dwo objects and .dwp package files have the package file index sections.

If there is an error of some sort the function returns DW_DLV_ERROR, leaves returned_die untouched, and sets *error to indicate the precise error encountered.

6.32.3 dwarf_get_debugfission_for_die()


```
int dwarf_get_debugfission_for_die(Dwarf_Die die,  
    Dwarf_Debug_Fission_Per_CU * percu_out,  
    Dwarf_Error * error);
```

The function returns the debug fission for the compilation unit the DIE is a part of. Any DIE in the compilation (or type) unit will get the same result.

On a call to this function ensure the pointed-to space is fully initialized.

On success the function returns DW_DLV_OK and fills in the fields of *percu_out for which it has data.

If there is no DWP Package File section the function returns DW_DLV_NO_ENTRY and leaves *percu_out untouched. Only .dwp package files have the package file index sections.

If there is an error of some sort the function returns DW_DLV_ERROR, leaves *percu_out untouched, and sets *error to indicate the precise error encountered.

6.32.4 dwarf_get_debugfission_for_key()

```
int dwarf_get_debugfission_for_key(Dwarf_Debug dbg,  
    Dwarf_Sig8 *          key,  
    const char *          key_type ,  
    Dwarf_Debug_Fission_Per_CU * percu_out,  
    Dwarf_Error *          error);
```

The function returns the debug fission data for the compilation unit in a .dwp package file.

If there is no DWP Package File section the function returns DW_DLV_NO_ENTRY and leaves *percu_out untouched. Only .dwp package files have the package file index sections.

If there is an error of some sort the function returns DW_DLV_ERROR, leaves *percu_out untouched, and sets *error to indicate the precise error encountered.

6.32.5 dwarf_get_xu_index_header()

```
int dwarf_get_xu_index_header(Dwarf_Debug dbg,
    const char * section_type, /* "tu" or "cu" */
    Dwarf_Xu_Index_Header * xuhdr,
    Dwarf_Unsigned * version_number,
    Dwarf_Unsigned * offsets_count /* L */,
    Dwarf_Unsigned * units_count /* N */,
    Dwarf_Unsigned * hash_slots_count /* M */,
    const char ** sect_name,
    Dwarf_Error * err);
```

takes as input a valid Dwarf_Debug pointer and an `section_type` value, which must be one of the strings `tu` or `cu`.

It returns `DW_DLV_NO_ENTRY` if the section requested is not in the object file.

It returns `DW_DLV_ERROR` if there is an error of some kind. The error is indicated by the value returned through the `error` pointer.

If successful, the function returns `DW_DLV_OK` and returns the following values through the pointers:

The `xuhdr` field is a pointer usable in other operations (see below).

The `version_number` field is the index version number. For gcc before DWARF5 the version number is 2. For DWARF5 the version number is 5.

The `offsets_count` field is the number of columns in the table of section offsets. Sometimes known as `L`.

The `units_count` field is the number of compilation units or type units in the index. Sometimes known as `N`.

The `hash_slots_count` field is the number of slots in the hash table. Sometimes known as `M`.

The `sect_name` field is the name of the section in the object file. Because non-Elf objects may not use section names callers must recognize that the `sect_name` may be set to `NULL` (zero) or to point to the empty string and this is not considered an error.

An example of initializing and disposing of a `Dwarf_Xu_Index_Header` follows.

Figure 36. Example `dwarf_get_xu_index_header()`

```
void example(Dwarf_Debug dbg, const char *type)
{
    /* type is "tu" or "cu" */
    int res = 0;
    Dwarf_Xu_Index_Header xuhdr = 0;
    Dwarf_Unsigned version_number = 0;
    Dwarf_Unsigned offsets_count = 0; /* L */
    Dwarf_Unsigned units_count = 0; /* M */
    Dwarf_Unsigned hash_slots_count = 0; /* N */
    Dwarf_Error err = 0;
    const char * section_name = 0;

    res = dwarf_get_xu_index_header(dbg,
        type,
        &xuhdr,
        &version_number,
        &offsets_count,
        &units_count,
        &hash_slots_count,
        &section_name,
        &err);
    if (res == DW_DLV_NO_ENTRY) {
        /* No such section. */
        return;
    }
    if (res == DW_DLV_ERROR) {
        /* Something wrong. */
        return;
    }
    /* Do something with the xuhdr here . */
    dwarf_xu_header_free(xuhdr);
}
```

6.32.6 `dwarf_get_xu_index_section_type()`

```
int dwarf_get_xu_index_section_type(
    Dwarf_Xu_Index_Header xuhdr,
    const char ** typename,
    const char ** sectionname,
    Dwarf_Error * error);
```

The function takes as input a valid `Dwarf_Xu_Index_Header`. It is only useful when one already has an open `xuhdr` but one does not know if this is a type unit or compilation unit index section.

If it returns `DW_DLV_NO_ENTRY` something is wrong (should never happen). If it returns `DW_DLV_ERROR` something is wrong and the `error` field is set to indicate a

specific error.

If successful, the function returns `DW_DLV_OK` and sets the following arguments through the pointers:

`typename` is set to the string `tu` or `cu` to indicate the index is of a type unit or a compilation unit, respectively.

`sectionname` is set to name of the object file section. Because non-Elf objects may not use section names callers must recognize that the `sect_name` may be set to `NULL` (zero) or to point to the empty string and this is not considered an error.

Neither string should be `free()`d.

6.32.7 `dwarf_get_xu_header_free()`

```
void dwarf_xu_header_free(Dwarf_Xu_Index_Header xuhdr);
```

The function takes as input a valid `Dwarf_Xu_Index_Header` and frees all the special data allocated for this access type. Once called, any pointers returned by use of the `xuhdr` should be considered stale and unusable.

6.32.8 `dwarf_get_xu_hash_entry()`

```
int dwarf_get_xu_hash_entry(  
    Dwarf_Xu_Index_Header xuhdr,  
    Dwarf_Unsigned      index,  
    Dwarf_Sig8 *        hash_value,  
    Dwarf_Unsigned *    index_to_sections,  
    Dwarf_Error *       error);
```

The function takes as input a valid `Dwarf_Xu_Index_Header` and an `index` of a hash slot entry (valid hash slot index values are zero (0) through `hash_slots_count - 1` (M-1)).

If it returns `DW_DLV_NO_ENTRY` something is wrong

If it returns `DW_DLV_ERROR` something is wrong and the `error` field is set to indicate a specific error.

If successful, the function returns `DW_DLV_OK` and sets the following arguments through the pointers:

`hash_value` is set to the 64bit hash of the symbol name.

`index_to_sections` is set to the index into offset-size tables of this hash entry.

If both `hash_value` and `index_to_sections` are zero (0) then the hash slot is unused. `index_to_sections` is used in calls to the function `dwarf_get_xu_section_offset()` as the `row_index`.

An example of use follows.

Figure 37. Exemplez dwarf_get_xu_hash_entry()

```
void exemplez( Dwarf_Xu_Index_Header xuhdr,
              Dwarf_Unsigned hash_slots_count)
{
    /* hash_slots_count returned by
       dwarf_get_xu_index_header(), see above. */
    static Dwarf_Sig8 zerohashval;

    Dwarf_Error err = 0;
    Dwarf_Unsigned h = 0;

    for( h = 0; h < hash_slots_count; h++) {
        Dwarf_Sig8 hashval;
        Dwarf_Unsigned index = 0;
        int res = 0;

        res = dwarf_get_xu_hash_entry(xuhdr,h,
                                     &hashval,&index,&err);
        if (res == DW_DLV_ERROR) {
            /* Oops. hash_slots_count wrong. */
            return;
        } else if (res == DW_DLV_NO_ENTRY) {
            /* Impossible */
            return;
        } else if (!memcmp(&hashval,&zerohashval,
                           sizeof(Dwarf_Sig8))
                   && index == 0 ) {
            /* An unused hash slot */
            continue;
        }
        /* Here, hashval and index (a row index into
           offsets and lengths) are valid.
           But the row to be passed into
           various functions here is index-1. */
    }
}
```

6.32.9 dwarf_get_xu_section_names()

```
int dwarf_get_xu_section_names(  
    Dwarf_Xu_Index_Header xuhdr,  
    Dwarf_Unsigned      column_index,  
    Dwarf_Unsigned*     number,  
    const char **       name,  
    Dwarf_Error *       err);
```

The function takes as input a valid `Dwarf_Xu_Index_Header` and a `column_index` of a hash slot entry (valid `column_index` values are zero (0) through `offsets_count - 1` (L-1)).

If it returns `DW_DLV_NO_ENTRY` something is wrong

If it returns `DW_DLV_ERROR` something is wrong and the `error` field is set to indicate a specific error.

If successful, the function returns `DW_DLV_OK` and sets the following arguments through the pointers:

`number` is set to a number identifying which section this column applies to. For example, if the value is `DW_SECT_INFO` (1) the column came from a `.debug_info.dwo` section. See the table of `DW_SECT_` identifiers and assigned numbers in DWARF5.

`name` is set to the applicable spelling of the section identifier, for example `DW_SECT_INFO`.

6.32.10 dwarf_get_xu_section_offset()

```
int dwarf_get_xu_section_offset(  
    Dwarf_Xu_Index_Header xuhdr,  
    Dwarf_Unsigned      row_index,  
    Dwarf_Unsigned      column_index,  
    Dwarf_Unsigned*     sec_offset,  
    Dwarf_Unsigned*     sec_size,  
    Dwarf_Error *       error);
```

The function takes as input a valid `Dwarf_Xu_Index_Header` and a `row_index` (see `dwarf_get_xu_hash_entry()` above) and a `column_index`.

Valid `row_index` values are zero (0) through `units_count-1` (N) but one uses `dwarf_get_xu_hash_entry()` (above) to get row index and it returns a 1-origin index as that is what the DWARF5 standard specifies. Since a zero index from `dwarf_get_xu_hash_entry()` means this is not an actual entry such must be skipped.

Hence it makes (some) sense to subtract one making a zero-origin as that is the sense of all but the first row of the offsets table.

Valid `column_index` values are zero (0) through `offsets_count - 1` (L-1).

If it returns `DW_DLV_NO_ENTRY` something is wrong.

If it returns `DW_DLV_ERROR` something is wrong and the `error` field is set to indicate a specific error.

If successful, the function returns `DW_DLV_OK` and sets the following arguments through the pointers:

`sec_offset`, (`base_offset`) is set to the base offset of the initial compilation-unit-header section taken from a `.dwo` object. The `base_offset` is the data from a single section of a `.dwo` object.

`sec_size` is set to the length of the original section taken from a `.dwo` object. This is the length in the applicable section in the `.dwp` over which the base offset applies.

An example of use of `dwarf_get_xu_section_names()` and `dwarf_get_xu_section_offset()` follows.

Figure 38. Exampleza dwarf_get_xu_section_names()

```
void exampleza(Dwarf_Xu_Index_Header xuhdr,
    Dwarf_Unsigned offsets_count, Dwarf_Unsigned index )
{
    Dwarf_Error err = 0;
    Dwarf_Unsigned col = 0;
    /* We use 'offsets_count' returned by
       a dwarf_get_xu_index_header() call.
       We use 'index' returned by a
       dwarf_get_xu_hash_entry() call. */
    for (col = 0; col < offsets_count; col++) {
        Dwarf_Unsigned off = 0;
        Dwarf_Unsigned len = 0;
        const char * name = 0;
        Dwarf_Unsigned num = 0;
        int res = 0;

        res = dwarf_get_xu_section_names(xuhdr,
            col, &num, &name, &err);
        if (res != DW_DLV_OK) {
            break;
        }
        res = dwarf_get_xu_section_offset(xuhdr,
            index-1, col, &off, &len, &err);
        if (res != DW_DLV_OK) {
            break;
        }
        /* Here we have the DW_SECT_ name and number
           and the base offset and length of the
           section data applicable to the hash
           that got us here.
           Use the values.*/
    }
}
```

6.33 TAG ATTR etc names as strings

These functions turn a value into a string. So applications wanting the string "DW_TAG_compile_unit" given the value 0x11 (the value defined for this TAG) can do so easily.

The general form is


```
int dwarf_get_<something>_name(
    unsigned value,
    char **s_out,
);
```

If the value passed in is known, the function returns DW_DLV_OK and places a pointer to the appropriate string into *s_out. The string is in static storage and applications must never free the string.

If the value is not known, DW_DLV_NO_ENTRY is returned and *s_out is not set. DW_DLV_ERROR is never returned.

Libdwarf generates these functions by reading dwarf.h, processing that the maintainers do and the generated source is part of the source repository and every release.

All these follow this pattern rigidly, so the details of each are not repeated for each function.

The choice of 'unsigned' for the value type argument (the code value) argument is somewhat arbitrary, 'int' could have been used.

The library simply assumes the value passed in is applicable. So, for example, passing a TAG value code to dwarf_get_ACCESS_name() is a coding error which libdwarf will process as if it was an accessibility code value. Examples of bad and good usage are:

Figure 39. Examplezb dwarf_get_TAG_name()

```
void examplezb(void)
{
    const char * out = 0;
    int res = 0;

    /* The following is wrong, do not do it! */
    res = dwarf_get_ACCESS_name(DW_TAG_entry_point,&out);
    /* Nothing one does here with 'res' or 'out'
       is meaningful. */

    /* The following is meaningful.*/
    res = dwarf_get_TAG_name(DW_TAG_entry_point,&out);
    if( res == DW_DLV_OK) {
        /* Here 'out' is a pointer one can use which
           points to the string "DW_TAG_entry_point". */
    } else {
        /* Here 'out' has not been touched, it is
           uninitialized. Do not use it. */
    }
}
```

The function list is

- `int dwarf_get_ADDR_name(unsigned int v,char**out);`
- `int dwarf_get_ATCF_name(unsigned int v,char**out);`
- `int dwarf_get_ADDR_name(unsigned int v,char**out);`
- `int dwarf_get_ATCF_name(unsigned int v,char**out);`
- `int dwarf_get_ATE_name(unsigned int v,char**out);`
- `int dwarf_get_AT_name(unsigned int v,char**out);`
- `int dwarf_get_CC_name(unsigned int v,char**out);`
- `int dwarf_get_CFA_name(unsigned int v,char**out);`
- `int dwarf_get_children_name(unsigned int v,char**out);`
- `int dwarf_get_CHILDREN_name(unsigned int v,char**out);`
- `int dwarf_get_DEFAULTED_name(unsigned int v,char**out);`
- `int dwarf_get_DSC_name(unsigned int v,char**out);`
- `int dwarf_get_DS_name(unsigned int v,char**out);`
- `int dwarf_get_EH_name(unsigned int v,char**out);`
- `int dwarf_get_END_name(unsigned int v,char**out);`
- `int dwarf_get_FORM_name(unsigned int v,char**out);`
- `int dwarf_get_FORM_CLASS_name(enum Dwarf_Form_Class fc,char**out);`
- `int dwarf_get_FRAME_name(unsigned int v,char**out);`
- `int dwarf_get_GNUIKIND_name(unsigned int v,char**out);`
- `int dwarf_get_GNUIVIS_name(unsigned int v,char**out);`
- `int dwarf_get_ID_name(unsigned int v,char**out);`
- `int dwarf_get_IDX_name(unsigned int v,char**out);`
- `int dwarf_get_INL_name(unsigned int v,char**out);`
- `int dwarf_get_ISA_name(unsigned int v,char**out);`
- `int dwarf_get_LANG_name(unsigned int v,char**out);`
- `int dwarf_get_LLE_name(unsigned int v,char**out);`
- `int dwarf_get_LLEX_name(unsigned int v,char**out);`
- `int dwarf_get_LNCT_name(unsigned int v,char**out);`
- `int dwarf_get_LNE_name(unsigned int v,char**out);`
- `int dwarf_get_LNS_name(unsigned int v,char**out);`

- `int dwarf_get_MACINFO_name(unsigned int v,char**out);`
- `int dwarf_get_MACRO_name(unsigned int v,char**out);`
- `int dwarf_get_OP_name(unsigned int v,char**out);`
- `int dwarf_get_ORD_name(unsigned int v,char**out);`
- `int dwarf_get_RLE_name(unsigned int v,char**out);`
- `int dwarf_get_SECT_name(unsigned int v,char**out);`
- `int dwarf_get_TAG_name(unsigned int v,char**out);`
- `int dwarf_get_UT_name(unsigned int v,char**out);`
- `int dwarf_get_VIRTUALITY_name(unsigned int v,char**out);`
- `int dwarf_get_VIS_name(unsigned int v,char**out);`

6.34 Section Operations

In checking DWARF in linkonce sections for correctness it has been found useful to have certain section-oriented operations when processing object files. Normally these operations are not needed or useful in a fully-linked executable or shared library.

While the code is written with Elf sections in mind, it is quite possible to process non-Elf objects with code that implements certain function pointers (see `struct Dwarf_Obj_Access_interface_s`).

So far no one with such non-elf code has come forward to open-source it.

6.34.1 `dwarf_get_section_count()`

```
int dwarf_get_section_count(  
    Dwarf_Debug dbg)
```

Returns a count of the number of object sections found.

If there is an incomplete or damaged dbg passed in this can return -1;

6.34.2 `dwarf_get_section_info_by_name()`

```
int dwarf_get_section_info_by_name(  
    const char *section_name,  
    Dwarf_Addr *section_addr,  
    Dwarf_Unsigned *section_size,  
    Dwarf_Error *error)
```

The function returns DW_DLV_OK if the section given by `section_name` was seen by

libdwarf. On success it sets `*section_addr` to the virtual address assigned to the section by the linker or compiler and `*section_size` to the size of the object section.

It returns `DW_DLV_ERROR` on error.

6.34.3 dwarf_get_section_info_by_index()

```
int dwarf_get_section_info_by_index(
    int section_index,
    const char **section_name,
    Dwarf_Addr *section_addr,
    Dwarf_Unsigned *section_size,
    Dwarf_Error *error)
```

The function returns `DW_DLV_OK` if the section given by `section_index` was seen by libdwarf. `*section_addr` to the virtual address assigned to the section by the linker or compiler and `*section_size` to the size of the object section.

No free or deallocate of information returned should be done by callers.

6.35 Utility Operations

These functions aid in the management of errors encountered when using functions in the *libdwarf* library and releasing memory allocated as a result of a *libdwarf* operation.

For clients that wish to encode LEB numbers two interfaces are provided to the producer code's internal LEB function.

6.35.1 dwarf_errno()

```
Dwarf_Unsigned dwarf_errno(
    Dwarf_Error error)
```

The function returns the error number corresponding to the error specified by `error`.

6.35.2 dwarf_errmsg()

```
const char* dwarf_errmsg(
    Dwarf_Error error)
```

The function returns a pointer to a null-terminated error message string corresponding to the error specified by `error`. The string should not be deallocated using `dwarf_dealloc()`.

The string should be considered to be a temporary string. That is, the returned pointer may become stale if you do libdwarf calls on the `Dwarf_Debug` instance other than `dwarf_errmsg()` or `dwarf_errno()`. So copy the `errmsg` string (or print it) but do not depend on the pointer remaining valid past other libdwarf calls to the `Dwarf_Debug` instance that detected an error.

6.35.3 dwarf_errmsg_by_number()

```
const char* dwarf_errmsg_by_number(  
    Dwarf_Unside errcode)
```

The function returns a pointer to a null-terminated error message string corresponding to the error number specified by `errcode`. The string should not be deallocated or freed. If the `errcode` is too large for the table of static error strings a string reflecting that fact is returned.

For some places in the code a `Dwarf_Error()` is inconvenient and this function lets `dwarfdump` report better information in those cases.

6.35.4 dwarf_error_creation()

```
void dwarf_error_creation(Dwarf_Debug dbg,  
    Dwarf_Error* error, char *errmsg);  
Dwarf_Unside errcode)
```

This is a very specialized function. It is a way to create a `Dwarf_Error` out of thin air from your own code. The error code becomes `DW_DLE_USER_DECLARED_ERROR` and the string pass in, one presumes, is a meaningful string.

dwarfdump uses this in a a very few places.

If the `Dwarf_Debug` passed in is `NULL` the function returns after doing...nothing at all.

6.35.5 dwarf_set_stringcheck()

```
int dwarf_set_stringcheck(int /*check*/)
```

The function sets the stringcheck value to the argument value. It returns the previous value of the stringcheck value.

By default all strings looked at by the library are checked to be sure they are not too long by checking the string against a bounded range of memory.

The bound can be a section length or some other well defined value. By passing in a non-zero value you are asserting all strings are always in-bounds (well-formed) and the checks are bypassed.

The current global value copied into every `Dwarf_Debug` struct created by any `dwarf_init_path()` etc at the time the `Dwarf_Debug` is created, and that `Dwarf_Debug` setting will affect that `Dwarf_Debug` until it is `dwarf_finish()`ed..

Bypassing the bounds check is normally a very bad idea, though it may speed up `libdwarf` a little bit.

6.35.6 dwarf_get_endian_copy_function()

```
void (*dwarf_get_endian_copy_function(Dwarf_Debug /*dbg*/))  
    (void *, const void * /*src*/, unsigned long /*srclen*/)
```

When reader client code wants to extract endian-dependent integers from dwarf and the existing interfaces won't do that (for example in printing frame instructions as done by dwarfdump) dwarf_get_endian_copy_function helps by returning the proper copy function needed, the one libdwarf itself uses. The client code needs a bit of glue to finish the job, as demonstrated by the ASNAR macro in dwarfdump/print_frames.c

On success this returns a pointer to the correct copy function.

On failure it returns the null pointer. It's up to the client code to decide how to deal with the situation. In no reasonable case will the null pointer be returned.

New December 2018.

6.35.7 dwarf_get_harmless_error_list()

```
int dwarf_get_harmless_error_list(Dwarf_Debug dbg,  
    unsigned count,  
    const char ** errmsg_ptrs_array,  
    unsigned * newerr_count);
```

The harmless errors are not denoted by error returns from the other libdwarf functions. Instead, this function returns strings of any harmless errors that have been seen in the current object. Clients never need call this, but if a client wishes to report any such errors it may call.

Only a fixed number of harmless errors are recorded. It is a circular list, so if more than the current maximum is encountered older harmless error messages are lost.

The caller passes in a pointer to an array of pointer-to-char as the argument `errmsg_ptrs_array`. The caller must provide this array, libdwarf does not provide it. The caller need not initialize the array elements.

The caller passes in the number of elements of the array of pointer-to-char thru `count`. Since the

If there are no unreported harmless errors the function returns `DW_DLV_NO_ENTRY` and the function arguments are ignored. Otherwise the function returns `DW_DLV_OK` and uses the arguments.

libdwarf assigns error strings to the `errmsg_ptrs_array`. The MINIMUM(count-1, number of messages recorded) pointers are assigned to the array. The array is terminated with a NULL pointer. (That is, one array entry is reserved for a NULL pointer). So if count is 5 up to 4 strings may be returned through the array, and one array entry is set to NULL.

Because the list is circular and messages may have been dropped the function also returns the actual error count of harmless errors encountered through `newerr_count` (unless the argument is `NULL`, in which case it is ignored).

Each call to this function resets the circular error buffer and the error count. So think of this call as reporting harmless errors since the last call to it.

The pointers returned through `errmsg_ptrs_array` are only valid till the next call to `libdwarf`. Do not save the pointers, they become invalid. Copy the strings if you wish to save them.

Calling this function neither allocates any space in memory nor frees any space in memory.

6.35.8 dwarf_insert_harmless_error()

```
void dwarf_insert_harmless_error(Dwarf_Debug dbg,  
    char * newerror);
```

This function is used to test `dwarf_get_harmless_error_list`. It simply adds a harmless error string. There is little reason client code should use this function. It exists so that the harmless error functions can be easily tested for correctness and leaks.

6.35.9 dwarf_set_harmless_error_list_size()

```
unsigned dwarf_set_harmless_error_list_size(Dwarf_Debug dbg,  
    unsigned maxcount)
```

`dwarf_set_harmless_error_list_size` returns the number of harmless error strings the library is currently set to hold. If `maxcount` is non-zero the library changes the maximum it will record to be `maxcount`.

It is extremely unwise to make `maxcount` large because `libdwarf` allocates space for `maxcount` strings immediately.

The set of errors enumerated in Figure 8 below were defined in Dwarf 1. These errors are not used by the `libdwarf` implementation for Dwarf 2 or later.

SYMBOLIC NAME	DESCRIPTION
DW_DLE_NE	No error (0)
DW_DLE_VMM	Version of DWARF information newer than libdwarf
DW_DLE_MAP	Memory map failure
DW_DLE_LEE	Propagation of libelf error
DW_DLE_NDS	No debug section
DW_DLE_NLS	No line section
DW_DLE_ID	Requested information not associated with descriptor
DW_DLE_IOF	I/O failure
DW_DLE_MAF	Memory allocation failure
DW_DLE_IA	Invalid argument
DW_DLE_MDE	Mangled debugging entry
DW_DLE_MLE	Mangled line number entry
DW_DLE_FNO	File descriptor does not refer to an open file
DW_DLE_FNR	File is not a regular file
DW_DLE_FWA	File is opened with wrong access
DW_DLE_NOB	File is not an object file
DW_DLE_MOF	Mangled object file header
DW_DLE_EOLL	End of location list entries
DW_DLE_NOLL	No location list section
DW_DLE_BADOFF	Invalid offset
DW_DLE_EOS	End of section
DW_DLE_ATRUNC	Abbreviations section appears truncated
DW_DLE_BADBITC	Address size passed to dwarf bad

Figure 40. Dwarf Error Codes

The set of errors returned by `Libdwarf` functions is listed below. The list does lengthen: the ones listed here are far from a complete list. Some of the errors are SGI specific. See `libdwarf/dwarf_errmsg_list.h` for the complete list.

SYMBOLIC NAME (description not shown here)
DW_DLE_DBG_ALLOC
DW_DLE_FSTAT_ERROR
DW_DLE_FSTAT_MODE_ERROR
DW_DLE_INIT_ACCESS_WRONG
DW_DLE_ELF_BEGIN_ERROR
DW_DLE_ELF_GETEHDR_ERROR
DW_DLE_ELF_GETSHDR_ERROR
DW_DLE_ELF_STRPTR_ERROR
DW_DLE_DEBUG_INFO_DUPLICATE
DW_DLE_DEBUG_INFO_NULL
DW_DLE_DEBUG_ABBREV_DUPLICATE
DW_DLE_DEBUG_ABBREV_NULL
DW_DLE_DEBUG_ARANGES_DUPLICATE
DW_DLE_DEBUG_ARANGES_NULL
DW_DLE_DEBUG_LINE_DUPLICATE
DW_DLE_DEBUG_LINE_NULL
DW_DLE_DEBUG_LOC_DUPLICATE
DW_DLE_DEBUG_LOC_NULL
DW_DLE_DEBUG_MACINFO_DUPLICATE
DW_DLE_DEBUG_MACINFO_NULL
DW_DLE_DEBUG_PUBNAMES_DUPLICATE
DW_DLE_DEBUG_PUBNAMES_NULL
DW_DLE_DEBUG_STR_DUPLICATE
DW_DLE_DEBUG_STR_NULL
DW_DLE_CU_LENGTH_ERROR
DW_DLE_VERSION_STAMP_ERROR
DW_DLE_ABBREV_OFFSET_ERROR
DW_DLE_ADDRESS_SIZE_ERROR
DW_DLE_DEBUG_INFO_PTR_NULL
DW_DLE_DIE_NULL
DW_DLE_STRING_OFFSET_BAD
DW_DLE_DEBUG_LINE_LENGTH_BAD
DW_DLE_LINE_PROLOG_LENGTH_BAD
DW_DLE_LINE_NUM_OPERANDS_BAD
DW_DLE_LINE_SET_ADDR_ERROR

Figure 41. Dwarf 2 and later Error Codes

This list of errors is not complete; additional errors have been added. Some of the above errors may be unused. Errors may not have the same meaning in different releases. Since most error codes are returned from only one place (or a very small number of places) in the source it is normally very useful to simply search the `libdwarf` source to find out where a particular error code is generated. See `libdwarf/dwarf_errmsg_list.h` for the complete message set with short descriptions.

6.35.10 dwarf_dealloc()

```
void dwarf_dealloc(  
    Dwarf_Debug dbg,  
    void* space,  
    Dwarf_Unsigned type)
```

The function frees the dynamic storage pointed to by `space`, and allocated to the given `Dwarf_Debug`. The argument `type` is an integer code that specifies the allocation type of the region pointed to by the `space`. Refer to section 4 for details on *libdwarf* memory management.

6.35.11 dwarf_encode_leb128()

```
int dwarf_encode_leb128(Dwarf_Unsigned val,  
    int * nbytes,  
    char * space,  
    int splen);
```

The function encodes the value `val` in the caller-provided buffer that `space` points to. The caller-provided buffer must be at least `splen` bytes long.

The function returns `DW_DLV_OK` if the encoding succeeds. If `splen` is too small to encode the value, `DW_DLV_ERROR` will be returned.

If the call succeeds, the number of bytes of `space` that are used in the encoding are returned through the pointer `nbytes`

6.35.12 dwarf_encode_signed_leb128()

```
int dwarf_encode_signed_leb128(Dwarf_Signed val,  
    int * nbytes,  
    char * space,  
    int splen);
```

The function is the same as `dwarf_encode_leb128` except that the argument `val` is signed.

6.36 Finding Memory Leaks

If you are using `dwarf_set_de_alloc_flag(0)` to turn off the garbage collection `dwarfinish()` does and you find memory leaks there are a couple specific tools provided that may ease the process of tracking down the errors you have made.

This chapter is new as of 26 March 2020.

6.36.1 Compiling libdwarf -DDEBUG=1

The first tool is to build libdwarf with options `-g -O0 -DDEBUG=1`. The `-O0` is simply to help a debugger, valgrind or other tool identify source lines accurately. The `-DDEBUG=1` Turns on `printf` statements in `dwarf_alloc.c` and `dwarf_error.c` that emit lines like

```
libdwarfdetector ALLOC ret 0x... size
libdwarfdetector DEALLOC ret 0x... size
libdwarfdetector ALLOC creating error string
libdwarfdetector DEALLOC Now destruct error string
```

at each point of particular interest.

The first two relate to actually malloc/free. The `ret 0x...` will be a hex address of the pointer your code is presented for allocations inside libdwarf.

The second two relate to allocation/free of a string in `Dwarf_Error` record when an error record with variable descriptive error information is being built/freed.

6.36.2 Making use of the output of -DDEBUG=1

A small Python 3 program (`alloctrack.py`) in the libdwarf regressiontests on SourceForge.net will read through a file with libdwarfdetector lines and report on mismatches in the alloc/dealloc counts for each memory-blob libdwarf created. All other lines are skipped.

This has been found very useful.

Since the regression tests are large and you won't otherwise need them a copy of `alloctrack.py` follows so you need not clone the test code.

```
#!/usr/bin/env python3
# Copyright 2020 David Anderson
# This Python code is hereby placed into the public domain
# for use by anyone for any purpose.

# Useful for finding the needle of
# a single leaking allocation
# in the haystack of all the libdwarfdetector
# lines libdwarf can emit if compiled -DDEBUG=1
import sys
import os

def trackallocs(fi, valdict):
    line = 0
    while True:
        line = int(line)+1
        try:
            recf = fi.readline()
        except EOFError:
            break
        if len(recf) < 1:
            # eof
            break
        rec = recf.strip()
        if rec.find("ALLOC") != -1:
            if rec.find("libdwarfdetector ALLOC ret 0x") != -1:
                wds = rec.split()
                off = wds[3]
                if off in valdict:
                    (allo, deallo) = valdict[off]
                    if int(allo) == 0:
                        r = (1, deallo)
                        valdict[off] = r
                    else:
                        print("Duplicate use of ", off, "line", line)
                        r = (int(allo)+1, deallo)
                        valdict[off] = r
                else:
                    allo = 1
                    deallo = 0
                    r = (allo, deallo)
                    valdict[off] = r
            continue

        if rec.find("libdwarfdetector DEALLOC ret 0x") != -1:
            wds = rec.split()
```

```
off = wds[3]
if off in valdict:
    (allo,deallo) = valdict[off]
    if int(deallo) == 0:
        r = (allo,1)
        valdict[off] = r
    else:
        print("Duplicate use of ",off,"line",line)
        r = (allo,int(deallo)+1)
        valdict[off] = r
else:
    allo = 0
    deallo = 1
    r=(allo,deallo)
    valdict[off] = r
continue

if __name__ == '__main__':
    if len(sys.argv) > 1:
        fname = sys.argv[1]
        try:
            file = open(fname,"r")
        except IOError as message:
            print("File could not be opened: ", fname, " ", message)
            sys.exit(1)
        else:
            file = sys.stdin

    vals = {}
    trackallocs(file,vals)
    for s in vals:
        (allo,deallo) = vals[s]
        if int(allo) != int(deallo):
            print("Mismatch on ",s," a vs d: ",allo,deallo)
        if int(allo) > 1:
            print("Reuse of ",s," a vs d: ",allo,deallo)
```


CONTENTS

1. INTRODUCTION	1
1.1 Copyright	1
1.2 Purpose and Scope	1
1.3 Document History	2
1.4 Definitions	2
1.5 Overview	2
1.6 Items Changed	3
1.7 Items Removed	4
1.8 Revision History	5
2. Types Definitions	5
2.1 General Description	5
2.2 Scalar Types	5
2.3 Aggregate Types	6
2.3.1 Data Block	7
2.3.2 Frame Operation Codes: DWARF 3 (for DWARF2 and later)	7
2.3.3 Frame Regtable3: DWARF2 and later	7
2.3.4 Macro Details Record	9
2.4 Opaque Types	10
3. UTF-8 strings	13
4. Error Handling	14
4.1 Returned values in the functional interface	18
5. Memory Management	19
5.1 Read-only Properties	19
5.2 Storage Deallocation	19
5.2.1 dwarf_dealloc()	19
5.2.2 dwarf_dealloc_die()	20
5.2.3 dwarf_dealloc_attribute()	20
5.2.4 dwarf_dealloc_error()	20
5.2.5 Errors Returned from dwarf_init* calls	22
5.2.6 Error DW_DLA error free types	24
6. Functional Interface	26
6.1 Initialization Operations	26
6.1.1 dwarf_init_path()	26

6.1.2	dwarf_init_path_dl()	28
6.1.3	dwarf_init_b()	28
6.1.4	dwarf_set_de_alloc_flag()	29
6.1.5	Dwarf_Handler function	30
6.1.6	dwarf_set_tied_dbg()	30
6.1.7	dwarf_get_tied_dbg()	32
6.1.8	dwarf_finish()	32
6.1.9	dwarf_set_stringcheck()	32
6.1.10	dwarf_set_reloc_application()	32
6.1.11	dwarf_record_cmdline_options()	33
6.1.12	dwarf_object_init_b()	33
6.1.13	dwarf_object_finish()	33
6.1.14	dwarf_get_real_section_name()	34
6.1.15	dwarf_package_version()	35
6.2	Object Type Detectors	35
6.2.1	dwarf_object_detector_path_b()	35
6.2.2	dwarf_object_detector_path_dSYM()	37
6.2.3	dwarf_object_detector_fd()	38
6.3	Section Group Operations	38
6.3.1	dwarf_sec_group_map()	38
6.4	Section size operations	41
6.4.1	dwarf_get_section_max_offsets_d()	41
6.5	Printf Callbacks	42
6.5.1	dwarf_print_lines()	42
6.5.2	dwarf_register_printf_callback	42
6.5.3	Dwarf_Printf_Callback_Info_s	43
6.5.4	dwarf_printf_callback_function_type	43
6.5.5	Example of printf callback use in a C++ application using libdwarf	43
6.6	Debugging Information Entry Delivery Operations	44
6.6.1	dwarf_get_die_section_name()	44
6.6.2	dwarf_get_die_section_name_b()	45
6.6.3	dwarf_next_cu_header_d()	45
6.6.4	dwarf_siblingof_b()	47
6.6.5	dwarf_child()	48
6.6.6	dwarf_offdie_b()	49
6.6.7	dwarf_validate_die_sibling()	50
6.7	Debugging Information Entry Query Operations	50
6.7.1	dwarf_get_die_infotypes_flag()	51
6.7.2	dwarf_cu_header_basics()	51

6.7.3	dwarf_tag()	52
6.7.4	dwarf_dieoffset()	52
6.7.5	dwarf_addr_form_is_indexed()	52
6.7.6	dwarf_debug_addr_index_to_addr()	53
6.7.7	dwarf_die_CU_offset()	53
6.7.8	dwarf_die_offsets()	53
6.7.9	dwarf_CU_dieoffset_given_die()	54
6.7.10	dwarf_find_die_given_sig8()	55
6.7.11	dwarf_die_CU_offset_range()	55
6.7.12	dwarf_diename()	55
6.7.13	dwarf_die_text()	56
6.7.14	dwarf_die_abbrev_code()	56
6.7.15	dwarf_die_abbrev_children_flag()	56
6.7.16	dwarf_die_abbrev_global_offset()	57
6.7.17	dwarf_get_version_of_die()	57
6.7.18	dwarf_attrlist()	57
6.7.19	dwarf_hasattr()	58
6.7.20	dwarf_attr()	59
6.7.21	dwarf_lowpc()	59
6.7.22	dwarf_highpc_b()	59
6.7.23	dwarf_dietype_offset()	60
6.7.24	dwarf_offset_list()	60
6.7.25	dwarf_bytesize()	61
6.7.26	dwarf_bitsize()	61
6.7.27	dwarf_bitoffset()	62
6.7.28	dwarf_srclang()	62
6.7.29	dwarf_arrayorder()	62
6.8	Attribute Queries	63
6.8.1	dwarf_hasform()	63
6.8.2	dwarf_whatform()	63
6.8.3	dwarf_whatform_direct()	64
6.8.4	dwarf_whatattr()	64
6.8.5	dwarf_attr_offset()	64
6.8.6	dwarf_formref()	64
6.8.7	dwarf_global_formref()	65
6.8.8	dwarf_global_formref_b()	65
6.8.9	dwarf_convert_to_global_offset()	66
6.8.10	dwarf_formaddr()	66
6.8.11	dwarf_get_debug_str_index()	67
6.8.12	dwarf_formflag()	67

6.8.13	dwarf_formudata()	68
6.8.14	dwarf_formsdata()	68
6.8.15	dwarf_formdata16()	69
6.8.16	dwarf_formblock()	69
6.8.17	dwarf_formstring()	69
6.8.18	dwarf_formsig8()	69
6.8.19	dwarf_formsig8_const()	70
6.8.20	dwarf_formexprloc()	70
6.8.21	dwarf_uncompress_integer_block_a()	71
6.8.22	dwarf_dealloc_uncompressed_block()	71
6.8.23	dwarf_get_form_class()	71
6.8.24	dwarf_discr_list()	72
6.8.25	dwarf_discr_entry_u()	75
6.8.26	dwarf_discr_entry_s()	75
6.9	Location List Operations, Raw .debug_loclists	75
6.9.1	dwarf_load_loclists()	78
6.9.2	dwarf_get_loclist_context_basics()	79
6.9.3	dwarf_get_loclist_offset_index_value()	80
6.9.4	dwarf_get_loclist_lle()	80
6.10	Location List operations .debug_loc & .debug_loclists	81
6.10.1	dwarf_get_loclist_c()	81
6.10.2	dwarf_get_locdesc_entry_d()	85
6.10.3	dwarf_get_loclist_head_kind()	86
6.10.4	dwarf_get_loclist_head_basics()	86
6.10.5	dwarf_get_location_op_value_d()	87
6.10.6	dwarf_loclist_from_expr_c()	88
6.10.7	dwarf_loc_head_c_dealloc()	91
6.11	Line Number Operations	92
6.11.1	Get A Set of Lines (including skeleton line tables)	92
6.11.2	dwarf_srclines_b()	92
6.11.3	dwarf_get_line_section_name()	93
6.11.4	dwarf_check_lineheader_b()	93
6.11.5	dwarf_get_line_section_name_from_die()	93
6.11.6	dwarf_srclines_from_linecontext()	94
6.11.7	dwarf_srclines_two_levelfrom_linecontext()	94
6.11.8	dwarf_srclines_dealloc_b()	95
6.12	Line Context Details (DWARF5 style)	99
6.12.1	dwarf_srclines_table_offset()	99
6.12.2	dwarf_srclines_version()	99
6.12.3	dwarf_srclines_comp_dir()	99

6.12.4	dwarf_srclines_files_indexes()	100
6.12.5	dwarf_srclines_files_data_b()	100
6.12.6	dwarf_srclines_include_dir_count()	101
6.12.7	dwarf_srclines_include_dir_data()	101
6.12.8	dwarf_srclines_subprog_count()	101
6.12.9	dwarf_srclines_subprog_data()	102
6.13	Get the set of Source File Names	102
6.13.1	dwarf_srcfiles()	102
6.14	Get Information About a Single Line Table Line	104
6.14.1	dwarf_linebeginstatement()	104
6.14.2	dwarf_lineendsequence()	104
6.14.3	dwarf_lineno()	104
6.14.4	dwarf_line_srcfileno()	105
6.14.5	dwarf_lineaddr()	105
6.14.6	dwarf_lineoff_b()	105
6.14.7	dwarf_linesrc()	106
6.14.8	dwarf_lineblock()	106
6.14.9	dwarf_is_addr_set()	106
6.14.10	dwarf_prologue_end_etc()	107
6.15	Accelerated Access By Name operations	107
6.15.1	Fine Tuning Accelerated Access	107
6.15.1.1	dwarf_return_empty_pubnames	108
6.15.1.2	dwarf_get_globals_header	108
6.15.2	Accelerated Access Pubnames	109
6.15.2.1	dwarf_get_globals()	109
6.15.2.2	dwarf_globname()	110
6.15.2.3	dwarf_global_die_offset()	110
6.15.2.4	dwarf_global_cu_offset()	110
6.15.2.5	dwarf_get_cu_die_offset_given_cu_header_offset_b()....	111
6.15.2.6	dwarf_global_name_offsets()	111
6.15.3	Accelerated Access Pubtypes	112
6.15.3.1	dwarf_get_pubtypes()	112
6.15.3.2	dwarf_pubtypename()	112
6.15.3.3	dwarf_pubtype_type_die_offset()	112
6.15.3.4	dwarf_pubtype_cu_offset()	113
6.15.3.5	dwarf_pubtype_name_offsets()	113
6.15.3.6	dwarf_pubtypes_dealloc()	113
6.15.4	Accelerated Access Weaknames	113
6.15.4.1	dwarf_get_weakes()	114
6.15.4.2	dwarf_weakes_dealloc()	114

6.15.4.3	dwarf_weakname()	114
6.15.4.4	dwarf_weak_die_offset()	114
6.15.4.5	dwarf_weak_cu_offset()	114
6.15.4.6	dwarf_weak_name_offsets()	114
6.15.6	Accelerated Access Funcnames (static functions)	115
6.15.6.1	dwarf_get_funcs()	115
6.15.6.2	dwarf_funcname()	115
6.15.6.3	dwarf_funcs_dealloc()	115
6.15.6.4	dwarf_func_die_offset()	116
6.15.6.5	dwarf_func_cu_offset()	116
6.15.6.6	dwarf_func_name_offsets()	116
6.15.7	Accelerated Access Typenames	116
6.15.7.1	dwarf_get_types()	116
6.15.7.2	dwarf_typename()	117
6.15.7.3	dwarf_type_die_offset()	117
6.15.7.4	dwarf_type_cu_offset()	117
6.15.7.5	dwarf_type_name_offsets()	117
6.15.7.6	dwarf_types_dealloc()	117
6.15.8	Accelerated Access varnames	117
6.15.8.1	dwarf_get_vars()	118
6.15.8.2	dwarf_vars_dealloc()	118
6.15.8.3	dwarf_varname()	118
6.15.8.4	dwarf_var_die_offset()	118
6.15.8.5	dwarf_var_cu_offset()	118
6.15.8.6	dwarf_var_name_offsets()	118
6.16	Names Fast Access (DWARF5) .debug_names	119
6.16.1	dwarf_dnames_header()	119
6.16.2	dwarf_dnames_sizes()	120
6.16.3	dwarf_dnames_cu_entry()	121
6.16.4	dwarf_dnames_local_tu_entry()	121
6.16.5	dwarf_dnames_foreign_tu_entry()	122
6.16.6	dwarf_dnames_bucket()	122
6.16.7	dwarf_dnames_name()	122
6.16.8	dwarf_dnames_abbrev_by_index()	123
6.16.9	dwarf_dnames_abbrev_form_by_index()	123
6.16.10	dwarf_dnames_abbrev_by_code()	123
6.16.11	dwarf_dnames_entrypool()	123
6.16.12	dwarf_dnames_entrypool_values()	124
6.16.13	dwarf_dnames_cu_table()	124
6.16.14	dwarf_dnames_name()	125

6.17	Names Fast Access .debug_gnu_pubnames	125
6.17.1	dwarf_get_gnu_index_head()	125
6.17.2	dwarf_gnu_index_dealloc()	126
6.17.3	dwarf_get_gnu_index_block()	126
6.17.4	dwarf_get_gnu_index_block_entry()	127
6.18	Macro Information Operations (DWARF4, DWARF5)	128
6.18.1	Getting access	128
6.18.1.1	dwarf_get_macro_context()	128
6.18.1.2	dwarf_get_macro_context_by_offset()	129
6.18.1.3	dwarf_macro_context_total_length()	129
6.18.1.4	dwarf_dealloc_macro_context()	130
6.18.2	Getting Macro Unit Header Data	134
6.18.2.1	dwarf_macro_context_head()	134
6.18.2.2	dwarf_get_macro_section_name()	135
6.18.2.3	dwarf_macro_operands_table()	136
6.18.3	Getting Individual Macro Operations Data	136
6.18.3.1	dwarf_get_macro_op()	136
6.18.3.2	dwarf_get_macro_defundef()	137
6.18.3.3	dwarf_get_macro_startend_file()	138
6.18.3.4	dwarf_get_macro_import()	139
6.19	Macro Information Operations (DWARF2, DWARF3, DWARF4)	139
6.19.1	General Macro Operations	139
6.19.1.1	dwarf_find_macro_value_start()	139
6.19.2	Debugger Interface Macro Operations	140
6.19.3	Low Level Macro Information Operations	140
6.19.3.1	dwarf_get_macro_details()	140
6.20	Low Level Frame Operations	142
6.20.1	dwarf_get_frame_section_name()	143
6.20.2	dwarf_get_frame_section_name_eh_gnu()	143
6.20.3	dwarf_get_fde_list()	144
6.20.4	dwarf_dealloc_fde_cie_list()	145
6.20.5	dwarf_get_fde_list_eh()	145
6.20.6	dwarf_get_cie_augmentation_data()	147
6.20.7	dwarf_get_fde_augmentation_data()	148
6.20.8	dwarf_get_cie_of_fde()	148
6.20.9	dwarf_get_fde_for_die()	149
6.20.10	dwarf_get_fde_range()	149
6.20.11	dwarf_get_cie_info_b()	150
6.20.12	dwarf_get_cie_index()	150

6.20.13	dwarf_get_fde_instr_bytes()	151
6.20.14	dwarf_fde_section_offset()	151
6.20.15	dwarf_cie_section_offset()	151
6.20.16	dwarf_set_frame_rule_table_size()	152
6.20.17	dwarf_set_frame_rule_initial_value()	152
6.20.18	dwarf_set_frame_same_value()	153
6.20.19	dwarf_set_frame_rule_undefined_value()	153
6.20.20	dwarf_set_default_address_size()	153
6.20.21	dwarf_get_fde_info_for_reg3_b()	154
6.20.22	dwarf_get_fde_info_for_cfa_reg3_b()	155
6.20.23	dwarf_get_fde_info_for_all_regs3()	156
6.20.24	dwarf_get_fde_n()	156
6.20.25	dwarf_get_fde_at_pc()	157
6.20.26	dwarf_expand_frame_instructions()	157
6.20.27	dwarf_get_frame_instruction()	160
6.20.28	dwarf_dealloc_frame_instr_head()	161
6.20.29	dwarf_get_fde_exception_info()	161
6.21	Location Expression Evaluation	161
6.22	Abbreviations access	162
6.22.1	dwarf_get_abbrev()	162
6.22.2	dwarf_get_abbrev_tag()	162
6.22.3	dwarf_get_abbrev_code()	162
6.22.4	dwarf_get_abbrev_children_flag()	163
6.22.5	dwarf_get_abbrev_entry_b()	163
6.23	String Section Operations	164
6.23.1	dwarf_get_string_section_name()	164
6.23.2	dwarf_get_str()	165
6.24	String Offsets Section Operations	165
6.24.1	dwarf_open_str_offsets_table_access()	167
6.24.2	dwarf_close_str_offsets_table_access()	167
6.24.3	dwarf_next_str_offsets_table()	168
6.24.4	dwarf_str_offsets_value_by_index()	169
6.24.5	dwarf_str_offsets_statistics()	169
6.25	Address Range Operations	170
6.25.1	dwarf_get_aranges_section_name()	170
6.25.2	dwarf_get_aranges()	170
6.25.3	dwarf_get_arange()	171
6.25.4	dwarf_get_cu_die_offset()	172
6.25.5	dwarf_get_arange_cu_header_offset()	172
6.25.6	dwarf_get_arange_info_b()	172

6.26	General Low Level Operations	173
6.26.1	dwarf_get_offset_size()	173
6.26.2	dwarf_get_address_size()	173
6.26.3	dwarf_get_die_address_size()	173
6.26.4	dwarf_decode_leb128()	174
6.26.5	dwarf_decode_signed_leb128()	174
6.27	Ranges Operations DWARF5 (.debug_rnglists)	175
6.27.1	Getting rnglists data for a DIE	176
6.27.1.1	dwarf_rnglists_get_rle_head()	178
6.27.1.2	dwarf_get_rnglist_head_basics()	179
6.27.1.3	dwarf_get_rnglists_entry_fields_a()	179
6.27.1.4	dwarf_dealloc_rnglists_head()	180
6.27.2	Getting raw .debug_rnglists entries	181
6.27.2.1	dwarf_load_rnglists()	183
6.27.2.2	dwarf_get_rnglist_context_basics()	184
6.27.2.3	dwarf_get_rnglist_offset_index_value()	185
6.27.2.4	dwarf_get_rnglist_rle()	185
6.28	Ranges Operations DWARF3,4 (.debug_ranges)	186
6.28.1	dwarf_get_ranges_section_name()	186
6.28.2	dwarf_get_ranges_b()	187
6.28.3	dwarf_dealloc_ranges()	188
6.29	Gdb Index operations	189
6.29.1	dwarf_gdbindex_header()	189
6.29.2	dwarf_gdbindex_culist_array()	192
6.29.3	dwarf_gdbindex_culist_entry()	192
6.29.4	dwarf_gdbindex_types_culist_array()	193
6.29.5	dwarf_gdbindex_types_culist_entry()	193
6.29.6	dwarf_gdbindex_addressarea()	193
6.29.7	dwarf_gdbindex_addressarea_entry()	194
6.29.8	dwarf_gdbindex_symboltable_array()	195
6.29.9	dwarf_gdbindex_symboltable_entry()	198
6.29.10	dwarf_gdbindex_cuvector_length()	198
6.29.11	dwarf_gdbindex_cuvector_inner_attributes()	199
6.29.12	dwarf_gdbindex_cuvector_instance_expand_value()	199
6.29.13	dwarf_gdbindex_string_by_offset()	200
6.30	GNU linking (.gnu_debuglink, .note.gnu.build-id) operations	200
6.30.1	dwarf_gnu_debuglink()	201
6.30.2	dwarf_add_debuglink_global_path()	204
6.30.3	dwarf_crc32()	205
6.30.4	dwarf_basic_crc32()	205

6.31	DWARF5 .debug_sup section access	205
6.31.1	dwarf_get_debug_sup()	205
6.32	Debug Fission (.debug_tu_index, .debug_cu_index) operations	206
6.32.1	Dwarf_Debug_Fission_Per_CU	207
6.32.2	dwarf_die_from_hash_signature()	208
6.32.3	dwarf_get_debugfission_for_die()	208
6.32.4	dwarf_get_debugfission_for_key()	209
6.32.5	dwarf_get_xu_index_header()	209
6.32.6	dwarf_get_xu_index_section_type()	211
6.32.7	dwarf_get_xu_header_free()	212
6.32.8	dwarf_get_xu_hash_entry()	212
6.32.9	dwarf_get_xu_section_names()	213
6.32.10	dwarf_get_xu_section_offset()	214
6.33	TAG ATTR etc names as strings	216
6.34	Section Operations	219
6.34.1	dwarf_get_section_count()	219
6.34.2	dwarf_get_section_info_by_name()	219
6.34.3	dwarf_get_section_info_by_index()	220
6.35	Utility Operations	220
6.35.1	dwarf_errno()	220
6.35.2	dwarf_errmsg()	220
6.35.3	dwarf_errmsg_by_number()	221
6.35.4	dwarf_error_creation()	221
6.35.5	dwarf_set_stringcheck()	221
6.35.6	dwarf_get_endian_copy_function()	222
6.35.7	dwarf_get_harmless_error_list()	222
6.35.8	dwarf_insert_harmless_error()	223
6.35.9	dwarf_set_harmless_error_list_size()	223
6.35.10	dwarf_dealloc()	226
6.35.11	dwarf_encode_leb128()	226
6.35.12	dwarf_encode_signed_leb128()	226
6.36	Finding Memory Leaks	226
6.36.1	Compiling libdwarf -DDEBUG=1	227
6.36.2	Making use of the output of -DDEBUG=1	227

LIST OF FIGURES

Figure 1.	Scalar Types	21
Figure 2.	Error Indications	33
Figure 3.	Example_dwarf_dealloc()	35
Figure 4.	Example_dwarf_dealloc_die()	35
Figure 5.	Example_dwarf_dealloc_attribute()	35
Figure 6.	Example_dwarf_dealloc_error()	36
Figure 7.	Example1 dwarf_attrlist()	37
Figure 8.	Allocation/Deallocation Identifiers	40
Figure 9.	Example2 dwarf_set_died_dbg()	46
Figure 10.	Example3 dwarf_set_tied_dbg() obsolete	46
Figure 11.	Example4 dwarf_siblingof_b()	62
Figure 12.	Example5 dwarf_child()	63
Figure 13.	Example6 dwarf_offdie_b()	64
Figure 14.	Example7 dwarf_CU_dieoffset_given_die()	69
Figure 15.	Example8 dwarf_attrlist() free	73
Figure 16.	Exampleoffset_list dwarf_offset_list() free	76
Figure 17.	Example Raw Loclist	91
Figure 18.	Examplec dwarf_srclines_b()	110
Figure 19.	Exampled dwarf_srcfiles()	118
Figure 20.	Examplef dwarf_get_globals()	124
Figure 21.	Examplep5 dwarf_dealloc_macro_context()	145
Figure 22.	Examplep2 dwarf_get_macro_details()	155
Figure 23.	Frame Information Special Values any architecture	157

Figure 24.	Exampleq dwarf_get_fde_list()	159
Figure 25.	Example r dwarf_get_fde_list_eh()	161
Figure 26.	Examples dwarf_expand_frame_instructions()	173
Figure 27.	examplestringoffsets dwarf_open_str_offsets_table_access() etc	180
Figure 28.	Exampleu dwarf_get_aranges()	186
Figure 29.	Example .debug_rnglist for attribute	192
Figure 30.	Examplev dwarf_rnglists)	196
Figure 31.	Examplev dwarf_get_ranges_b()	203
Figure 32.	Examplew dwarf_get_gdbindex_header()	205
Figure 33.	Examplewgdbindex dwarf_gdbindex_addressarea()	210
Figure 34.	Examplex dwarf_gdbindex_symboltable_array()	212
Figure 35.	Example debuglink ()	218
Figure 36.	Exampley dwarf_get_xu_index_header()	226
Figure 37.	Examplez dwarf_get_xu_hash_entry()	228
Figure 38.	Exampleza dwarf_get_xu_section_names()	231
Figure 39.	Examplezb dwarf_get_TAG_name()	232
Figure 40.	Dwarf Error Codes	239
Figure 41.	Dwarf 2 and later Error Codes	240

A Consumer Library Interface to DWARF

David Anderson

ABSTRACT

This document describes an interface to a library of functions to access DWARF debugging information entries, DWARF line number information, and other DWARF2/3/4/5 information).

There are a few sections which are SGI-specific (those are clearly identified in the document).

Starting December 2020 we rearrange the pdf that GNU groff -mm gives us (mm is not exceptionally flexible) using tools pdftotext, pdfseparate, and pdfunite from the poppler-utils package for debian/ubuntu. We hope the new arrangement with the table of contents following this page followed by the library documentation itself makes the document easier to navigate.

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