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Title: SC22/WG21 Liaison Report, ISO C++2017 & ISO C Differences.

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Attached is a copy of Annex C.1 of ISO/IEC 14882:2017, Programming Language C++, listing the differences between C++ 2017 and ISO C (C11). This information is provided to JTC 1 SC22/WG14 solely for the purpose of consideration of changes by SC22/WG14 to the next revision of the C Standard (ISO/IEC 9899:202x). A number of these differences have significant impact on implementers writing compilers for both C and C+ who use the same implementation for both languages.

Annex C (informative)

Compatibility [diff]

C.1 C++ and ISO C [diff.iso]

This subclause lists the differences between C++ 17 and ISO C11, by the chapters of this document (C++ 2017).

C.1.1 Clause 5: lexical conventions [diff.lex]

5.11

Change: New Keywords

New keywords are added to C++; see 5.11.

Rationale: These keywords were added in order to implement the new semantics of C++.

Effect on original feature: Change to semantics of well-defined feature. Any ISO C programs that used any of these keywords as identifiers are not valid C++ programs.

Difficulty of converting: Syntactic transformation. Converting one specific program is easy. Converting a large collection of related programs takes more work.

How widely used: Common.

C++new keywords:

alignas (C: _Alignas)

alignof (C: _Alignof)

asm

bool

catch

char16_t

char32_t

class

constexpr

const_cast

decl_type

explicit

export

friend

mutable

namespace

new

noexcept

nullptr

operator

private

protected

public

reinterpret_cast

static_assert (C: _Static_assert)

static_cast

template
this
thread_local (C: _Thread_local)
throw
true
try
typename
using
virtual
wchar_t

Alternate representations (Certain operators punctuators are reserved and shall not be used otherwise:

and
and_eq
bitand
bitor
compl
not
not_eq
or
or_eq
xor
xor_eq

5.13.3

Change: Type of character literal is changed from int to char.

Rationale: This is needed for improved overloaded function argument type matching. For example:

```
int function( int i );  
int function( char c );  
  
function( 'x' );
```

It is preferable that this call match the second version of function rather than the first.

Effect on original feature: Change to semantics of well-defined feature. ISO C programs which depend on

```
sizeof('x') == sizeof(int)
```

will not work the same as C++ programs.

Difficulty of converting: Simple.

How widely used: Programs which depend upon sizeof('x') are probably rare.

5.13.5:

Change: String literals made const.

The type of a string literal is changed from "array of char" to "array of const char". The type of a char16_t string literal is changed from "array of *some-integer-type*" to "array of const char16_t". The

type of a `char32_t` string literal is changed from “array of *some-integer-type*” to “array of `const char32_t`”. The type of a wide string literal is changed from “array of `wchar_t`” to “array of `const wchar_t`”.

Rationale: This avoids calling an inappropriate overloaded function, which might expect to be able to modify its argument.

Effect on original feature: Change to semantics of well-defined feature.

Difficulty of converting: Syntactic transformation. The fix is to add a cast:

```
char* p = "abc";           // valid in C, invalid in C++
void f(char*) {
    char* p = (char*)"abc"; // OK: cast added
    f(p);
    f((char*)"def");       // OK: cast added
}
```

How widely used: Programs that have a legitimate reason to treat string literals as pointers to potentially modifiable memory are probably rare.

C.1.2 Clause 6: basic concepts [diff.basic]

6.1

Change: C++ does not have “tentative definitions” as in C.

E.g., at file scope,

```
int i;
int i;
```

is valid in C, invalid in C++. This makes it impossible to define mutually referential file-local static objects, if initializers are restricted to the syntactic forms of C. For example,

```
struct X { int i; struct X* next; };
static struct X a;
static struct X b = { 0, &a };
static struct X a = { 1, &b };
```

Rationale: This avoids having different initialization rules for fundamental types and user-defined types.

Effect on original feature: Deletion of semantically well-defined feature.

Difficulty of converting: Semantic transformation. In C++, the initializer for one of a set of mutually referential file-local static objects must invoke a function call to achieve the initialization.

How widely used: Seldom.

6.3

Change: A struct is a scope in C++, not in C.

Rationale: Class scope is crucial to C++, and a struct is a class.

Effect on original feature: Change to semantics of well-defined feature.

Difficulty of converting: Semantic transformation.

How widely used: C programs use struct extremely frequently, but the change is only noticeable when struct, enumeration, or enumerator names are referred to outside the struct. The latter is probably rare.

6.5 [also 10.1.7]

Change: A name of file scope that is explicitly declared const, and not explicitly declared extern, has internal linkage, while in C it would have external linkage.

Rationale: Because const objects may be used as values during translation in C++, this feature urges programmers to provide an explicit initializer for each const object. This feature allows the user to put const objects in source files that are included in more than one translation unit.

Effect on original feature: Change to semantics of well-defined feature.

Difficulty of converting: Semantic transformation.

How widely used: Seldom.

6.6.1

Change: The main function cannot be called recursively and cannot have its address taken.

Rationale: The main function may require special actions.

Effect on original feature: Deletion of semantically well-defined feature.

Difficulty of converting: Trivial: create an intermediary function such as mymain(argc, argv).

How widely used: Seldom.

6.9

Change: C allows “compatible types” in several places, C++ does not.

For example, otherwise-identical struct types with different tag names are “compatible” in C but are distinctly different types in C++.

Rationale: Stricter type checking is essential for C++.

Effect on original feature: Deletion of semantically well-defined feature.

Difficulty of converting: Semantic transformation. The “typesafe linkage” mechanism will find many, but not all, of such problems. Those problems not found by typesafe linkage will continue to function properly, according to the “layout compatibility rules” of this document.

How widely used: Common.

C.1.3 Clause 7: standard conversions [diff.conv]

7.11

Change: Converting void* to a pointer-to-object type requires casting.

```
char a[10];
void* b=a;
void foo() {
    char* c=b;
}
```

ISO C will accept this usage of pointer to void being assigned to a pointer to object type. C++ will not.

Rationale: C++ tries harder than C to enforce compile-time type safety.

Effect on original feature: Deletion of semantically well-defined feature.

Difficulty of converting: Could be automated. Violations will be diagnosed by the C++ translator. The fix is to add a cast. For example:

```
char* c = (char*) b;
```

How widely used: This is fairly widely used but it is good programming practice to add the cast when assigning pointer-to-void to pointer-to-object. Some ISO C translators will give a warning if the cast is not used.

C.1.4 Clause 8: expressions [diff.expr]

8.2.2

Change: Implicit declaration of functions is not allowed.

Rationale: The type-safe nature of C++.

Effect on original feature: Deletion of semantically well-defined feature. Note: the original feature was labeled as “obsolescent” in ISO C.

Difficulty of converting: Syntactic transformation. Facilities for producing explicit function declarations are fairly widespread commercially.

How widely used: Common.

8.2.6, 8.3.2

Change: Decrement operator is not allowed with bool operand. (C++ 17)

Rationale: Feature with surprising semantics.

Effect on original feature: A valid ISO C expression utilizing the decrement operator on a bool lvalue (for instance, via the C typedef in <stdbool.h>) is ill-formed in this International Standard (C++17).

8.3.3, 8.4

Change: Types must be defined in declarations, not in expressions.

In C, a sizeof expression or cast expression may define a new type. For example,

```
p = (void*)(struct x {int i;} *)0;
```

defines a new type, struct x.

Rationale: This prohibition helps to clarify the location of definitions in the source code.

Effect on original feature: Deletion of semantically well-defined feature.

Difficulty of converting: Syntactic transformation.

How widely used: Seldom.

8.16, 8.18, 8.19

Change: The result of a conditional expression, an assignment expression, or a comma expression may be an lvalue.

Rationale: C++ is an object-oriented language, placing relatively more emphasis on lvalues. For example, functions may return lvalues.

Effect on original feature: Change to semantics of well-defined feature. Some C expressions that implicitly rely on lvalue-to-rvalue conversions will yield different results. For example,

```
char arr[100];  
sizeof(0, arr)
```

yields 100 in C++ and sizeof(char*) in C.

Difficulty of converting: Programs must add explicit casts to the appropriate rvalue.

How widely used: Rare.

C.1.5 Clause 9: statements [diff.stat]

9.4.2, 9.6.4

Change: It is now invalid to jump past a declaration with explicit or implicit initializer (except across entire block not entered).

Rationale: Constructors used in initializers may allocate resources which need to be de-allocated upon leaving the block. Allowing jump past initializers would require complicated runtime determination of allocation. Furthermore, any use of the uninitialized object could be a disaster. With this simple compile-time rule, C++ assures that if an initialized variable is in scope, then it has assuredly been initialized.

Effect on original feature: Deletion of semantically well-defined feature.

Difficulty of converting: Semantic transformation.

How widely used: Seldom.

9.6.3

Change: It is now invalid to return (explicitly or implicitly) from a function which is declared to return a value without actually returning a value.

Rationale: The caller and callee may assume fairly elaborate return-value mechanisms for the return of class objects. If some flow paths execute a return without specifying any value, the implementation must embody many more complications. Besides, promising to return a value of a given type, and then not returning such a value, has always been recognized to be a questionable practice, tolerated only because very-old C had no distinction between void functions and int functions.

Effect on original feature: Deletion of semantically well-defined feature.

Difficulty of converting: Semantic transformation. Add an appropriate return value to the source code, such as zero.

How widely used: Seldom. For several years, many existing C implementations have produced warnings in this case.

C.1.6 Clause 10: declarations [diff.dcl]

10.1.1

Change: In C++, the static or extern specifiers can only be applied to names of objects or functions. Using these specifiers with type declarations is illegal in C++. In C, these specifiers are ignored when used on type declarations.

Example:

```
static struct S {           // valid C, invalid in C++
    int i;
};
```

Rationale: Storage class specifiers don't have any meaning when associated with a type. In C++, class

members can be declared with the static storage class specifier. Allowing storage class specifiers on type declarations could render the code confusing for users.

Effect on original feature: Deletion of semantically well-defined feature.

Difficulty of converting: Syntactic transformation.

How widely used: Seldom.

10.1.1

Change: In C++, register is not a storage class specifier. (C++ 17)

Rationale: The storage class specifier had no effect in C++.

Effect on original feature: Deletion of semantically well-defined feature.

Difficulty of converting: Syntactic transformation.

How widely used: Common.

10.1.3

Change: A C++ typedef name must be different from any class type name declared in the same scope (except if the typedef is a synonym of the class name with the same name). In C, a typedef name and a struct tag name declared in the same scope can have the same name (because they have different name spaces).

Example:

```
typedef struct name1 { /* ... */ } name1;      // valid C and C++
struct name { /* ... */ };
typedef int name;                             // valid C, invalid C++
```

Rationale: For ease of use, C++ doesn't require that a type name be prefixed with the keywords class, struct or union when used in object declarations or type casts.

Example:

```
class name { /* ... */ };
name i;                                       // i has type class name
```

Effect on original feature: Deletion of semantically well-defined feature.

Difficulty of converting: Semantic transformation. One of the 2 types has to be renamed.

How widely used: Seldom.

10.1.7 [see also 6.5]

Change: const objects must be initialized in C++ but can be left uninitialized in C.

Rationale: A const object cannot be assigned to so it must be initialized to hold a useful value.

Effect on original feature: Deletion of semantically well-defined feature.

Difficulty of converting: Semantic transformation.

How widely used: Seldom.

10.1.7

Change: Banning implicit int.

In C++ a *decl-specifier-seq* must contain a *type-specifier*, unless it is followed by a declarator for a constructor, a destructor, or a conversion function. In the following example, the left-hand column presents valid C; the right-hand column presents equivalent C++:

C: void f(const parm); const n = 3; main() /* ... */	C++: void f(const int parm); const int n = 3; int main() /* ... */
---	---

Rationale: In C++, implicit int creates several opportunities for ambiguity between expressions involving function-like casts and declarations. Explicit declaration is increasingly considered to be proper style. Liaison with WG14 (C) indicated support for (at least) deprecating implicit int in the next revision of C.

Effect on original feature: Deletion of semantically well-defined feature.

Difficulty of converting: Syntactic transformation. Could be automated.

How widely used: Common.

10.1.7.4

Change: The keyword auto cannot be used as a storage class specifier.

```
void f() {
    auto int x;    // valid C, invalid C++
}
```

Rationale: Allowing the use of auto to deduce the type of a variable from its initializer results in undesired interpretations of auto as a storage class specifier in certain contexts.

Effect on original feature: Deletion of semantically well-defined feature.

Difficulty of converting: Syntactic transformation.

How widely used: Rare.

10.2

Change: C++ objects of enumeration type can only be assigned values of the same enumeration type. In C, objects of enumeration type can be assigned values of any integral type.

Example:

```
enum color { red, blue, green };
enum color c = 1;                // valid C, invalid C++
```

Rationale: The type-safe nature of C++.

Effect on original feature: Deletion of semantically well-defined feature.

Difficulty of converting: Syntactic transformation. (The type error produced by the assignment can be automatically corrected by applying an explicit cast.)

How widely used: Common.

10.2

Change: In C++, the type of an enumerator is its enumeration. In C, the type of an enumerator is int.

Example:

```
enum e { A };
```

```

sizeof(A) == sizeof(int)           // in C
sizeof(A) == sizeof(e)           // in C++
/* and sizeof(int) is not necessarily equal to sizeof(e) */

```

Rationale: In C++, an enumeration is a distinct type.

Effect on original feature: Change to semantics of well-defined feature.

Difficulty of converting: Semantic transformation.

How widely used: Seldom. The only time this affects existing C code is when the size of an enumerator is taken. Taking the size of an enumerator is not a common C coding practice.

C.1.7 Clause 11: declarators [diff.decl]

11.3.5

Change: In C++, a function declared with an empty parameter list takes no arguments. In C, an empty parameter list means that the number and type of the function arguments are unknown.

Example:

```

int f();           // means int f(void) in C++
                  // int f( unknown ) in C

```

Rationale: This is to avoid erroneous function calls (i.e., function calls with the wrong number or type of arguments).

Effect on original feature: Change to semantics of well-defined feature. This feature was marked as “obsolescent” in C.

Difficulty of converting: Syntactic transformation. The function declarations using C incomplete declaration style must be completed to become full prototype declarations. A program may need to be updated further if different calls to the same (non-prototype) function have different numbers of arguments or if the type of corresponding arguments differed.

How widely used: Common.

11.3.5 [see 8.3.3]

Change: In C++, types may not be defined in return or parameter types. In C, these type definitions are allowed.

Example:

```

void f( struct S { int a; } arg ) {}           // valid C, invalid C++
enum E { A, B, C } f() {}                   // valid C, invalid C++

```

Rationale: When comparing types in different translation units, C++ relies on name equivalence when C relies on structural equivalence. Regarding parameter types: since the type defined in a parameter list would be in the scope of the function, the only legal calls in C++ would be from within the function itself.

Effect on original feature: Deletion of semantically well-defined feature.

Difficulty of converting: Semantic transformation. The type definitions must be moved to file scope, or in header files.

How widely used: Seldom. This style of type definition is seen as poor coding style.

11.4

Change: In C++, the syntax for function definition excludes the “old-style” C function. In C, “old-style”

syntax is allowed, but deprecated as “obsolescent”.

Rationale: Prototypes are essential to type safety.

Effect on original feature: Deletion of semantically well-defined feature.

Difficulty of converting: Syntactic transformation.

How widely used: Common in old programs, but already known to be obsolescent.

11.6.2

Change: In C++, when initializing an array of character with a string, the number of characters in the string (including the terminating ‘\0’) must not exceed the number of elements in the array. In C, an array can be initialized with a string even if the array is not large enough to contain the string-terminating ‘\0’.

Example:

```
char array[4] = "abcd";           // valid C, invalid C++
```

Rationale: When these non-terminated arrays are manipulated by standard string functions, there is potential for major catastrophe.

Effect on original feature: Deletion of semantically well-defined feature.

Difficulty of converting: Semantic transformation. The arrays must be declared one element bigger to contain the string terminating ‘\0’.

How widely used: Seldom. This style of array initialization is seen as poor coding style.

C.1.8 Clause 12: classes [diff.class]

12.1 [see also 10.1.3]

Change: In C++, a class declaration introduces the class name into the scope where it is declared and hides any object, function or other declaration of that name in an enclosing scope. In C, an inner scope declaration of a struct tag name never hides the name of an object or function in an outer scope.

Example:

```
int x[99];
void f() {
    struct x { int a; };
    sizeof(x);           /* size of the array in C */
                        /* size of the struct in C++ */
}
```

Rationale: This is one of the few incompatibilities between C and C++ that can be attributed to the new C++ name space definition where a name can be declared as a type and as a non-type in a single scope causing the non-type name to hide the type name and requiring that the keywords class, struct, union or enum be used to refer to the type name. This new name space definition provides important notational conveniences to C++ programmers and helps making the use of the user-defined types as similar as possible to the use of fundamental types. The advantages of the new name space definition were judged to outweigh by far the incompatibility with C described above.

Effect on original feature: Change to semantics of well-defined feature.

Difficulty of converting: Semantic transformation. If the hidden name that needs to be accessed is at global scope, the :: C++ operator can be used. If the hidden name is at block scope, either the type or the struct tag has to be renamed.

How widely used: Seldom.

12.2.4

Change: Bit-fields of type plain int are signed.

Rationale: Leaving the choice of signedness to implementations could lead to inconsistent definitions of template specializations. For consistency, the implementation freedom was eliminated for non-dependent types, too.

Effect on original feature: The choice is implementation-defined in C, but not so in C++.

Difficulty of converting: Syntactic transformation.

How widely used: Seldom.

12.2.5

Change: In C++, the name of a nested class is local to its enclosing class. In C the name of the nested class belongs to the same scope as the name of the outermost enclosing class.

Example:

```
struct X {
    struct Y { /* ... */ } y;
};
struct Y yy;                // valid C, invalid C++
```

Rationale: C++ classes have member functions which require that classes establish scopes. The C rule would leave classes as an incomplete scope mechanism which would prevent C++ programmers from maintaining locality within a class. A coherent set of scope rules for C++ based on the C rule would be very complicated and C++ programmers would be unable to predict reliably the meanings of nontrivial examples involving nested or local functions.

Effect on original feature: Change to semantics of well-defined feature.

Difficulty of converting: Semantic transformation. To make the struct type name visible in the scope of the enclosing struct, the struct tag could be declared in the scope of the enclosing struct, before the enclosing struct is defined. Example:

```
struct Y;                    // struct Y and struct X are at the same scope
struct X {
    struct Y { /* ... */ } y;
};
```

All the definitions of C struct types enclosed in other struct definitions and accessed outside the scope of the enclosing struct could be exported to the scope of the enclosing struct. Note: this is a consequence of the difference in scope rules, which is documented in 6.3.

How widely used: Seldom.

12.2.6

Change: In C++, a typedef name may not be redeclared in a class definition after being used in that definition.

Example:

```
typedef int I;
struct S {
    I i;
```

```
        int I;           // valid C, invalid C++
    };
```

Rationale: When classes become complicated, allowing such a redefinition after the type has been used can create confusion for C++ programmers as to what the meaning of I really is.

Effect on original feature: Deletion of semantically well-defined feature.

Difficulty of converting: Semantic transformation. Either the type or the struct member has to be renamed.

How widely used: Seldom.

C.1.9 Clause 15: special member functions [diff.special]

15.8

Change: Copying volatile objects.

The implicitly-declared copy constructor and implicitly-declared copy assignment operator cannot make a copy of a volatile lvalue. For example, the following is valid in ISO C:

```
    struct X { int i; };
    volatile struct X x1 = {0};
    struct X x2 = x1;           // invalid C++
    struct X x3;
    x3 = x1;                   // also invalid C++
```

Rationale: Several alternatives were debated at length. Changing the parameter to volatile const X& would greatly complicate the generation of efficient code for class objects. Discussion of providing two alternative signatures for these implicitly-defined operations raised unanswered concerns about creating ambiguities and complicating the rules that specify the formation of these operators according to the bases and members.

Effect on original feature: Deletion of semantically well-defined feature.

Difficulty of converting: Semantic transformation. If volatile semantics are required for the copy, a user-declared constructor or assignment must be provided. If non-volatile semantics are required, an explicit `const_cast` can be used.

How widely used: Seldom.

C.1.10 Clause 19: preprocessing directives [diff.cpp]

19.8

Change: Whether `__STDC__` is defined and if so, what its value is, are implementation-defined.

Rationale: C++ is not identical to ISO C. Mandating that `__STDC__` be defined would require that translators make an incorrect claim. Each implementation must choose the behavior that will be most useful to its marketplace.

Effect on original feature: Change to semantics of well-defined feature.

Difficulty of converting: Semantic transformation.

How widely used: Programs and headers that reference `__STDC__` are quite common.