Forward declaration of enumerations (rev. 1)

This is a revision of paper N2499. It incorporates comments from the EWG that lead to minor changes in the proposed wording of [basic.def]/2 and [dcl.type.elab]/3. Moreover, a new informative section has been added to provide more context and rationale about the proposed changes to [dcl.enum]/7.

1 Introduction

In C++03 every declaration of an enumeration is also a definition and must include the full list of enumerators. The list is always needed to determine the underlying type of the enumeration, which is necessary to generate code that manipulates values of the enumerations. However, there are use cases where it would be desirable to declare an enumeration without providing the enumerators. The compiler could still generate meaningful code, if at least the underlying type is known. The syntax introduced by paper N2347\(^1\), which allow the programmer to explicitly specify the underlying type, can easily be extended to cover this scenario.

2 Motivation

2.1 Reduce coupling

Consider the header file of a component providing support for localized strings:

```cpp
// file locstring.h

#include <string>

enum localized_string_id
{
    /* very long list of ids */
};

std::istream& operator>>(std::istream& is, localized_string_id& id);

std::string getlocalized_string(localized_string_id id);
```

The enumeration `localized_string_id` may have several hundreds entries and be generated automatically by a tool, rather than manually maintained; changes can therefore be very frequent. Every component that needs a localized string will eventually need to include `locstring.h` and therefore will have to be recompiled every time the enumeration changes.

Now, consider the following piece of code:

```cpp
localized_string_id id;
std::cin >> id;
std::cout << getlocalized_string(id);
```

\(^1\)Paper N2347 has been integrated in the draft for C++0X, that is paper N2641 at the time of writing.
Does this code depend on the list of enumerators? According to C++03 the answer is yes, because C++03 requires the presence of the entire list of enumerators to determine the underlying type of localized_string_id. Of course, if we didn't know the underlying type, we couldn't instantiate the variable id nor we pass it by value to function get_localized_string(). However, neither the names nor the values of the enumerators are actually used by the code! If we could just tell the compiler the underlying type, there would be no technical obstacle for it to produce the correct code even in absence of the list of enumerators.

2.2 Type-safe data hiding

Consider this class:

```cpp
class C
{
public:
    /* public interface */

private:
    enum E { /* enumerators */ };  
    E e;
};
```

According to C++03, the list of enumerators is required in order to determine the underlying type of the data member `e`, an essential information needed to determine the layout of class `C`. If the public interface of class `C` does not make any use of `E`, the list of enumerators of `E` would be merely an implementation detail, yet any change to the list requires re-compilation of all clients of class `C`.

Moreover, if class `C` is part of the interface of a closed-source library which is distributed in binary form, the names of the enumerator may need to be obfuscated in order to avoid disclosing internal details.

The obvious work-around is to define the member variable `e` with a basic integral type and then declare the enumeration in another file. This approach is inferior, because we lose the type safety provided by the enumeration.

3 Proposal

This proposal introduces a syntax that allows declaring an enumeration without providing a list of enumerators. Such declaration would not be definition in order to avoid problems with ODR and can be provided only for enumerations with fixed underlying type. An enumeration can be then be redeclared, possibly providing the missing list of enumerators, but the redeclaration shall match the previous declaration:

```cpp
enum E : short;         // Ok: unscoped, underlying type is short
enum F;                 // illegal: enum-base is required
enum class G : short;   // Ok: scoped, underlying type is short
enum class H;           // Ok: scoped, underlying type is int

enum E : short;         // Ok: redeclaration of E
enum class G : short;   // Ok: redeclaration of G
enum class H;           // Ok: redeclaration of H
enum class H : int;     // Ok: redeclaration of H

enum class E : short;   // illegal: previously declared as unscoped
enum G : short;         // illegal: previously declared as scoped

enum E;                 // illegal: enum-base is required
enum E : int;           // illegal: different underlying type
enum class G;           // illegal: different underlying type
```
enum class H : short; // illegal: different underlying type

enum class H { /* */ }; // OK: this redeclaration is a definition

The underlying type must be specified each time as a mean to avoid possible interpretation ambiguities that could depend on the order of the declarations.

Moreover, enumerations declared at class or namespace scope can be defined in an enclosing scope:

```cpp
struct S {
    enum E : int; // unscoped enumeration, underlying type is int
    E e; // e is an implemented as-if it was declared int
};

enum S::E : int // definition of the nested enumeration
{/ * ... */}
```

4 Interaction with N2347

N2347 changed the definition of `elaborated-type-specifier` by allowing `enum-keys` where only the `enum` keyword was previously allowed. Moreover, "the `enum-key` used in an `elaborated-type-specifier` need not match the one in the enumeration's definition." The author of this proposal believes this change was both unnecessary and a mistake. Moreover, it is an impediment for this proposal so a return to the previous definition is deemed necessary.

Paper N2347 makes this code legal:

```cpp
enum class E { a, b };  
enum E x = E::a;         // OK
```

however, it also makes this code legal:

```cpp
enum E { a, b };   
enum class E x = a; // OK ?
```

which doesn’t look as good as in the previous case: the extra `class` keyword in the second line is confusing to say the least. The objections to the change in the definition of `elaborated-type-specifier` can be summarized as follows:

a) `elaborated-type-specifiers` are used mainly for compatibility with legacy C code, they are not needed in practice in C++, where `E` is just as good as `enum E`, but it's shorter. Legacy C code won't need to support scoped enumerations explicitly

b) if `enum E` can be used in place of `enum class E`, the programmers will probably prefer the former, especially since adding `class` is not a reliable source of additional information about `E`

c) allowing `enum class E` to refer to an unscoped enumeration can be a source of confusion

d) the change was inessential to the other important changes introduced by paper N2347

The conflict with this proposal arises when parsing this declaration:

```cpp
enum class E;         // (1)
```

With N2347 wording, such code is ill-formed because an `elaborated-type-specifier` is the "sole constituent"
of the declaration and the form is not explicitly listed as legal in [dcl.type.elab]/1. We can’t just add (1)
to the list of legal forms, because E may still refer to either a scoped or unscoped enumeration and this
makes a lot of difference, because scoped enumerations always have fixed underlying type while unscoped
enumerations don’t.

According to this proposal, line (1) would unambiguously declare E as a scoped enumeration with
underlying type of int. The enum keyword would still be allowed to refer to scoped enumerations, while
enum class and enum struct would be banned from elaborated-type-specifiers, for example:

```cpp
enum class E { a, b }
enum F { a, b };   // OK in N2347, OK in this proposal
enum class E x2 = E::a;   // OK in N2347, illegal in this proposal
enum F y1 = a;    // OK in N2347, illegal in this proposal
enum class F y2 = a;   // OK in N2347, illegal in this proposal
```

Notice that the following:

```cpp
enum E;       // illegal
```

would remain illegal (as it is in both C++03 and N2347), because an elaborated-type-specifier is the "sole
constituent" of a declaration and this form is not among the allowed forms in [dcl.type.elab]/1. Instead,
none of the following

```cpp
enum E : int;       // OK: E is unscoped, underlying type is int
enum class F;       // OK: F is scoped, underlying type is int
```

would trigger [dcl.type.elab]/1, because in the first case the elaborated-type-specifier is no longer the "sole
constituent" of the declaration, while in the second case there is no elaborated-type-specifier.

5 Impact on the standard and implementability

This proposal provides a semantic to a syntax that was previously illegal and does not change the semantic
of code that was legal in C++03. The new syntax does not introduce new keywords. Code that was legal
according to N2347, however, can become illegal.

There are no known or anticipated difficulties in implementing these features.

6 Proposed text

In this section, changes are presented as modifications to existing wording in current draft, paper N2461,
where strikethrough text refers to existing text that is to be deleted, and underscored text refers to new
text that is to be added.

6.1 Changes to [basic.def]

Changes to paragraph 2:

A declaration is a definition unless it declares a function without specifying the function’s body
(8.4), it contains the extern specifier (7.1.1) or a linkage-specification (7.5) and neither an
initializer nor a function-body, it declares a static data member in a class definition (9.4), it is
a class name declaration (9.1), or it declares an enumeration without specifying an enum-body
(7.2), or it is a typedef declaration (7.1.3), a using-directive (7.3.3), or a using-declaration (7.3.4).
6.2 Changes to [dcl.type.elab]

elaborated-type-specifier :

\[
\text{class-key} :: \text{opt} \quad \text{nested-name-specifier} \text{opt} \quad \text{identifier} \\
\text{class-key} :: \text{opt} \quad \text{nested-name-specifier} \text{opt} \quad \text{template} \text{opt} \quad \text{simple-template-id} \\
\text{enum-key} :: \text{opt} \quad \text{nested-name-specifier} \text{opt} \quad \text{identifier} \\
\text{enum} :: \text{opt} \quad \text{nested-name-specifier} \text{opt} \quad \text{identifier}
\]

Changes to paragraph 3:

The class-key or enum-key enum keyword present in the elaborated-type-specifier shall agree in kind with the declaration to which the name in the elaborated-type-specifier refers. This rule also applies to the form of elaborated-type-specifier that declares a class-name or friend class since it can be construed as referring to the definition of the class. Thus, in any elaborated-type-specifier, the enum-key enum keyword shall be used to refer to an enumeration (7.2), the union class-key shall be used to refer to a union (clause 9), and either the class or struct class-key shall be used to refer to a class (clause 9) declared using the class or struct class-key. The enum-key used in an elaborated-type-specifier need not match the one in the enumeration’s definition. Example:

\[
\begin{align*}
\text{enum class E} & \{ a, b \}; \\
\text{enum E x} & = \text{E::a}; \quad // \text{OK}
\end{align*}
\]

--- end example ---

6.3 Changes to [dcl.enum]

Changes to paragraph 1:

\[
\begin{align*}
\text{enum-name} : & \quad \text{identifier} \\
\text{enum-specifier} : & \quad \text{enum-key} \quad \text{identifier} \text{opt} \quad \text{enum-base} \text{opt} \quad \{ \text{enumerator-list} \text{opt} \} \\
\text{enumerator-list} : & \quad \text{enumerator-definition} \\
\text{enumerator-definition} : & \quad \text{enumerator} \quad \text{enumerator-definition} \\
\text{enumerator} : & \quad \text{identifier} \quad = \quad \text{constant-expression}
\end{align*}
\]

Add as new paragraph 7:

If the enum-body is absent in an enumeration declaration, the declaration is ill-formed unless it has one of the following forms:
enum identifier enum-base;
enum class identifier enum-base opt;
enum struct identifier enum-base opt;

[ Note: a well-formed declaration without enum-body is not a definition and the declared
enumeration has fixed underlying type. — end note ] A scoped enumeration shall not be later
redeclared as unscoped or with a different underlying type. An unscoped enumeration shall not
be later redeclared as scoped and a redeclaration shall have an enum-base specifying the same
underlying type.

Add as new paragraph 8:

If the enum-key is followed by a nested-name-specifier, the enum-specifier shall refer to an
enumeration that was previously declared directly in the class or namespace to which the
nested-name-specifier refers (i.e., neither inherited nor introduced by a using-declaration), and
the enum-specifier shall appear in a namespace enclosing the previous declaration.

7 About the redeclaration syntax

The proposed wording in [dcl.enum]/7 requires the programmer to specify the underlying type on each
redeclaration including the definition, as in:

```c
enum E : int;
enum E : int { a, b, c };
```

This redundant syntax may seem verbose and error prone. Two alternatives were considered in a discus-
sion on comp.std.c++, namely:

a) a redeclaration of a previously declared enumeration shall not specify an enum-base, the underlying
type is the one determined by the first declaration.

b) a redeclaration of a previously declared enumeration shall either have no enum-base or have an
enum-base specifying the same type as the underlying type of the first declaration. In any case, the
underlying type is the one determined by the first declaration.

The problem with these approaches is that they allow the presence or absence of a previous declaration
to change the meaning of an otherwise perfectly valid definition:

```c
// E.h
enum E { ea, eb }; // underlying type of E is implementation-defined
enum class F { fa, fb }; // underlying type of F is int
```

```c
// A.cpp
enum E : short;
enum class F : short;

#include "E.h" // defines both E and F with underlying type short
```

This can be more disorientating than requiring the programmer to be verbose. In a certain sense, the
proposed wording is actually less error prone than the alternatives, as mistakes can be easily detected
and correctly diagnosed by compiler.

8 Acknowledgments

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