Proposal of Bit-field Default Member Initializers

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Summary

We propose default member initializers for bit-fields.

Example:

```c
struct S {
    int x : 6 = 42;
};
```

To ease parsing we specify a rule, roughly summarized as “you have to use =, and = always starts the initializer”. We apply this rule by adjusting the grammar.

Background

The declarators of class members are called `member-declarators`:

```
member-declarator:
    declarator virt-specifier-seq_opt pure-specifier_opt
deaclator brace-or-equal-initializer_opt
    identifier_opt attribute-specifier-seq_opt: constant-expression
```

As can be seen, non-bit-field members may have default member initializers. Bit-fields may not.

The motivation for having initializers for bit-fields is the same as having initializers for non-bit-fields. It can be argued that the motivation is even stronger for bit-fields, as they usually occur in “simple structs” where member initializers are heavily used for their tersity/compactness.

Naively adding them...

```
member-declarator:
```
...creates parsing difficulties and parsing ambiguities. In particular, if a constant-expression is immediately followed by an optional brace-or-equal-initializer, it can be unclear if a non-nested = or { is the first token of the initializer or a continuation of the constant-expression, and in some of those cases this remains ambiguous even with infinite lookahead.

For example:

```cpp
struct S {
    int y : true ? 1 : a = 42; // Is 42 a default member initializer
                             // or the rhs of an assignment?
    int x : 1 || new int { 43 }; // Is 43 a default member initializer
                             // or part of the new expression?
};
```

**Proposal**

We propose to resolve these ambiguities by effectively adding a couple of special parsing rules that serves to both (a) resolve potential ambiguities; and (b) make it easy to parse.

**Roughly, the first proposed rule is that, in a bitfield declarator, the first non-nested = token terminates parsing of the constant-expression.**

Consequences: A bitfield width may not contain a non-nested = token. A non-nested = token after the : token in a bitfield declarator unambiguously commences the initializer in a well-formed program.

Rationale: It would be a very strange constant-expression that uses an overloaded assignment operator. In such bizarre cases, it remains possible to wrap the bitfield width in parenthesis to get it to parse as intended.

**Roughly, the second proposed rule is that, in a bitfield declarator, a { token does not start parsing of the brace-or-equal-initializer.**

Consequences: The initializer of a bitfield must start with an = token. That is, it must use the copy-initialization or copy-list-initialization form, and may not use the direct-initialization or direct-list-initialization form. Informally the rule is "you have to use the equals" in a bitfield default member initializer.
Rationale:

1. For a bit-field, there is no difference in effect between copy-initialization and direct-initialization (likewise no difference between copy-list-initialization and direct-list-initialization). Therefore a would-be use of the direct forms can be replaced with the copy forms, without semantic difference.

2. Leaving it ambiguous lead to complaints about implementation difficulty.

3. Non-nested braces are useful in constant expressions. For example:

```cpp
enum E { k = 4; }
struct X { int n : int{E::k}; };
```

Weighing these three points we decided to propose that the brace be given to the constant expression.

We apply these two rules by adjusting the grammar, reducing the would-be constant-expression to not allow non-nested = syntactically, and reducing the would-be brace-or-equal-initializer to = initializer.

Wording

Add to grammar and member-declarator:

```cpp
member-declarator:
    declator virt-specifier-seq_opt pure-specifier_opt
    declator brace-or-equal-initializer_opt
    identifier Opt attribute-specifier-seq_opt:
    noassign-conditional-expression
    identifier attribute-specifier-seq_opt:
    noassign-conditional-expression = initializer

noassign-conditional-expression:
    logical-or-expression
    logical-or-expression ? noassign-conditional-expression :
    noassign-conditional-expression
```

Modify [class.bit]:

A member-declarator of one of the forms:

```cpp
    identifier_opt attribute-specifier-seq_opt:
```
specifies a bit-field; its length is set off from the bit-field name by a colon. If an \texttt{initializer} is present, it is treated as a \texttt{brace-or-equal-initializer} of this data member ([class.mem]/4). The optional \texttt{attribute-specifier-seq} appertains to the entity being declared. The bit-field attribute is not part of the type of the class member. The \texttt{noassign-conditional-expression} shall be an integral constant expression with a value greater than or equal to zero.

Add new paragraph to [class.bit]:

A \texttt{noassign-conditional-expression} is equivalent, by definition, to a \texttt{conditional-expression} that consists of the same sequence of tokens.

Add new section [diff.cpp14.class]:

\textbf{Change:} Change bit-field widths to be \texttt{noassign-conditional-expressions}.
\textbf{Rationale:} To enable bit-field default member initializers.
\textbf{Effect on original feature:} Valid C++ 2014 code may fail to compile or change meaning in this International Standard:

```cpp
int a;
struct S {
    int b : true ? 2 : a = 1;
    // before: bit-field width of 2, not initialized
    // after: bit-field width of 2, initialized with the value 1.
};
```

\textbf{References}

CWG ISSUE 1341
Thread starting [c++std-core-28391] “another observation on core issue 1341”
CWG Kona 2015 discussion about same
Acknowledgements

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