A Preliminary Proposal for a Static `if`

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1 Introduction

This paper proposes a generalized compile-time conditional facility for possible future C++ standardization. In the remainder of this document, we refer to the proposed feature via a notional keyword `static_if` and refrain from any (bicycle-shed!) discussion of possible alternate nomenclature and keywords.¹

2 Feature description

We envision high-level syntax and semantics for the proposed `static_if` analogous to those of the conventional `if`. Syntactically, there must be a predicate and two bodies, the second of which is taken to be empty if not explicitly provided:

```cpp
static_if( predicate ) {
  body 1
}
else {
  body 2
}
```

Semantically, the predicate is evaluated, followed by a selection of one of the bodies according to the predicate's truth value. Our proposal differs from the conventional `if` in that all of this is required to happen during compilation rather than during execution.

- To ensure that a `static_if`'s predicate can always be evaluated at compile-time, we will require that the predicate be a constant expression that can be converted to `bool`.

¹For the record, the following alternatives have already been proposed by reviewers of preliminary drafts of this document: `compile_if`, `only_if`, `enable_if/disable_if`, `if...`, and (our current preference) `if<...>`.
• In selecting one of the two bodies, a static_if decides which is to be compiled and which is to be ignored.

• We propose to allow static_if to appear at least at namespace, class, and block scope, and perhaps also wheresoever else C++11 permits braces.

• Finally, we propose to permit multiple static_if constructs to be nested and otherwise composed (e.g., static_if ... else static_if ...) exactly as is possible with a conventional if.

3 Prior art

3.1 static_assert
C++11 standardized static_assert, a core language feature that allows programs to decide, based on a given “constant expression that can be converted to bool,” whether to emit a diagnostic containing a given string-literal. The specification of such a constant expression is precisely the specification we would propose for our static_if’s predicate. Indeed, had static_if been available, today’s static_assert might well have evolved along the following lines:

```cpp
1 static_if( predicate ) { 
2     issue_diagnostic( string-literal );
3 }
```

Moreover, we propose to permit static_if to appear in (at least) each of the scopes in which C++11 permits static_assert to appear.

3.2 #if
C++ has supported, ab initio, the C preprocessor’s #if ... #endif mechanism for conditional compilation. Thus we have precedent for precisely the semantics we propose for our static_if construct.

However, the preprocessor operates during compilation at an earlier stage than that in which C++ constant expressions are available to be evaluated. It is conceivable that our proposed static_if, in combination with future introspection facilities, may one day permit us to deprecate this long-standing preprocessor use.

3.3 Template-based techniques

3.3.1 Specialization
Even the most straightforward application of C++ template specialization can be viewed as a form of conditional compilation: if template arguments match those of a specialization, then instantiate the specialization, else instantiate the primary template.

While undeniably useful, today’s need to specialize an entire class template for the sake of only a small difference in, say, a single member function demonstrates that the granularity afforded by specialization can be too coarse. The proposed static_if affords programmer control with much finer resolution.

3.3.2 SFINAE
As a special case, SFINAE affords conditional compilation of function templates. Most obviously exploited with the help of std::enable_if, substitution failure in this context is tantamount to a compile-time decision not to instantiate and compile a given template.
3.3.3 Tag dispatching

Another technique in this general category has been termed tag dispatching, “a way of using function overloading to effect concept-based overloading.”\(^2\) We will start with this technique in §4, below, and show how the use of the static_if in its place leads to a straightforward implementation technique with every detail in one place, thus needing no overloading.

3.4 D 2.0

The D programming language (version 2) natively provides several forms of conditional compilation, with grammar as outlined at http://www.digitalmars.com/d/2.0/version.html. Of these, the “Static If Condition”\(^3\) corresponds to the current proposal. While it seems worthwhile to consider some or all of the additional forms\(^4\) for C++, we do not propose them here.

4 An example

Consider the following example, copied verbatim from 24.4.3 [std.iterator.tags]/3, meant to illustrate the use of tag-based dispatching techniques:

```cpp
template <class BidirectionalIterator>
inline void evolve(BidirectionalIterator first, BidirectionalIterator last) {
    evolve(first, last,
        typename iterator_traits<BidirectionalIterator>::iterator_category());
}

template <class BidirectionalIterator>
void evolve(BidirectionalIterator first, BidirectionalIterator last,
        bidirectional_iterator_tag) {
    // more generic, but less efficient algorithm
}

template <class RandomAccessIterator>
void evolve(RandomAccessIterator first, RandomAccessIterator last,
        random_access_iterator_tag) {
    // more efficient, but less generic algorithm
}
```

Note that three templates are involved here: one (lines 1-6) provides the user interface, while the other two (lines 8-12 and 14-18) provide implementation alternatives to one of which the interface template will dispatch.\(^5\)

Using the proposed static_if, the example code might instead be written as a single template:

```
7template <class BidirectionalIterator>
8void evolve(BidirectionalIterator first, BidirectionalIterator last,
9        bidirectional_iterator_tag) {
10    // more generic, but less efficient algorithm
11}
```

---


\(^4\)For example, code that is compiled (or not) depending on a debugging status.

\(^5\)The example might have been clearer had the implementation templates been placed into a distinct namespace or been given a distinct name such as evolve_impl.
Note that the size of the example could be reduced from fifteen to nine lines with the aid of some generally useful constexpr helper templates, is_bidirectional and is_random_access, whose semantics match those of the bulkier code above. Further, the example could be extended by three lines so as to provide a compile-time diagnostic whenever instantiation is attempted with an Iterator whose classification is neither bidirectional nor random-access:

```cpp
template <class Iterator>
inline void evolve(Iterator first, Iterator last)
static_if( is_bidirectional<Iterator>() ) { 
// more generic, but less efficient algorithm
}
elseif( is_random_access<Iterator>() ) { 
// more efficient, but less generic algorithm
}
else {
issue_diagnostic(...);
}
```

It seems clear from the above example that the static_if facility would become even more useful in the presence of more powerful C++ introspection capabilities, but such features are outside the scope of this proposal.

5 A second example

We now present (in abstracted form) the actual coding scenario that inspired this preliminary proposal.

Assume that we have a number of constexpr function templates, each of the form:

```cpp
template< class T >
constexpr bool has_property_n( ) { return ...; }
```

Assume further that we have a class template C with a single type parameter, and that the implementations of most of C’s member functions must vary according to the truth values of the property inquiry functions, often in combinations.

In both C++03 and C++11, specialization is a candidate implementation technique. If we have \( n \) property inquiries, we would perhaps add \( n \) non-type bool template parameters and then
provide as many as $2^n$ specializations. Worse, many of these specializations may duplicate code found in other specializations.\textsuperscript{6}

However, implementation with the help of \texttt{static if} is entirely straightforward, with no tag dispatch, no extra template parameters, and no code duplication:

```
template< class T >
class C {
  void common( ) { ... }

  static_if( has_property1<T>() ) {
    void f1( ) { ... }
  }

  static_if( has_property2<T>() ) {
    void f2( ) { ... }
  }

  else {
    void f2( ) = delete;
  }
};
```

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\textsuperscript{6}Our actual use case (a form of decorator pattern) has \texttt{enum}-returning property functions that characterize a type along three axes, allowing $5 \cdot 3 \cdot 3 = 45$ possible value combinations.