

Copenhagen, 17 December 2001

**Title:**

New CPH STL headers  
<compile-time-assert> and <type>

**Speaker:**

Jyrki Katajainen

Datalogisk Institut

Københavns Universitet

My source: Andrei Alexandrescu, *Modern C++ Design: Generic Programming and Design Patterns Applied*. Addison-Wesley (2001)

# Partial template specialization

```
template <typename T>
class X {

    // Most general version.
}

template <typename T>
class X<T*> {

    // Version for general pointers.
}

template <>
class X<void*> {

    // Version for one specific pointer type.
}
```

## Local classes

```
void fun() {  
    class local {  
        ... member variables ...  
        ... member function definitions ...  
    }  
    ... code using local ...  
}
```

- Local classes cannot define static member variables and cannot access nonstatic variables.
- Local classes defined inside template functions can use the template parameters of the enclosing function.

# Compile-time computations in C++

**Operands:** typelists, types, or compile-time numeric constants

**Operations:** template class, typedef, enum, static constant, sizeof

**Restrictions:** All compile-time values are **immutable**! After you have defined an integral constant, say an enumerated value, you cannot change it. typedefs can be seen as introducing named type constants. Again after definition, they are frozen—you cannot later redefine a typedef'd symbol to hold another type.

Although C++ is mostly an imperative language, any compile-time computation must rely on techniques that definitely are reminiscent of pure functional languages—languages unable to mutate values.

## Where are these needed?

- doing optimizations (e.g., copy)
- handling C++ anomalies (e.g., pair)
- implementing concept checks
- implementing tuples (generalizations of pairs)
- implementing integer classes: `integer<8>`, `integer<16>`, `integer<32>`, etc.

## Compile-time assertions in C

```
tyr> cat c.c
#define STATIC_CHECK(expression) { \
    char compile_time_assert[(expression) ? 1 : -1]; \
    compile_time_assert[0] = 0; \
}

template <typename to, typename from>
to safe_reinterpret_cast(from source) {
    STATIC_CHECK(sizeof(from) <= sizeof(to));
    to target = reinterpret_cast<to>(source);
    return target;
}

int main() {
    void* p = 0;
    char c = safe_reinterpret_cast<char>(p);
    c = 0;
    void* buf = safe_reinterpret_cast<void*>(0xF00F);
    buf = 0;
    return 0;
}

tyr> g++ -Wall c.c
c.c: In function
'char safe_reinterpret_cast<char, void *>(void *)':
c.c:15:   instantiated from here
c.c:8:   size of array 'compile_time_assert' is negative
c.c:9:   reinterpret_cast from 'void *' to 'char' loses
precision
```

## compile-time-assert File Reference

This file defines the macro `compile_time_assert` that performs a compile-time assertion. More...

Go to the source code of this file.

### Namespaces

namespace `cphstl`

### Compounds

class `cphstl::compile_time_checker`

### Defines

```
#define compile_time_assert(expression, message)
    Macro compile_time_assert. More...
```


---

## Detailed Description

This file defines the macro `compile_time_assert` that performs a compile-time assertion.

>

---

Generated at Mon Dec 17 01:40:31 2001 for *TheCopenhagenSTL* by  1.2.3 written by Dimitri van

Heesch, © 1997-2000

# Compile-time assert

## Compounds

class `cphstl::compile_time_checker`

## Defines

```
#define compile_time_assert(expression, message)
    Macro compile_time_assert. More...
```

---

## Detailed Description

This module contains the definitions associated with the CPH STL extension `<compile-time-assert>`.

### Original author

Jyrki Katajainen <jyrki@diku.dk>, December 2001

---

## Define Documentation

```
#define compile_time_assert( expression, message )
```

### Initializer:

```
{ \
    struct ERROR_##message { \
    }; \
    typedef cphstl::compile_time_checker<(expression)> type; \
    type temp = type(ERROR_##message()); \
    (void) sizeof(temp); \
}
```

Macro `compile_time_assert`.

### Input

A Boolean expression that can be evaluated at compile time and an error message in the form of a legal C++ identifier (no spaces, should not start with a digit, and so on).


## Effect

If the compile-time expression evaluates to `true`, the resulting program is valid. Otherwise a compile-time error occurs.

## Implementation

The implementation is taken from the book: Andrei Alexandrescu, *Modern C++ Design: Generic Programming and Design Patterns Applied*, Addison-Wesley (2001), see Section 2.1.

---


Generated at Mon Dec 17 01:40:32 2001 for *TheCopenhagenSTL* by  1.2.3 written by Dimitri van Heesch, © 1997-2000

## compile-time-assert

Go to the documentation of this file.

```
00001 /* -*- C++ -*- $Id: compile-time-assert-source.ps,v 1.1 2002/01/22 11:15:30
00002
00019 #ifndef __cphstl_compile_time_assert__
00020 #define __cphstl_compile_time_assert__
00021
00022 namespace cphstl {
00023
00045     template<bool>
00046     class compile_time_checker {
00047     public:
00051         compile_time_checker(...) {
00052         }
00053     };
00054
00055     template<>
00056     class compile_time_checker<false> {
00057     };
00058
00086     #define compile_time_assert(expression, message) { \
00087         struct ERROR_##message { \
00088         }; \
00089         typedef cphstl::compile_time_checker<(expression)> type; \
00090         type temp = type(ERROR_##message()); \
00091         (void) sizeof(temp); \
00092     }
00093 }
00094
00095 #endif // __cphstl_compile_time_assert__
```

---

Generated at Mon Dec 17 01:40:31 2001 for TheCopenhagenSTL by  1.2.3 written by Dimitri van

Heesch, © 1997-2000

## Testing it

```
grimer> cat Testsuite/c++.cpp
#include <compile-time-assert>
```

```
template <typename to, typename from>
to safe_reinterpret_cast(from source) {
    compile_time_assert(sizeof(from) <= sizeof(to),
        reinterpret_cast_looses_precision);
    to target = reinterpret_cast<to>(source);
    return target;
}
```

```
int main() {
    void* p = 0;
    char c = safe_reinterpret_cast<char>(p);
    c = 0;
    void* buf = safe_reinterpret_cast<void*>(0xF00F);
    buf = 0;
    return 0;
}
```

```
grimer> gmake unittest
g++ -I. -O6 -Wall Testsuite/c++.cpp -o Testsuite/c++.exe
Testsuite/c++.cpp: In function
‘char safe_reinterpret_cast<char, void *>(void *)’:
Testsuite/c++.cpp:13:   instantiated from here
Testsuite/c++.cpp:5: no matching function for call to
‘cphstl::compile_time_checker<false>::compile_time_checker
(safe_reinterpret_cast<char, void *>(void *)::
ERROR_reinterpret_cast_looses_precision)’
compile-time-assert:52: candidates are:
cphstl::compile_time_checker<false>::
compile_time_checker(const cphstl::compile_time_checker<false>
compile-time-assert:52:
cphstl::compile_time_checker<false>::compile_time_checker()
Testsuite/c++.cpp:7: reinterpret_cast from ‘void *’ to ‘char
precision
```

## type File Reference

This file defines a collection of tools for performing type mappings. More...

[Go to the source code of this file.](#)

### Namespaces

namespace `unnamed`  
namespace `cphstl`

### Compounds

```
class cphstl::convert
struct cphstl::int2type
struct cphstl::convert::plain_to_reference
class cphstl::query
struct cphstl::test::same
struct cphstl::select
class cphstl::test
struct cphstl::type2type
struct cphstl::typelist
struct cphstl::convert::un_const
struct cphstl::convert::un_volatile
```

### Defines

```
#define TYPELIST_1(T1) typelist<T1, nil>
    This macro defines a typelist of lenght 1.

#define TYPELIST_2(T1, T2) typelist<T1, TYPELIST_1(T2) >
    This macro defines a typelist of lenght 2.

#define TYPELIST_3(T1, T2, T3) typelist<T1, TYPELIST_2(T2, T3) >
    This macro defines a typelist of lenght 3.

#define TYPELIST_4(T1, T2, T3, T4) typelist<T1, TYPELIST_3(T2, T3, T4) >
    This macro defines a typelist of lenght 4.
```

---

### Detailed Description

This file defines a collection of tools for performing type mappings.

---

# Type mappings

## Compounds

```
class cphstl::convert
struct cphstl::index_of
struct cphstl::int2type
struct cphstl::select
class cphstl::test
struct cphstl::type2type
struct cphstl::typelist
```

---

## Detailed Description

This module is a CPH STL extension defining a collection of tools for performing type mappings.

### Original author


Jyrki Katajainen <jyrki@diku.dk>, December 2001

### Sources

Andrei Alexandrescu, *Modern C++ Design: Generic Programming and Design Patterns Applied*, Addison-Wesley (2001), see Chapters 2 and 3.

Jaakko Järvi, Tuple types and multiple return values, *C/C++ Users Journal* **19,8** (2001), 24-35.

---

Generated at Mon Dec 17 01:29:56 2001 for *TheCopenhagenSTL* by  1.2.3 written by Dimitri van

Heesch, © 1997-2000

## type

Go to the documentation of this file.

```
00001 /* -*- C++ -*- $Id: type-sourcel.ps,v 1.1 2002/01/22 11:15:39 jyrki Exp $
00002
00028 #ifndef __cphstl_type__
00029 #define __cphstl_type__
00030
00031 namespace cphstl {
00032
00038     template <int v>
00039     struct int2type {
00040         enum { value = v };
00041     };
00042
00049     template <typename T>
00050     struct type2type {
00054         typedef T original_type;
00055     };
00056
00061     template <bool, typename T, typename U>
00062     struct select {
00066         typedef T type;
00067     };
00068
00069     template <typename T, typename U>
00070     struct select<false, T, U> {
00071         typedef U type;
00072     };
00073
00078     template <typename T, typename U>
00079     class test {
00080     private:
00084         template <typename X, typename Y>
00085         struct same {
00086             enum { pos = false };
00087             enum { neg = true };
00088         };
00089         template <typename X>
00090         struct same<X, X> {
00091             enum { pos = true };
00092             enum { neg = false };
00093         };
00094
00095     public:
00096         enum { is_equal_to = same<T, U>::pos };
00097         enum { is_not_equal_to = same<T, U>::neg };
00098     };
00099
00104     template <typename T>
00105     class convert {
00106     private:
00110         template <typename U>
00111         struct un_const {
00112             typedef U type;
00113         };
00114         template <typename U>
```

```

00115     struct un_const<const U> {
00116         typedef U type;
00117     };
00118
00122     template <typename U>
00123     struct un_volatile {
00124         typedef U type;
00125     };
00126     template <typename U>
00127     struct un_const<volatile U> {
00128         typedef U type;
00129     };
00130
00135     template <typename U>
00136     struct plain_to_reference {
00137         typedef const U& cref;
00138         typedef U& ref;
00139     };
00140     template <typename U>
00141     struct plain_to_reference<U&> {
00142         typedef U& cref;
00143         typedef U& ref;
00144     };
00145
00146     public:
00150         typedef un_const<T>::type non_const;
00155         typedef un_volatile<T>::type non_volatile;
00159         typedef un_volatile<un_const<T>::type>::type non_qualified;
00164         typedef plain_to_reference<T>::cref const_reference;
00169         typedef plain_to_reference<T>::ref reference;
00170     };
00171
00176     namespace {
00177
00181         struct nil {
00182             };
00183     }
00184
00190     template <typename H, typename T>
00191     struct typelist {
00195         typedef H head;
00199         typedef T tail;
00200     };
00201
00205     #define TYPELIST_1(T1) typelist<T1, nil>
00206
00209     #define TYPELIST_2(T1, T2) typelist<T1, TYPELIST_1(T2) >
00210
00213     #define TYPELIST_3(T1, T2, T3) typelist<T1, TYPELIST_2(T2, T3) >
00214
00217     #define TYPELIST_4(T1, T2, T3, T4) typelist<T1, TYPELIST_3(T2, T3, T4) >
00218
00224     template <typename T, typename list>
00225     struct index_of;
00226
00227     template <typename T>
00228     struct index_of<T, nil> {
00229         enum { position = -1 };
00230     };
00231
00232     template <typename T, typename tail>
00233     struct index_of<T, typelist<T, tail> > {
00234         enum { position = 0 };
00235     };
00236


```

```

00237     template <typename T, typename head, typename tail>
00238     struct index_of<T, typelist<head, tail> > {
00239     private:
00240         enum { temp = index_of<T, tail>::position };
00241     public:
00242         enum { position = (temp == -1) ? -1 : 1 + temp };
00243     };
00244
00248     template <typename T>
00249     class query {
00250     private:
00251         template <typename U>
00252         struct pointer_traits {
00253             enum { result = false };
00254         };
00255         template <typename U>
00256         struct pointer_traits<U*> {
00257             enum { result = true };
00258         };
00259     public:
00260         typedef TYPELIST_4(
00261             unsigned char, unsigned short int,
00262             unsigned int, unsigned long int) unsigned_integrals;
00272         typedef TYPELIST_4(signed char, short int, int, long int) signed_integ:
00276         typedef TYPELIST_3(bool, char, wchar_t) other_integrals;
00280         typedef TYPELIST_3(float, double, long double) floating_points;
00281
00282         enum { is_pointer = pointer_traits<T>::result };
00283         enum { is_unsigned_integral = index_of<T, unsigned_integrals>::positio:
00284         enum { is_signed_integral = index_of<T, signed_integrals>::position >=
00285         enum { is_integral = is_unsigned_integral || is_signed_integral ||
00286             index_of<T, other_integrals>::position >= 0 };
00287         enum { is_floating_point = index_of<T, floating_points>::position >= 0
00288         enum { is_arithmetic = is_integral || is_floating_point };
00289         enum { is_fundamental = is_arithmetic || is_floating_point ||
00290             test<T, void>::is_equal_to };
00291     };
00292 }
00293
00294 #endif // __cphstl_type__
00295
00296
00297

```

---

Generated at Mon Dec 17 01:29:55 2001 for TheCopenhagenSTL by  1.2.3 written by Dimitri van

Heesch, © 1997-2000

## copy.cpp File Reference

This file defines the function `copy`. [More...](#)

```
#include <iterator>
#include <type>
#include <cstring>
```

[Go to the source code of this file.](#)

## Namespaces

namespace `cphstl`

---

## Detailed Description

This file defines the function `copy`.

### Original author


Jyrki Katajainen <jyrki@diku.dk>, December 2001

### Sources

Andrei Alexandrescu, *Modern C++ Design: Generic Programming and Design Patterns Applied*, Addison-Wesley (2001), see Section 2.10.5.

John Maddock and Steve Cleary, C++ type traits, *Dr. Dobbs's Journal*, 25,10 (2000), 38-44.

---

Generated at Mon Dec 17 00:52:10 2001 for *TheCopenhagenSTL* by  1.2.3 written by Dimitri van

Heesch, © 1997-2000

## copy.cpp

Go to the documentation of this file.


```

00001
00020
00021 #include <iterator> /* defines cphstl::iterator_traits */
00022 #include <type> /* defines cphstl::int2type and cphstl::query */
00023 #include <cstring> /* defines memcpy */
00024
00025 namespace cphstl {
00026
00027     namespace {
00028
00029         enum copy_algorithm_selector { conservative, fast };
00030
00033
00034         template <typename input_iterator, typename output_iterator>
00035         inline output_iterator
00036         copy (
00037             input_iterator p,
00038             input_iterator one_past_the_end,
00039             output_iterator r,
00040             cphstl::int2type<conservative>
00041         ) {
00042
00043             for (; p != one_past_the_end; ++p, ++r) {
00044                 *r = *p;
00045             }
00046             return r;
00047         }
00048
00051
00052         template <typename input_iterator, typename output_iterator>
00053         inline output_iterator
00054         copy (
00055             input_iterator first,
00056             input_iterator one_past_the_end,
00057             output_iterator result,
00058             cphstl::int2type<fast>
00059         ) {
00060
00061             typedef std::iterator_traits<input_iterator>::difference_type size;
00062             size n = one_past_the_end - first;
00063             memcpy(result, first, n * sizeof(*first));
00064             return result + n;
00065         }
00066     }
00067
00144
00145     template <typename input_iterator, typename output_iterator>
00146     output_iterator
00147     copy (
00148         input_iterator first,
00149         input_iterator one_past_the_end,
00150         output_iterator result
00151     ) {
00152         typedef std::iterator_traits<input_iterator>::value_type input_element;
00153         typedef std::iterator_traits<output_iterator>::value_type output_element;

```

```
00154
00155     enum { algorithm_flag =
00156           cphstl::query<input_iterator>::is_pointer &&
00157           cphstl::query<output_iterator>::is_pointer &&
00158           cphstl::query<input_element>::is_fundamental &&
00159           cphstl::query<output_element>::is_fundamental &&
00160           sizeof(input_element) == sizeof(output_element) ? fast : conservativ
00161     };
00162     return copy(first, one_past_the_end, result, cphstl::int2type<algorithm
00163   }
00164 }
```

---

Generated at Mon Dec 17 00:52:10 2001 for TheCopenhagenSTL by  1.2.3 written by Dimitri van

Heesch, © 1997-2000