Programming in Modern C++

Module M33: Type Casting & Cast Operators: Part 2

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All url's in this module have been accessed in September, 2021 and found to be functional

Module Recap

- Understood casting in C and C++
- Explained cast operators in C++ and discussed the evils of C-style casting
- Studied `const_cast` with examples

Module Objectives

- Understand casting in C and C++
- Understand `static_cast`, and `reinterpret_cast` operators

Module Outline

Cast Operators

Casting in C and C++: RECAP (Module 32)

- Casting in C
  - Implicit cast
  - Explicit C-Style cast
  - Loses type information in several contexts
  - Lacks clarity of semantics
- Casting in C++
  - Performs fresh inference of types without change of value
  - Performs fresh inference of types with change of value
    - Using implicit computation
    - Using explicit (user-defined) computation
  - Preserves type information in all contexts
  - Provides clear semantics through cast operators:
    - `const_cast`
    - `static_cast`
    - `reinterpret_cast`
    - `dynamic_cast`
  - Cast operators can be grep-ed (searched by cast operator name) in source
  - C-Style cast must be avoided in C++

static_cast Operator

- `static_cast` performs all conversions allowed implicitly (not only those with pointers to classes), and also the opposite of these. It can:
  - Convert from `void*` to any pointer type
  - Convert integers, floating-point values to `enum` types
  - Convert one `enum` type to another `enum` type
- `static_cast` can perform conversions between pointers to related classes:
  - Not only up-casts, but also down-casts
  - No checks are performed during run-time to guarantee that the object being converted is in fact a full object of the destination type
- Additionally, `static_cast` can also perform the following:
  - Explicitly call a single-argument constructor or a conversion operator – The User-Defined Cast
  - Convert to rvalue references
  - Convert `enum` values into integers or floating-point values
  - Convert any type to `void`, evaluating and discarding the value

static_cast Operator: Built-in Types


```
#include <iostream>
using namespace std;
int main() { // Built-in Types
    int i = 2; long j; double d = 3.7; int *pi = &i; double *pd = &d; void *pv = 0;

    i = d;                      // implicit -- warning
    i = static_cast<int>(d);    // static_cast -- okay
    i = (int)d;                 // C-style -- okay

    d = i;                      // implicit -- okay
    d = static_cast<double>(i); // static_cast -- okay
    d = (double)i;              // C-style -- okay

    pv = pi;                    // implicit -- okay
    pi = pv;                    // implicit -- error
    pi = static_cast<int*>(pv); // static_cast -- okay
    pi = (int*)pv;              // C-style -- okay

    j = pd;                     // implicit -- error
    j = static_cast<long>(pd);  // static_cast -- error
    j = (long)pd;               // C-style -- okay: sizeof(long) = 8 = sizeof(double*)
                                // RISKY: Should use reinterpret_cast
    i = (int)pd;                // C-style -- error: sizeof(int) = 4 != 8 = sizeof(double*)
                                // Refer to Module 26 for details
}
```

static_cast Operator: Class Hierarchy


```
#include <iostream>
using namespace std;

// Class Hierarchy
class A { };
class B: public A { };

int main() {
    A a;
    B b;

    // UPCAST
    A *p = 0;
    p = &b;                     // implicit -- okay
    p = static_cast<A*>(&b); // static_cast -- okay
    p = (A*)&b;                 // C-style -- okay

    // DOWNCAST
    B *q = 0;
    q = &a;                     // implicit -- error
    q = static_cast<B*>(&a); // static_cast -- okay: RISKY: Should use dynamic_cast
    q = (B*)&a;                 // C-style -- okay
}
```

static_cast Operator: Pitfall


```
class Window { public:
    virtual void onResize(); ...
}
class SpecialWindow: public Window { // derived class
public:
    virtual void onResize() { // derived onResize impl;
        static_cast<Window>(*this).onResize(); // cast *this to Window, then call its onResize;
            // this doesn't work!

        ... // do SpecialWindow-specific stuff
    }
    ...
};
```

Slices the object, creates a temporary and calls the method!

```
class SpecialWindow: public Window { // derived class
public:
    virtual void onResize() { // derived onResize impl;
        Window::onResize();   // Direct call works

        ... // do SpecialWindow-specific stuff
    }
    ...
};
```

static_cast Operator: Unrelated Classes


```
#include <iostream>
using namespace std;

// Un-related Types
class B;
class A { public:


};
class B { };

int main() {
    A a; B b;
    int i = 5;

    // B ==> A
    a = b;                  // error
    a = static_cast<A>(b); // error
    a = (A)b;               // error

    // int ==> A
    a = i;                  // error
    a = static_cast<A>(i); // error
    a = (A)i;               // error
}
```

```
#include <iostream>
using namespace std;

// Un-related Types
class B;
class A { public:
    A(int i = 0) { cout << "A::A(i)\n"; }
    A(const B&) { cout << "A::A(B&)\n"; }
};
class B { };

int main() {
    A a; B b;
    int i = 5;

    // B ==> A
    a = b;                  // Uses A::A(B&)
    a = static_cast<A>(b); // Uses A::A(B&)
    a = (A)b;               // Uses A::A(B&)

    // int ==> A
    a = i;                  // Uses A::A(int)
    a = static_cast<A>(i); // Uses A::A(int)
    a = (A)i;               // Uses A::A(int)
}
```

static_cast Operator: Unrelated Classes


```
#include <iostream>
using namespace std;

// Un-related Types
class B;
class A { int i_; public:


};
class B { public:

};
int main() { A a; B b; int i = 5;

    // B ==> A
    a = b;                  // error
    a = static_cast<A>(b); // error
    a = (A)b;               // error

    // A ==> int
    i = a;                    // error
    i = static_cast<int>(a); // error
    i = (int)a;               // error
}
```

```
#include <iostream>
using namespace std;

// Un-related Types
class B;
class A { int i_; public:
    A(int i = 0) : i_(i) { cout << "A::A(i)\n"; }
    operator int() { cout << "A::operator int()\n"; return i_; }
};
class B { public:
    operator A() { cout << "B::operator A()\n"; return A(); }
};
int main() { A a; B b; int i = 5;

    // B ==> A
    a = b;                  // B::operator A()
    a = static_cast<A>(b); // B::operator A()
    a = (A)b;               // B::operator A()

    // A ==> int
    i = a;                    // A::operator int()
    i = static_cast<int>(a); // A::operator int()
    i = (int)a;               // A::operator int()
}
```

reinterpret_cast Operator

- `reinterpret_cast` converts *any pointer type* to *any other pointer type*, even of unrelated classes
- The operation result is a simple binary copy of the value from one pointer to the other
- All pointer conversions are allowed: neither the content pointed nor the pointer type itself is checked
- It can also cast pointers to or from integer types
- The format in which this integer value represents a pointer is platform-specific
- The only guarantee is that a pointer cast to an integer type large enough to fully contain it (such as `intptr_t`), is guaranteed to be able to be cast back to a valid pointer (Refer to Module 26)
- The conversions that can be performed by `reinterpret_cast` but not by `static_cast` are low-level operations based on reinterpreting the binary representations of the types, which on most cases results in code which is system-specific, and thus non-portable

reinterpret_cast Operator


```
#include <iostream>
using namespace std;

class A { };
class B { };

int main() {
    long i = 2;
    double d = 3.7;
    double *pd = &d;

    i = pd;                                  // implicit -- error
    i = reinterpret_cast<long>(pd);          // reinterpret_cast -- okay
    i = (long)pd;                            // C-style -- okay
    cout << pd << " " << i << endl;

    A *pA;
    B *pB;

    pA = pB;                                 // implicit -- error
    pA = reinterpret_cast<A*>(pB);           // reinterpret_cast -- okay
    pA = (A*)pB;                             // C-style -- okay
}
```

Module Summary

- Studied `static_cast`, and `reinterpret_cast` with examples