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Const correctness



What is const correctness ?

- It is a semantic constraint, enforced by the compiler, to avoid that a particular object marked as `const` should not be modified
- `const` can be used in various scopes:
 - outside of classes at global/namespace scope:

```
const double AspectRatio = 1.653;  
// much better than a C style define:  
#define ASPECT_RATIO 1.653
```



Class constants

- It's usable for static objects at file, function and block level
- It's usable also for class specific constants, e.g. for static and non-static data members:

```
class VideoFrame {  
private:  
    static const int PALFrameRate;  
    ...  
};  
const int VideoFrame::PALFrameRate = 25;
```



Pointers and constancy

- We can specify that a pointer is constant, that the data pointed to is constant, that both are constant (or neither):

```
char greeting[] = "Hello";  
char* p = greeting; // nothing is constant
```

```
const char* p = greeting; //non-const pointer  
                        //      const data
```

```
char* const p = greeting; //      const pointer  
                        // non-const data
```

```
const char* const p = greeting; // everything is const
```



Pointers and constancy - cont.

- If `const` appears to the left of `*` then what is pointed to is constant, if it's on the right then the pointer is constant:

`const char* const p` means that `p` is a constant pointer to constant chars

- according to this writing `char const* p` is the same of `const char* p`



References and constancy

- You can not change an alias, i.e. you can't reassign a reference to a different object, so:

`Fred& const x` makes no sense (it's the same thing of `Fred& x`), however:

`const Fred& x` is OK: you can't change the Fred object using the x reference.



Functions and constancy

- The most powerful use of const is its application to function declarations: we can refer to function return value, function parameters and (for member functions) to the function itself
- Helps in reducing errors, e.g. you are passing an object as parameter using a reference/pointer and do not want to have it modified:

```
void foo(const bar& b);  
// b can't be modified  
// use const params whenever possible
```




const return value

- Using a const return value reduces errors in client code, e.g.

```
class Rational { //...};  
const Rational operator*(const Rational&  
lhs, const Rational& rhs);
```

```
Rational a,b,c;  
// let's say we missed an =  
// to make a comparison...  
(a*b)=c; // it's now illegal thanks to  
          // const return value !
```



const return value - cont.

- When returning a reference probably it's better to return it as constant or it may be used to modify the referenced object:

```
class Person {  
public:  
    string& badGetName() const; // returns a reference to _name  
    //...  
private:  
    string _name;  
};  
  
void myCode(const Person& p) {  
    p.badGetName() = "Igor"; // can change the _name  
                             // attribute of Person  
}
```



const member functions

- The purpose of `const` member functions is to identify which functions can be invoked on `const` objects.
These functions inspect and do not mutate an object.
- NOTE: it's possible to overload methods that change only in constancy !
It's useful if you need a method to inspect and mutate with the same name



const member functions - cont.

```
class TextBlock {
public:
    const char& operator[](size_t pos) const {
        return text[pos];
    }
    char& operator[](size_t pos) { // has to be reference
        return text[pos];        // to be modifiable:
    }                             // C++ returns by value !
private:
    string text;
};
```

- this is useful when dealing with objects that are passed as const references:

```
void print(const TextBlock& ctb, size_t pos) {
    cout << ctb[pos]; // calls the const version of []
};
```



const member functions - cont.

- C++ compilers implement bitwise constancy, but we are interested in logical constancy, e.g. the const reference return value seen before or we may need to modify some data member within a const method (declared `mutable`):

```
class TextBlock {  
public:  
    size_t length() const;  
private:  
    string text;  
    mutable size_t _length;  
    mutable bool isValidLength;  
};
```

```
size_t TextBlock::length()  
const {  
    if(!isValidLength) {  
        _length=text.size();  
        isValidLength=true;  
    }  
    return _length;  
}
```



const member functions - cont.

- To avoid code duplication between const and non-const member functions that have the same behaviour can be solved:
- putting common tasks in private methods called by the two versions of the const/non-const methods
- casting away constancy, with the non-const method calling the const method (see later)



C++ and casting



C++ casting

- In the previous example we have seen how to cast an object to a const version of itself and then how to cast away constancy
- C++ casts are more restricted than C style casts
- In general the lesser we cast the better: C++ is a type safe language and casts subvert this behaviour
- we used those casts to eliminate code duplication: the benefits are worth the risk



C and C++ casts

- C style casts, to cast an expression to be of type T:
 - (T) expression
 - T(expression)
- C++ style casts:
 - `const_cast<T>(expression)`
 - `dynamic_cast<T>(expression)`
 - `static_cast<T>(expression)`
 - `reinterpret_cast<T>(expression)`



const_cast

- `const_cast` is used to cast away the constness of an object
- It's the only cast that can do it



static_cast

- `static_cast` forces implicit conversions, such as non-const objects to const objects (as seen in const/non-const methods), int to double, `void*` to typed pointers, pointer-to-base to pointer-to-derived (but no runtime check).
- it's the most useful C++ style cast

```
int j = 41;
```

```
int v = 4;
```

```
float m = j/v; // m = 10
```

```
float d = static_cast<float>(j)/v; // d = 10.25
```

```
BaseClass* a = new DerivedClass();
```

```
static_cast<DerivedClass*>(a)->derivedClassMethod();
```



static_cast - cont.

- Prefer static_cast over C style cast, because we get the type safe conversion of C++:

```
class MyClass : public MyBase {...};
class MyOtherStuff {...} ;
MyBase *pSomething; // filled somewhere
MyClass *pMyObject;
pMyObject = static_cast<MyClass*>(pSomething); // Safe; as
long as we checked
pMyObject = (MyClass*)(pSomething); // Same as static_cast<>
// Safe; as long as we checked but harder to read
MyOtherStuff *pOther;
pOther = static_cast<MyOtherStuff*>(pSomething); // Compiler
error: Can't convert
pOther = (MyOtherStuff*)(pSomething); // No compiler error.
// Same as reinterpret_cast<> and it's wrong!!!
```



const member functions

- Let's review again how to avoid code duplication between const and non-const member functions...
- the non-const method calls the const method and then cast away its constancy with `const_cast`



const member functions - cont.

```
class TextBlock {
public:
    const char& operator[](size_t pos) const {
        //... checks over boundaries, etc.
        //...
        return text[pos];
    }
    char& operator[](size_t pos) {
        return
            const_cast<char&>( // take away constancy
                static_cast<const TextBlock&>(*this)[pos] // add constancy
            );
    }
    //...
};
```



const member functions - cont.

```
class TextBlock {
public:
    const char& operator[](size_t pos) const {
        //... checks over boundaries, etc.
        //...
        return text[pos];
    }
    char& operator[](size_t pos) {
        return
            const_cast<char&>( // take away constancy
                static_cast<const TextBlock&>(*this)[pos] // add constancy
            );
    }
    //...
};
```

First cast to const, to call the const method, then remove const-ness



dynamic_cast

- `dynamic_cast` performs safe (runtime check) downcasting: i.e. determines if an object is of a particular type in an inheritance hierarchy.
 - it has a runtime cost depending on the compiler implementation

```
class Window { //... };  
class SpecialWindow :  
public Window {  
public:  
    void blink();  
};
```

```
Window* pW;  
//...pW may point to whatever object  
// in Window hierarchy  
  
if( SpecialWindow*  
pSW=dynamic_cast<SpecialWindow*>pw )  
    pSW->blink();
```




reinterpret_cast

- `reinterpret_cast` is used for low-level casts, e.g. to perform conversions between unrelated types, like conversion between unrelated pointers and references or conversion between an integer and a pointer.
- It produces a value of a new type that has the same bit pattern as its argument. It is useful to cast pointers of a particular type into a `void*` and subsequently back to the original type.
- may be perilous: we are asking the compiler to trust us...



Credits

- These slides are (heavily) based on the material of:
- Marshall Cline, C++ FAQ Lite
- Scott Meyers, “Effective C++”, 3rd edition, Addison-Wesley