



Programmazione

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Const correctness



What is const correctness ?

- It is a semantic constraint, enforced by the compiler, to avoid modification of a particular object marked as `const`
- `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 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
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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)
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C++ and casting



C++ casting

- 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
 - e.g. `const_cast` can be used to eliminate code duplication: the benefits are worth the risk
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C and C++ casts

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



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();
```



const_cast

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



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`
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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
            );
    }
    //...
};
```

Don't panic: first cast to const, to call the const method, then remove constness



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...
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Reading material

- L.J.Aguilar, “Fondamenti di programmazione in C++. Algoritmi, strutture dati e oggetti” - pp. 84, pp. 125-128
 - D.S. Malik, "Programmazione in C++" - pp. 43-45, 47-48
 - Thinking in C++, 2nd ed. Volume 1, pp. 165-167, 181-186
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Credits

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