

C++ casting, RTTI

- Version 1: Dr. Ofir Pele
- Version 2: Dr. Miri Ben-Nissan
- Version 3: Dr. Erel Segal-Halevi

C style casting:

- `double d = 3.0;`
`int i = (int) d;`
- `const int *cP = &i;`
`int *ncP = (int*)cp;`
- `double * dP = (double*)ncp;`
- `Shape *s1 = new Circle;`
`Shape *s2 = new Shape;`
`Circle *s1c = (Circle*) s1; s1c->setrad(1);`
`Circle *s2c = (Circle*) s2; s2c->setrad(1);`

C++ style casting

- `const_cast<type>(expression)`
- `reinterpret_cast<type>(expression)`
- `static_cast<type>(expression)`
- `dynamic_cast<type>(expression)`

The 'const_cast' operator

```
const_cast<type>(expression)
```

Is used to remove const-ness:

```
void g(C* cp); // programmer forgot "const"
void f(C const* cp)
{
    g(const_cast<C *>(cp));
}
```

- Usually, you should design your variables/methods such that you won't have to use `const_cast`.
- Compile time operator
- Can cause serious trouble

'reinterpret_cast' operator

```
reinterpret_cast<type>(expression)
```

- Reinterpret byte patterns.
- Circumvents type checking.
- Implementation-dependent.
- (Should be) used rarely.
- Very dangerous! (folder 4).
- Usage example: writing an image file (folder 5).

'reinterpret_cast' operator

```
reinterpret_cast<type>(expression)
```

The 'static_cast' operator (folder 4)

```
static_cast<type>(expression)
```

When conversion method is known during compilation:

- double→int, int→double, etc.
- Conversion operator / conversion constructor.
- up-cast – Circle→Shape, Circle*→Shape*.

Safer than “old-style” casts

- e.g. won't cast int* to float*

Failure causes a compiler error

- No dynamic checking is done

static_cast vs reinterpret_cast

reinterpret_cast does not do anything at runtime.

static_cast does at runtime a conversion determined at compile time.

Copy&paste into godbolt.org to see.

```
int main() {  
    int i = 5;  
    double d;  
    d = (double)i;  
    d =  
    static_cast<double>(i);  
    int& ir = i;  
    double& dr0 =  
    (double&)ir;  
    double& dr =  
    reinterpret_cast<double&>(ir);  
}
```


Run Time Type Information (RTTI)

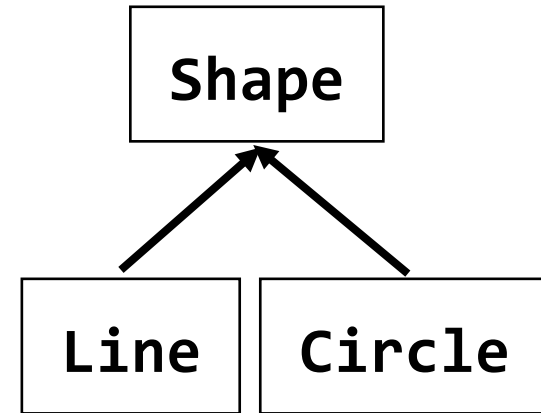
Run Time Type Information (RTTI) – why?

Problem:

Up-casting works fine.

- Treating sub-class as base class:

```
Shape * s = new Circle();
```



What about **down-casting**?

- might not be safe!
- correctness cannot be determined by the compiler.

```
Circle * c = (Circle*) s;
```

RTTI

RTTI – Run Time Type Information

Mechanisms for RTTI:

1. `dynamic_cast` operator
2. `typeid` operator (and `type_info` class)

The 'dynamic_cast' operator

```
dynamic_cast<T>(expression)
```

Enables run-time type checking:

When expression is a **pointer**:

- Returns a valid pointer if expression really points to type T
- null pointer value otherwise

The 'dynamic_cast' operator

```
dynamic_cast<T>(expression)
```

Enables run-time type checking:

When expression is a **reference**:

- Returns a valid reference if expression is really of type T
- Throws an exception when it fails ("bad_cast")

dynamic_cast : example

```
Shape* s = container.pop();  
Circle* c = dynamic_cast<Circle*>(s);  
if (c != nullptr) { // c is a circle  
    c->setRadius(42);  
} else {  
    ...  
}
```

dynamic_cast - more

`dynamic_cast<T>(expression)`

Note:

- Used only on **pointer** or **reference** types.
- Can be used for:
 - **up-cast** – useless – done automatically.
 - **down-cast** – most useful.
 - **cross-cast** – useful with multiple inheritance.
- **Only for types with virtual-functions** (“Polymorphic types”) - These object have a space for information about type: the virtual function table.

dynamic_cast: only for polymorphics

```
class Circle : public Shape
{
    virtual void draw();
}
class Date : public Time
{
    // Time has no virtual functions
}
void foo(Shape * s, Time * t)
{
    Circle * c =
        dynamic_cast<Circle*>( s ); //ok
    Date * date =
        dynamic_cast<Date*>( t ); //compilation error
}
```


RTTI : typeid operator

RTTI : typeid operator (folder 6)

▮ Obtains info about an object/expression

usage: `typeid(obj)` (like “`sizeof`”)

Example:

```
Dog d;
```

```
Cat c;
```

```
cout << "d is a " << typeid(d).name()  
      << ", c is a " << typeid(c).name()
```

```
<<endl;
```

Output (might be):

d is a Dog, c is a Cat

RTTI : typeid operator

▮ Obtains info about an object/expression

usage: `typeid(obj)` (like “`sizeof`”)

Example:

```
Dog d;
```

```
Cat c;
```

```
cout << "d is a " << typeid(d).name()  
      << ", c is a " << typeid(c).name()  
      << endl;
```

Output (because it does not have to be the name of the type that the programmer used, it might also be):

d is a 3Dog, c is a 3Cat

RTTI misuse

```
void rotate( shape const& s )
{
    if (typeid(s) == typeid(Circle) )
        //do nothing
    else if (typeid(s) == typeid(Triangle) )
        //rotate Triangle
    else if (typeid(s) == typeid(Rectangle) )
        //rotate Rectangle
}
```

- Use virtual functions when you can !
- Use RTTI only you cannot use virtual functions (e.g. the source code of Shape is unavailable).

Cast comparison

| | Compile-time | Run-time |
|-------------------------------|---|------------------|
| <code>const_cast</code> | Check that source, target are the same except const | nothing |
| <code>reinterpret_cast</code> | Check that source, target are pointers / refs | nothing |
| <code>static_cast</code> | Check that there is a conversion source → target | Fixed conversion |
| <code>dynamic_cast</code> | Check that the class is polymorphic | Expensive check |