

Implementing Factory builder on top of P2320

April 8, 2021

The goal

(Semi-)automate the implementation
of the
Factory design pattern

What is meant by “Factory” here?

- Class that constructs instances of a “Product” type.
- From some external representation:
 - XML,
 - JSON,
 - YAML,
 - a GUI,
 - a scripting language,
 - a relational database,
 - ...

Factory builder

- Framework combining the following parts
 - Meta-data
 - obtained from reflection.
 - Traits
 - units of code that handle various stages of construction,
 - specific to a particular external representation,
 - provided by user.

Factory builder

● Used meta-data

- type name strings,
- list of meta-objects reflecting constructors,
- list of meta-objects reflecting constructor parameters,
- parameter type,
- parameter name,
- . . .

Factory builder

- Units handling the stages of construction
 - selecting the “best” constructor,
 - invoking the selected constructor,
 - conversion of parameter values from the external representation,
 - may recursively use factories for composite parameter types.

Used reflection features

- `^T`
- `[: :]1`
- `meta::name_of`
- `meta::type_of`
- `meta::members_of`
- `meta::is_constructor`
- `meta::is_default_constructor`
- `meta::is_move_constructor`
- `meta::is_copy_constructor`
- `meta::parameters_of`
- `size(Range)`
- range iterators

¹to get back the reflected type

Reflection review

- The good²
 - How extensive and powerful the API is
- The bad
 - Didn't find much³
- The ugly
 - Some of the syntax⁴

²great actually!

³some details follow

⁴but then this is a matter of personal preference

What is missing

- The ability easily to unpack meta-objects from a range into a template, without un-reflecting them.
- I used the following workaround + `make_index_sequence`:

```
template <typename Iterator>
constexpr auto advance(Iterator it, size_t n) {
    while(n-- > 0) {
        ++it;
    }
    return it;
}
```

- Details follow...

Metaobject range unpacking

The goal is to unpack a metaobject range into a template like this:

```
template <meta::info... MO>
struct unpacked_range {
    constexpr static auto count = sizeof...(MO);
    // etc.
};
```

Metaobject range unpacking (cont.)

Unlike `meta::info` the `detail::range` type is not part of the public API, passing ranges as template parameters is not straightforward.

So we are using this helper function, which makes the whole thing less generic.

```
template <meta::info M0>
constexpr auto constructors_of() {
    return meta::members_of(M0, meta::is_constructor);
}
```

Metaobject range unpacking (cont.)

A helper:

```
template <meta::info M0, size_t... I>
constexpr auto do_unpack_range(index_sequence<I...>) {
    return unpacked_range<*advance(
        constructors_of<M0>().begin(),
        I)...>{};
}
```

The unpack function:

```
template <meta::info M0>
constexpr auto unpack_range() {
    return do_unpack_range<M0>(
        make_index_sequence<
            size(constructors_of<M0>())
        >{});
}
```

Metaobject range unpacking – use case

```
template <meta::info>
class my_base;

template <typename Metaobjects>
class my_derived;
```

```
template <meta::info ... MO>
class my_derived<unpacked_range<MO...>>
: public my_base<MO>... {
    // ...
};
```

Make ranges a “thing”

- It would be great if the ranges were:
 - either `meta::info` themselves or
 - had some public type like `meta::range`

Make ranges a “thing” (cont.)

Instead of:

```
template <typename Range>  
class my_class;
```

either

```
template <meta::info Range>  
class my_class;
```

or

```
template <meta::range Range>  
class my_class;
```

But generally,

kudos to the implementers!

Some details on the factory builder follow⁵

⁵it there's interest

The mirror reflection utilities

- <https://github.com/matus-chochlik/mirror>
- implements the factory builder framework and some traits:
 - simple input from `iostreams`,
 - input from JSON (using RapidJSON),
 - input from a GUI (using Qt5/QML),
 - others are planned.
- plans for some additional use-cases:
 - serialization/de-serialization,
 - Python bindings,
 - ...
- There is an older implementation using manually-provided meta-data: <https://sourceforge.net/projects/mirror-lib/>

Factory builder – test classes

```
class point {  
public:  
    point() noexcept = default;  
  
    point(float v) noexcept  
        : _x{v} , _y{v} , _z{v} {}  
  
    point(float x, float y, float z) noexcept  
        : _x{x} , _y{y} , _z{z} {}  
  
    // ...  
private:  
    float _x{0.F};  
    float _y{0.F};  
    float _z{0.F};  
};
```

Factory builder – test classes

```
class triangle {  
public:  
    triangle() noexcept = default;  
  
    triangle(point a, point b, point c)  
        : _a{a}  
        , _b{b}  
        , _c{c} {}  
  
    // ...  
private:  
    point _a;  
    point _b;  
    point _c;  
};
```

Factory builder – test classes

```
class tetrahedron {  
public:  
    tetrahedron() noexcept = default;  
    tetrahedron(const triangle& base, const point& apex)  
        : _base{base}  
        , _apex{apex} {}  
  
    // ...  
private:  
    triangle _base;  
    point _apex;  
};
```

Factory builder – JSON input

```
{
  "base": {
    "a": {
      "x": 2.0,
      "y": 0.0,
      "z": 0.0
    },
    "b": {
      "x": 0.0,
      "y": 1.0,
      "z": 0.0
    },
    "c": {
      "x": 0.0,
      "y": 0.0,
      "z": 1.0
    }
  },
  "apex": {
    "v": 0.0
  }
}
```

Factory builder – JSON factory, usage

Working example⁶:

```
void print_info(const test::tetrahedron&);  
const auto json_str = ...;  
  
rapidjson::Document json_doc;  
const rapidjson::ParseResult parse_result{  
    json_doc.Parse(json_str)};  
  
if(parse_result) {  
    using namespace mirror;  
    factory_builder<rapidjson_factory_traits> builder;  
    auto factory = builder.build<test::tetrahedron>();  
    print_info(factory.construct({json_doc}));  
  
}
```

⁶<https://github.com/matus-chochlik/mirror/blob/develop/example/factory/rapidjson.cpp>