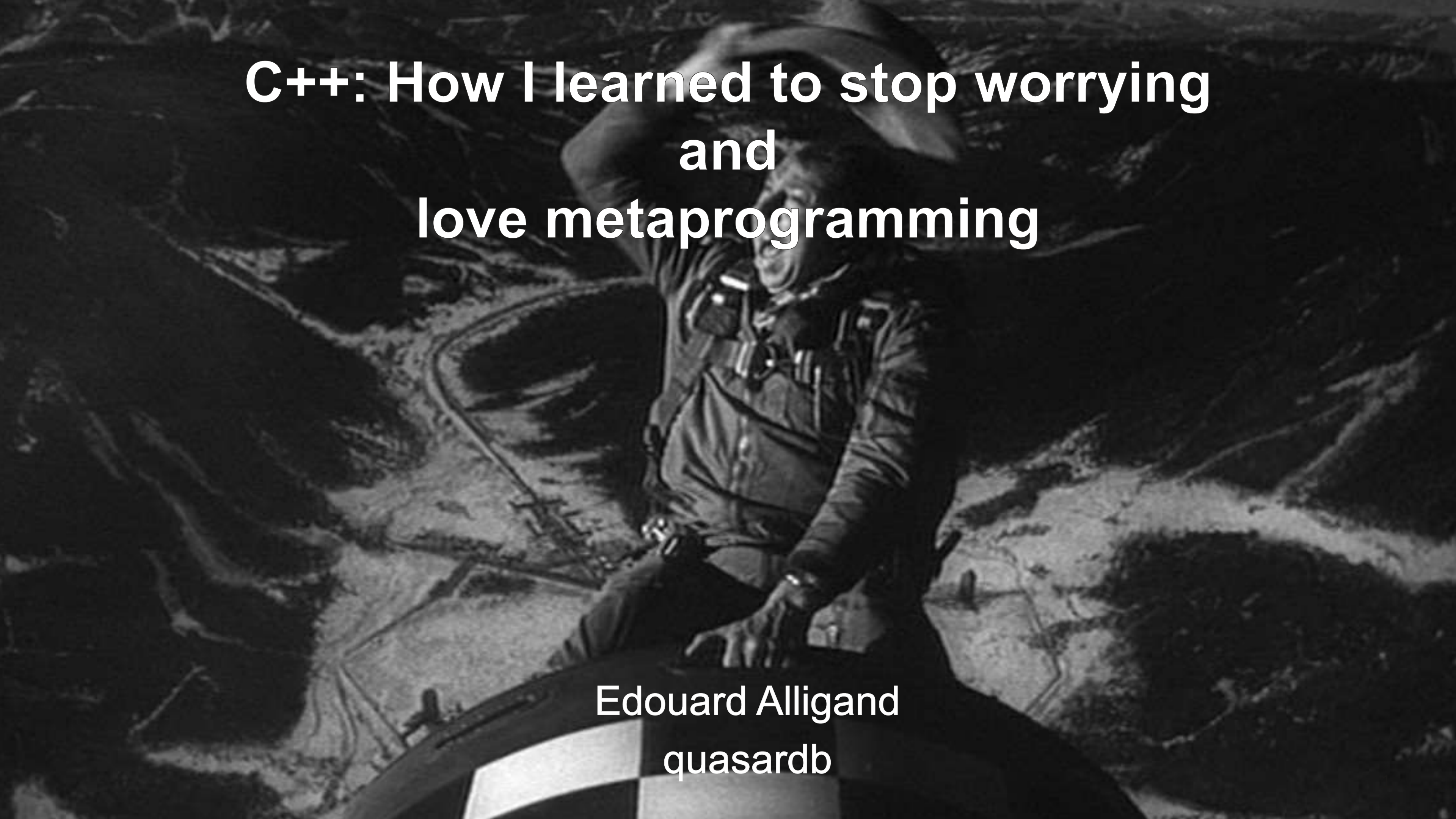

C++: How I learned to stop worrying and love metaprogramming

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quasardb

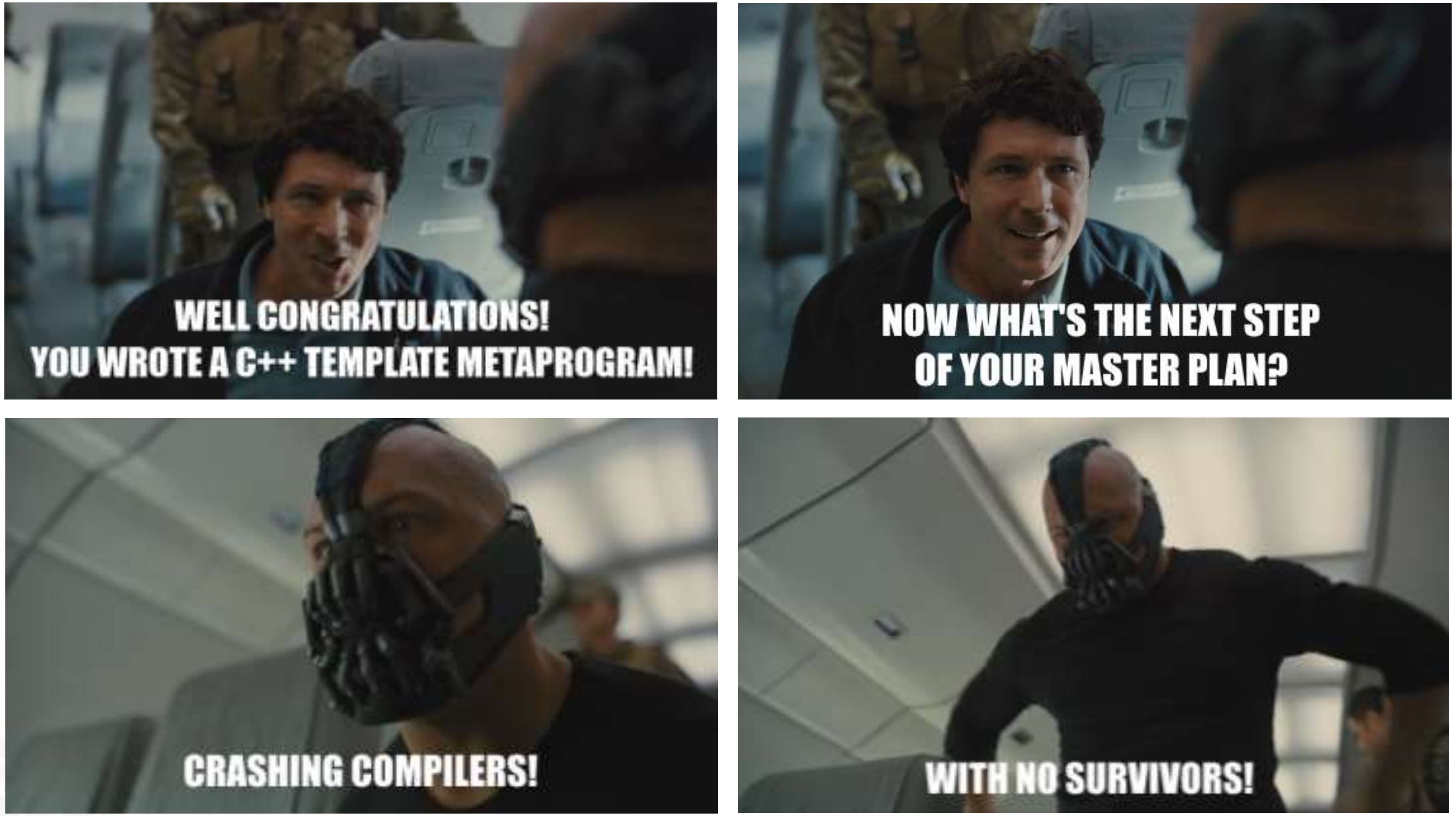
Metaprogramming

How I got into C++ metaprogramming

My first C++ metaprogram, ever

```
int main(int argc, char ** argv)
{
        static_assert(sizeof(int) == 4, “I want 32-bit integers!”);
        static_assert(LITTLE_ENDIAN, “I want little Endian!”);
}
```

Life of a C++ metaprogrammer


WELL CONGRATULATIONS! YOU WROTE A C++ TEMPLATE METAPROGRAM!
NOW WHAT'S THE NEXT STEP OF YOUR MASTER PLAN?
CRASHING COMPILERS!
WITH NO SURVIVORS!

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What we use metaprogramming for

- Checks
- Constant generation
- Parser generator
- Protocol generation
- Serializer generator

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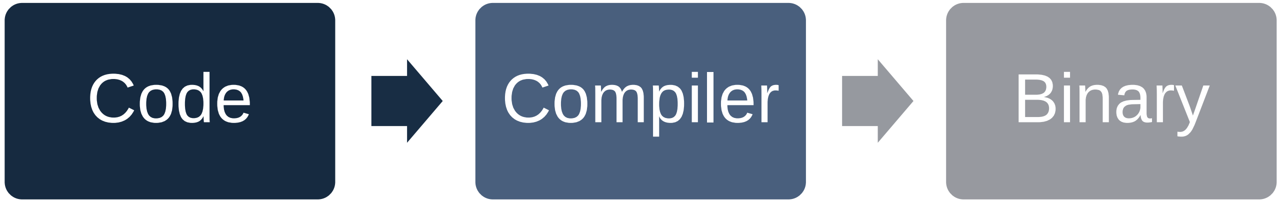
BUT IT IS HARD/IMPOSSIBLE/ILLEGAL/DANGEROUS AND MY DOG ATE MY HOMEWORK

Top 5 reasons to not do template-metaprogramming

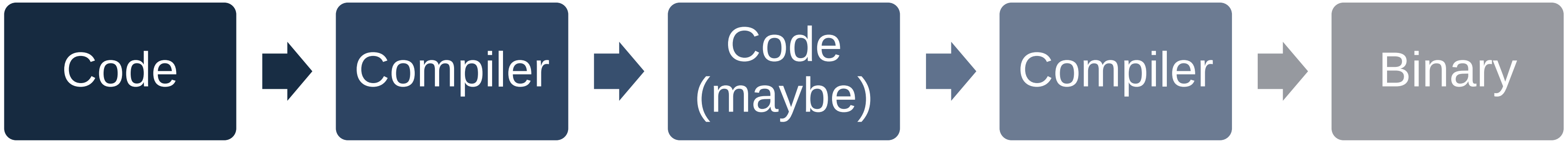
1. **Compilation time**
2. **Code complexity**
3. **Compiler support**
4. **Skills**
5. **Non-rational reasons**

But, what is metaprogramming, really?

Programming



Metaprogramming



Why we do it

Have the compiler generate the correct program for you

- It knows things you don’t
- It will not be afraid to do tedious work
- It makes less mistakes than you
- Why write code when you could be playing Baldur’s Gate 2 for the 10th time?

Also: it’s awesome

A gentle introduction

Brigand – A C++ 11 metaprogramming library

A **brigand** is a person who usually lives in a gang and lives by pillage and robbery.

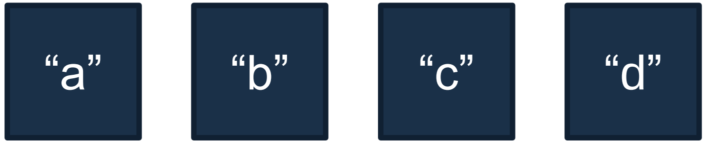
A lightweight C++ 11 meta-programming library

https://github.com/edouarda/brigand

Lightning talk Tuesday 23rd

List vs list

char my_list[4] = { ‘a’, ‘b’, ‘c’, ‘d’};



brigand::list<char, int, bool, int>;

∅

Why a collection of types?

```
using allowed_types = brigand::set<char, int, bool>;

template <typename T>
void my_func(T t)
{
    static_assert(brigand::contains<allowed_types, T>::value,
            “Ты делаешь это не правильно, чувак”);
}
```

Checking types, again

```
#include <type_traits>


template <typename T>
T factorial(T v)
{
        using threshold = std::integral_constant<T, 1>;
        static_assert(std::is_integral<T>::value, "I need an integral type");
        return (v <= threshold::value) ? v : (v * factorial(v - 1));
}
```

On the usefulness of compile-time computations

Why write

```
static const long magic = 120; // magic value is 5!
```

Which one year later will be

```
static const long magic = 720; // magic value is 5!
```

On the usefulness of compile-time computations

When you can write

```
static const long magic = factorial<5>::value;
```

Which one year later will be

```
static const long magic = factorial<6>::value;
```

A real metaprogram: compile time factorial

```
#include <type_traits>

template <long v>
struct factorial :
    std::integral_constant<long,
                           v * factorial<v - 1>::value> {};

template <>
struct factorial<0> : std::integral_constant<long, 1> {};
```

Last element of a list

```
template <class… R> struct last_element;

template <class T>
struct last_element<T> { using type = T; };

template <class T, class… R>
struct last_element<T, R…>
{
    using type = typename last_element<R…>::type;
};
```

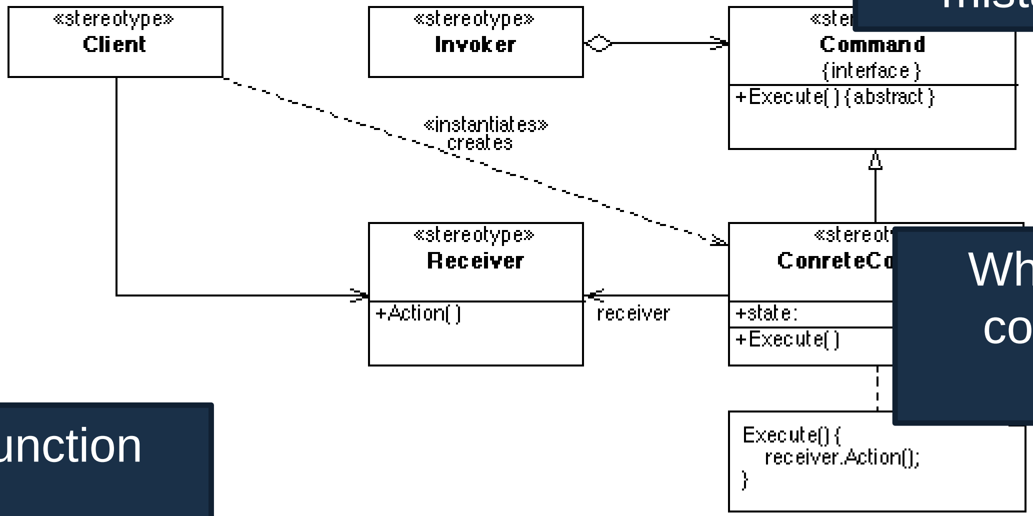
Top 5 game changers

1. Variadic templates
2. Decltype
3. Alias templates
4. Better type traits
5. Improved compilers

A “*useful*” metaprogram*

**may not be useful at all*

The command pattern



Compiler let many mistakes « pass »

Why should the commands be related?

pure virtual function call?

How can I list commands?

The command pattern, revisited

```
struct do_this { void execute(); std::string help() const; };
struct do_that { void execute(); std::string help() const; };

// you could create categories without changing the commands
using commands_list = brigand::list<do_this, do_that>;

// you might want to put them in a variant
using command = brigand::as_variant<commands_list>::value;
```

Execute a command

```
template <typename Command>
void execute(Command & cmd)
{
    static_assert(brigand::contains<commands_list, Command>::value,
        "you forgot to add the command in the list");

    cmd.execute();
}
```

Print help of all commands

```
struct help_caller
{
  template <typename U>
  void operator()(const brigand::type_<U> & u)
  {
      u.help();
  }
};

brigand::for_each(commands_list, help_caller);
```

C++ Metaprogramming : Awesomeness overflow time

Also: typename.

Wouldn’t it be cool to...

```
struct my_struct
{
    int alpha;
    std::string omega;
};
```

```
{
  "my_struct" :
  {
      "alpha": 2,
      "omega": "boom"
   }
}
```

```
my_struct blah = { 2, ”boom” };
auto boom = json::generate(json::from_fusion(blah));
```

Introducing Boost.Fusion

```
BOOST_FUSION_ADAPT_STRUCT(my_struct, (int, alpha)(std::string, omega))
```

- **Compile time introspection**
- **Bridge between compile time and runtime**

Example, set of various types:

```
    boost::fusion::set<struct1, struct2> blah;
    boost::fusion::at_key<struct1>(blah);
```

”Perfect” serialization

Goals

- Fast
  - Generate highly optimized code
  - No ”if mess”
- Frugal
  - Allocate memory only if needed
- Correct
  - Code is generated, not written
- Convenient
  - Unintrusive

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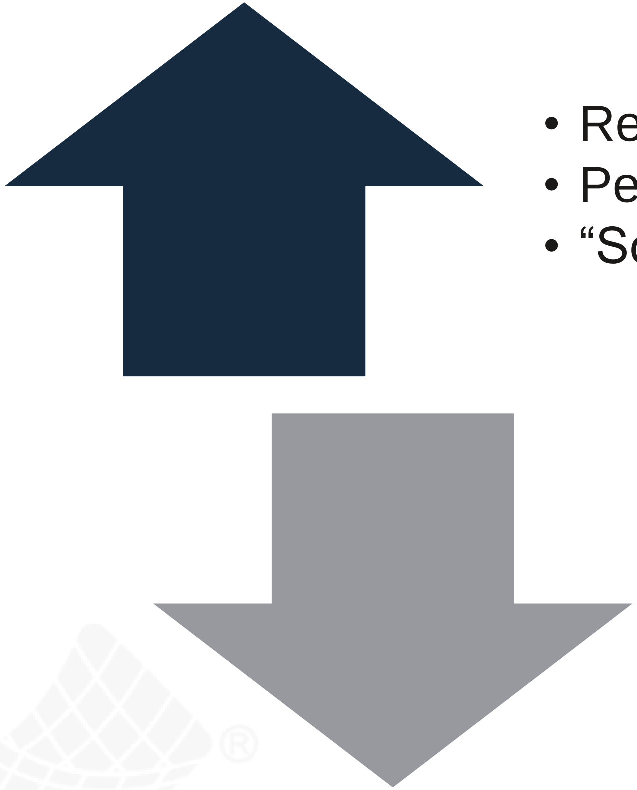
“LEFT AS AN EXERCISE TO THE READER”

Conclusion

When and why



- Reliability
- Performance
- “Scalability”

- Needs a modern toolchain
- Time investment
- Complexity trap

Tips to get started

C++ 11	Compiles faster
	Better libraries – like Brigand ☺
	More flexibility
Meta != complex	Start with simple checks – it’s safe!
	Move to the next level when you don’t event think about it anymore
	Metaprograms must be maintained like normal programs!

The Metaprogrammer toolbox

- Clang 3.5+
- <type_traits>
- <tuples>
- Boost.MPL
- Boost.Fusion
- Boost.Hana
- Brigand – https://github.com/edouarda/brigand/

MY[illegible] METAP[illegible]OGRAMM[illegible]G IS [illegible]ELESS

Thank you!

Questions & Answers