New standards to the rescue: the view through an IDE’s glasses

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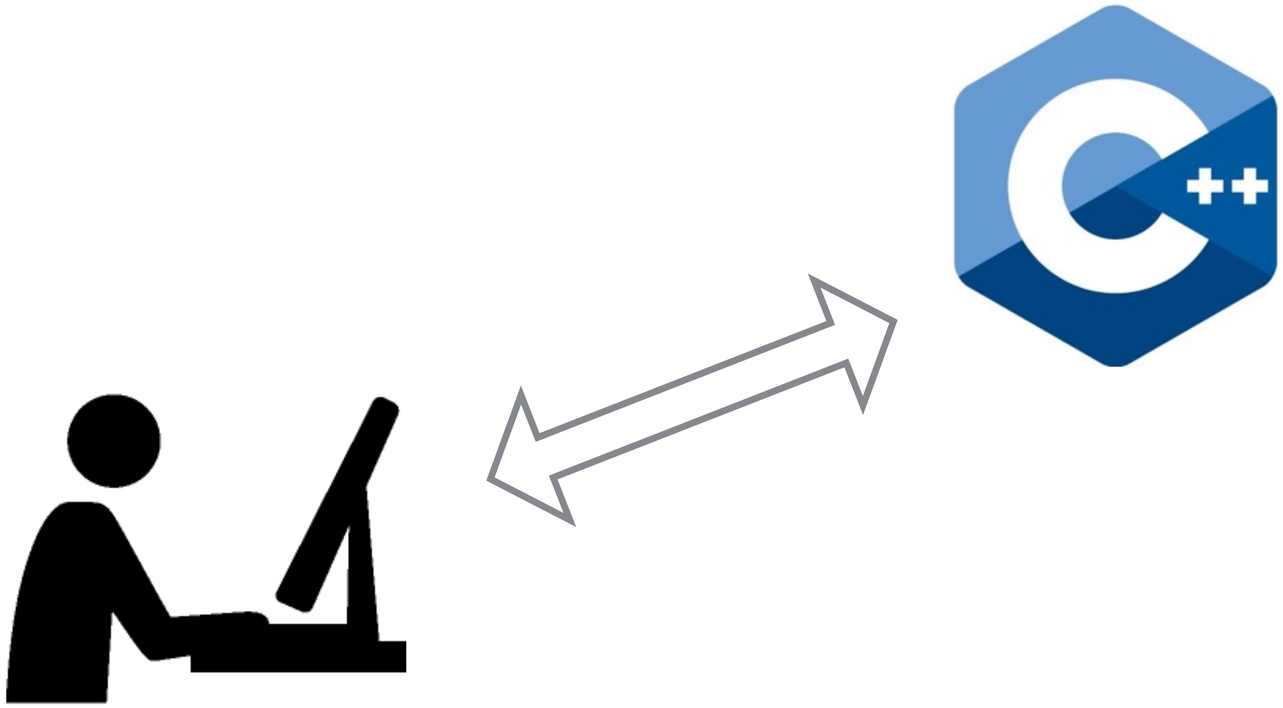
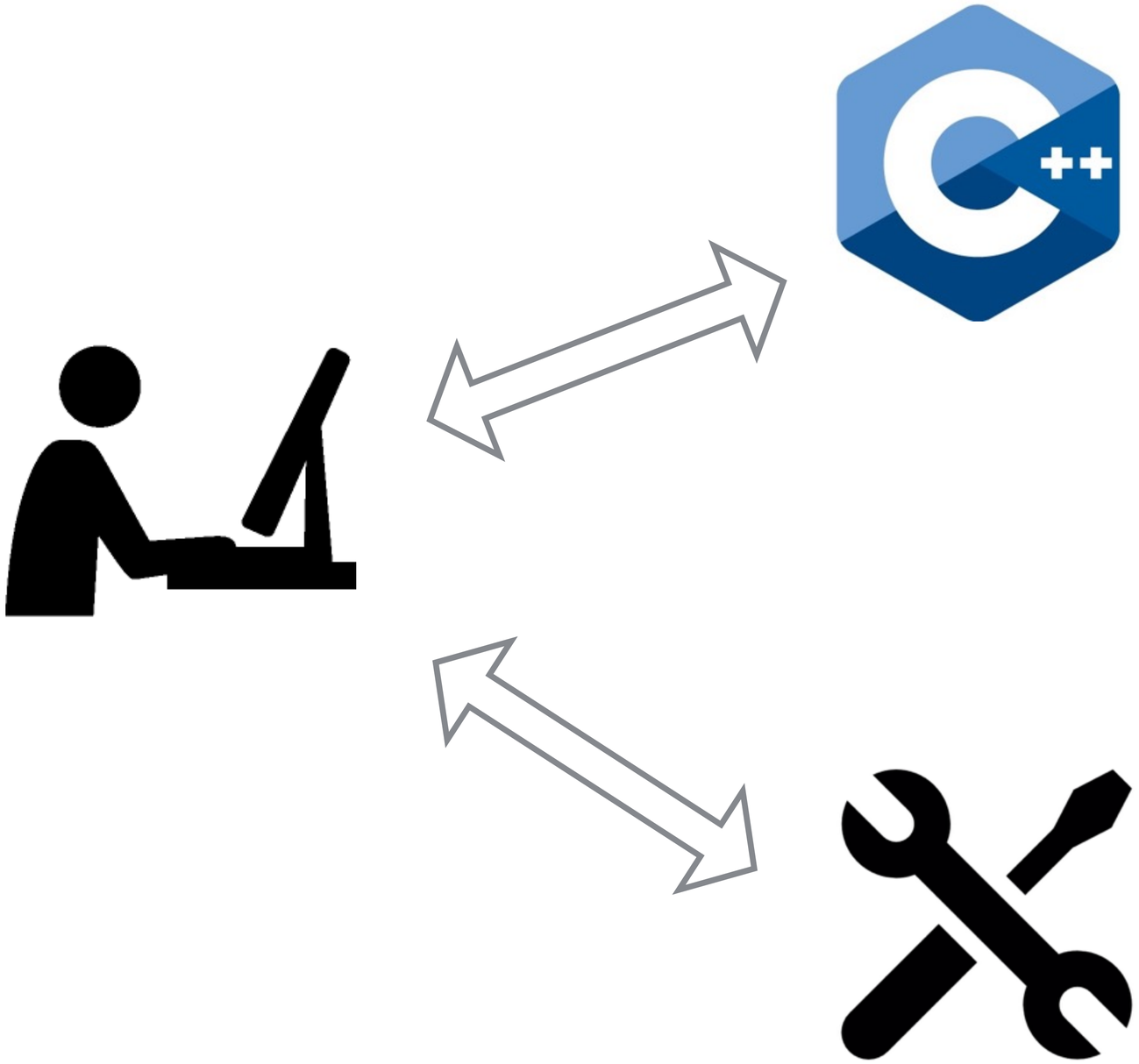
Perspective

Perspective



Perspective



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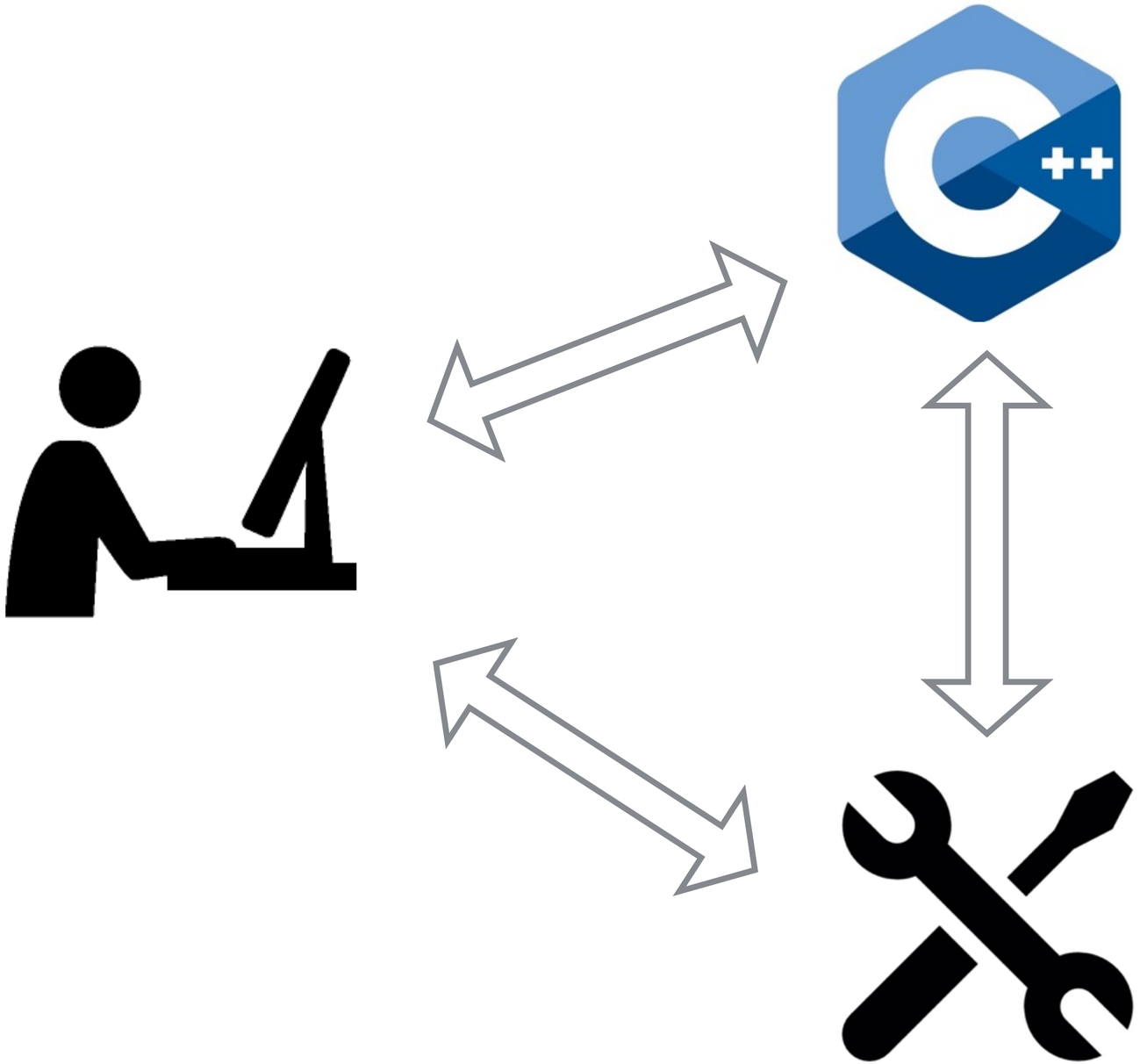

What this talk is about?

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- Where are we now with C++? Our C++ reality
- How do we (IDEs) cope?
- View on the language, hopes for the future

IDE: Expectation

—

- *Correctness*: 100% correct in terms of the language
- *Performance*: provides completion before I’m tired of waiting for it
- *Smartness*: more on-the-fly intellisense
- *Universal*: knows about the whole project
- *Helpful*: can work with the incorrect code
- *Swiss army knife*: other tools on board

IDE: Balance

- Correctness: 100% correct in terms of the language
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- Universal: knows about the whole project
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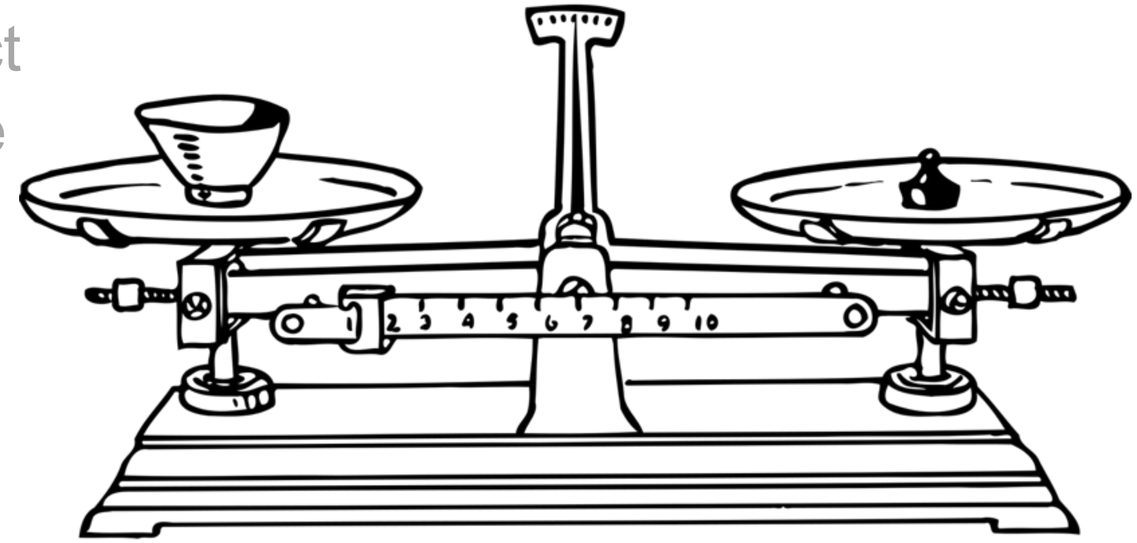
- Swiss army knife: other tools on board

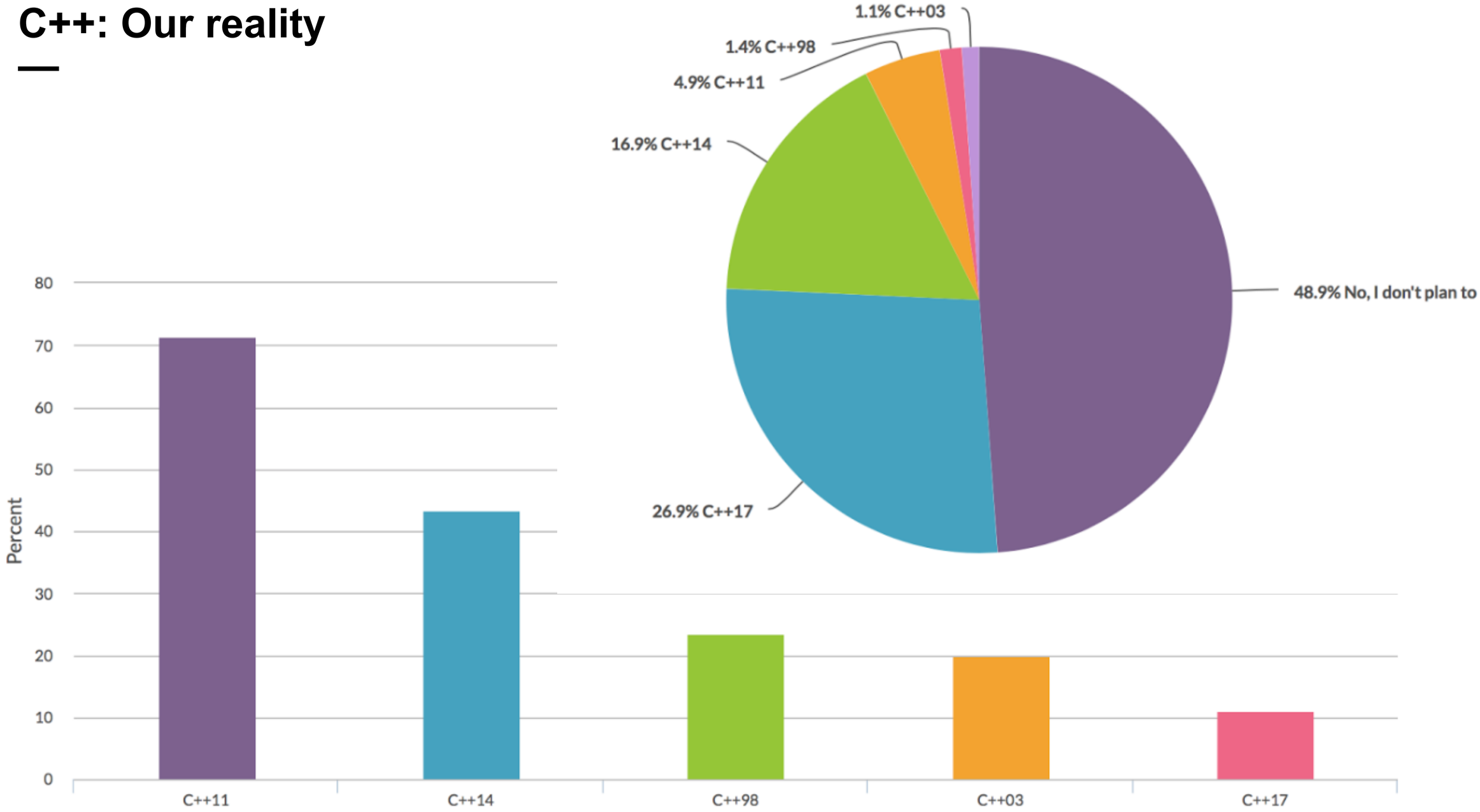


C++: Our reality

—

- IDE works with any code
  - Legacy code, decades of language baggage
  - Modern standards, drafts, TS, etc.
  - Legacy code and modern code co-exist
  - Incorrect code

C++: Our reality



C++ game

Are they different?

C++ game

```
template<int>
struct x {
    x(int i) { }
};

void test(int y) {

    const int a = 100;

    auto k = x<a>(0);
    auto l = y<a>(0);
}
```

C++ game

```
template<int>
struct x {
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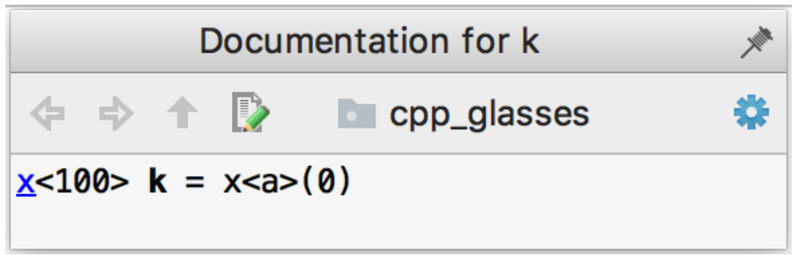
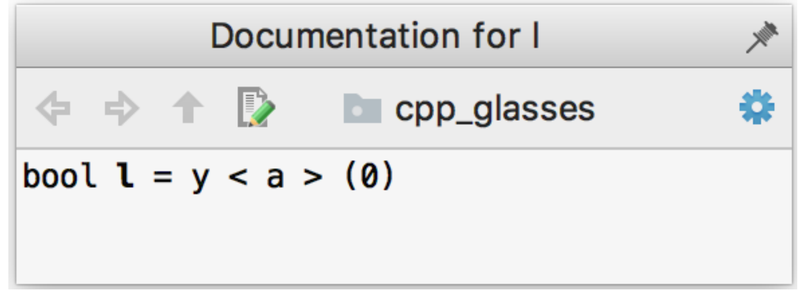


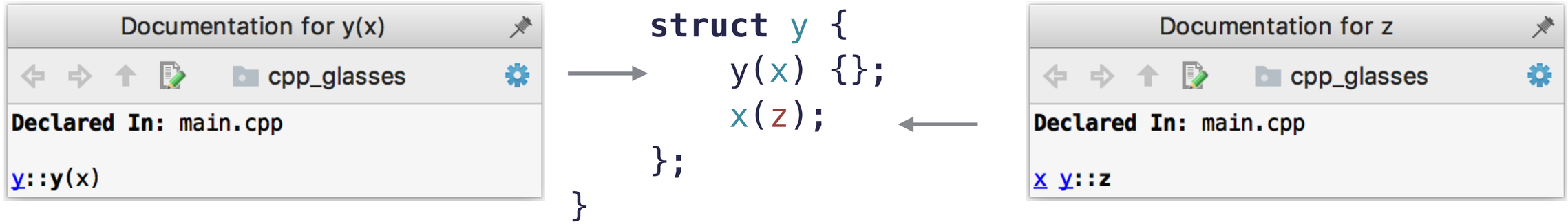


C++ game

```
void test() {
    struct x {
    };

    struct y {
        y(x) {};
        x(z);
    };
}
```

C++ game


Documentation for y(x)
cpp_glasses
Declared In: main.cpp
y::y(x)
void test() {
struct x {
};
struct y {
y(x) {};
x(z);
};
}
Documentation for z
cpp_glasses
Declared In: main.cpp
x y::z

C++ game

```
void test() {
    struct x {
        x(int) { };
    };

    int y = 100;

    auto a = (x)-5;
    auto b = (y)-5;
}
```

C++ game

```
void test() {
    struct x {
        x(int) { };
    };

    int y = 100;

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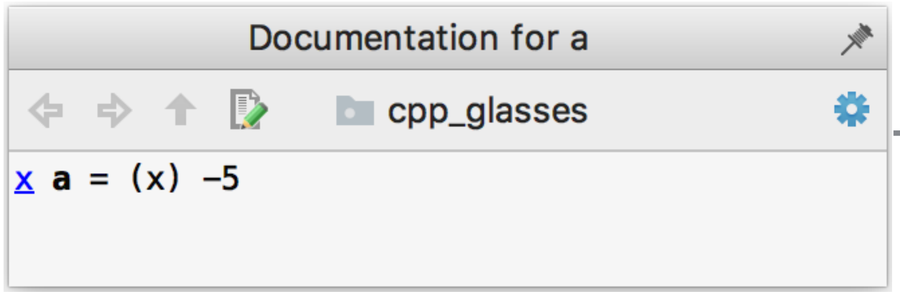

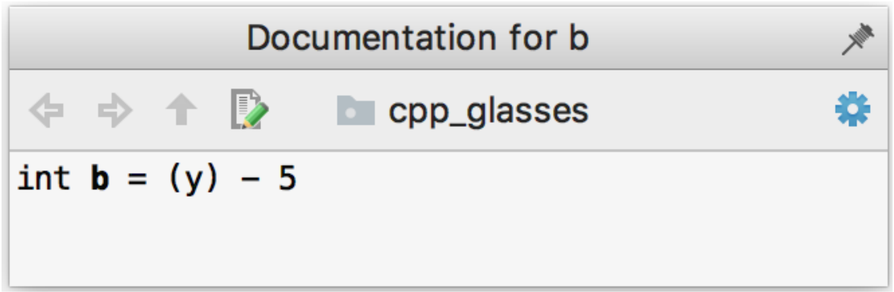

C++ game

```
int(x), y, *z;
int(x), y, new int;
```

C++ game

```
int(x), y, *z;
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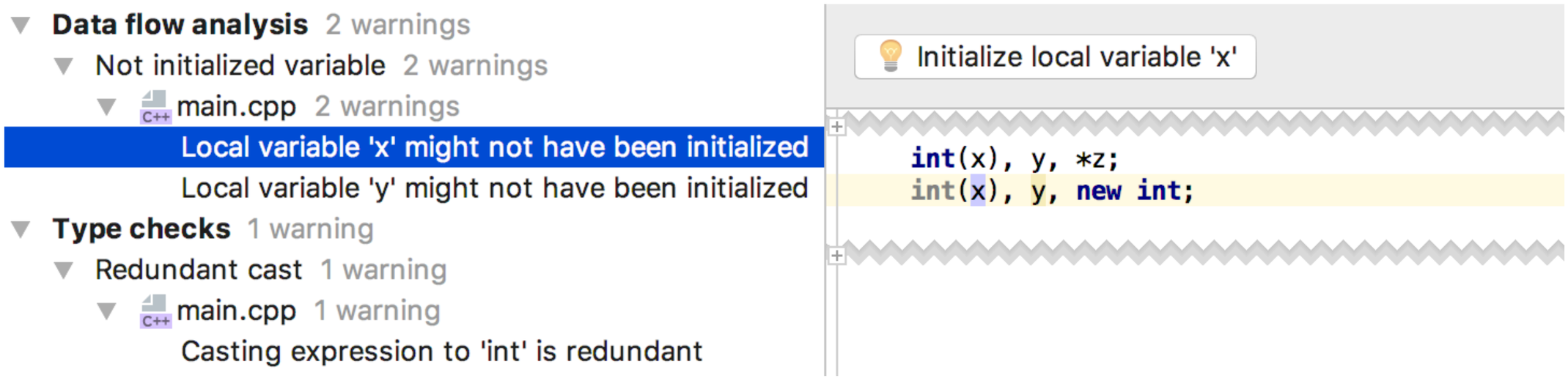

Parsing and resolving C++

To parse C++
we need to distinguish
types** from **non-types

What affects the resolve?

Resolve depends on:

- order of the definitions

```
void test1() {
    fun();
}

int fun();

void test2() {
    fun();
}
```

What affects the resolve?

Resolve depends on:

- order of the definitions
- default arguments

```
int fun(int);

void test1() {
    fun(); //Too few arguments
}

int fun(int = 0);

void test2() {
    fun();
}
```

What affects the resolve?

Resolve depends on:

- order of the definitions
- default arguments
- overload resolution

```
int fun(int (&arr)[3]);

struct c {
    static int arr[];
};

void test1() {
    fun(c::arr);
//no matching function for call to 'fun'
}

int c::arr[] = {0, 1, 2};

void test2() {
    fun(c::arr);
}
```

Consequences in IDE

IDE needs parsing/resolve for:

- highlighting
- code completion
- code generation
- navigation
- find usages
- refactoring
- code analysis

Example: code highlighting

Could we highlight with the lexer?

```
//-std=c++03, clang 4.0
template<typename T> struct S{};

void foo() {
    S<S<int>> t; //error: a space is
required between consecutive right angle
brackets (use '> >')
}
```

Example: code highlighting

Could we highlight with the lexer?

```
template<typename T> struct S{};

void foo() {
    S<S<int>> t;
}
```

Example: code highlighting

Could we highlight with the lexer?

```
#define X(T) T ## T

void foo() {
    int X(public);
}
```

How do we cope

- Game of parsers
  - heuristics
  - fuzzy parsers
  - several parsers at a time
  - clang

How do we cope

—

- Game of parsers
  - heuristics
  - fuzzy parsers
  - several parsers at a time

- Optimizations in parser:
  - Deferred resolve
  - Global includes
  - Local reparse
  - Global reparse

View on C++

1. if constexpr
2. Concepts
3. Modules
4. Contracts
5. Reflection
6. Metaclasses
7. Modernize tools

If constexpr

```
// with SFINAE and enable_if
template <typename T, std::enable_if_t<std::is_pointer<T>{}>* = nullptr>
auto get_value(T t) {
    return *t;
}

template <typename T, std::enable_if_t<!std::is_pointer<T>{}>* = nullptr>
auto get_value(T t) {
    return t;
}
```

If constexpr

```
// with If constexpr
template <typename T>
auto get_value(T t) {
    if constexpr (std::is_pointer_v<T>) return *t;
    else return t;
}
```

Concepts

Templates with proper interface – Concepts!

- clear semantic
- IDE analysis
- IDE performance improvement
- intellisense in templates

```
template<typename T> concept bool C =
    requires (T a, T b) {
      { a == b } -> bool;
    };
```

```
template <typename T> concept bool C =
    requires (T t) {
        {t.foo()} noexcept -> int;
    };
```

Includes?

- header files provide information to parser
- they are affected by the context
- no information about what is included
- takes most of the time
- same headers are included in multiple TU

```
//foo.h
#ifdef MAGIC
template<int>
struct x {
    x(int i) { }
};
#else
int x = 100;
#endif

//foo.cpp
#include "foo.h"
void test(int y) {

    const int a = 100;

    auto k = x<a>(0);
    auto l = y<a>(0);
}
```

Modules!

- interface is clear
- postponed parsing
- less context dependent

```
//my_module.ixx
module My;

export
int my_shiny_fun(int x) {
…
}

//usage.cpp
int main() {
    my_shiny_fun(10);
}
```

Contracts

- on-the-fly code analysis

```
void foo(int* p)
[[expects: p != nullptr]]
{
    int x = *p;
    //…
}

int area(int height, int width)
{
    auto res = height * width;
    [[ensures: res > 0]]
    return res;
}
```

Reflection

- Introspection

```
PersonData p = {31, 1234567, "Anastasia Kazakova"};

std::cout << "Person identifications comes with " <<
boost::pfr::tuple_size<PersonData>::value << " parameters. " << std::endl;
std::cout << boost::pfr::get<2>(p) << " is " << boost::pfr::get<0>(p) << std::endl;
```

Reflection

- Introspection
- Code generation

Metaclasses

```
$class interface {
    constexpr {
        compiler.require($interface.variables().empty(),
                         "interfaces may not contain data");
        for... (auto f : $interface.functions()) {
            compiler.require(!f.is_copy() && !f.is_move(),
                "interfaces may not copy or move; consider a"
                " virtual clone() instead");
            if (!f.has_access()) f.make_public();
            compiler.require(f.is_public(),
                "interface functions must be public");
            f.make_pure_virtual();
        }
    }
    virtual ~interface() noexcept { }
};
```

```
interface Shape {
    int area() const;
    void scale_by(double factor);
};
```

```
struct Shape {
    virtual int area() const = 0;
    virtual void scale_by(double factor) = 0;
    virtual ~Shape() noexcept {
    }
}
```

Metaclasses

- One way
  - allow all methods
  - treat metaclasses definitions as text
- Better way
  - check conditions
  - parse metaclass definition
  - complete metaclasses in hierarchical definitions
  - etc.

Modernize tools

- C++ Core Guidelines support
- Clang-Tidy
- Any other

Modernize tools

modernize.cpp

```
#include <functional>
#include <vector>
#include <iostream>

int add(int x, int y) { return x + y; }

void bind_to_lambda(int num) {
    int x = 2;
    auto clj = std::bind(add, x, num);
}

void loop_convert(const std::vector<int>& vec) {
    for(auto iter = vec.begin(); iter != vec.end(); ++iter) {
        std::cout << *iter;
    }
}

class MyClass {
public:
    MyClass(const std::string &Copied,
            const std::string &ReadOnly)
            : Copied(Copied), ReadOnly(ReadOnly) {}

private:
    std::string Copied;
    const std::string &ReadOnly;
};

```

References

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Thank you
for your attention
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Questions?