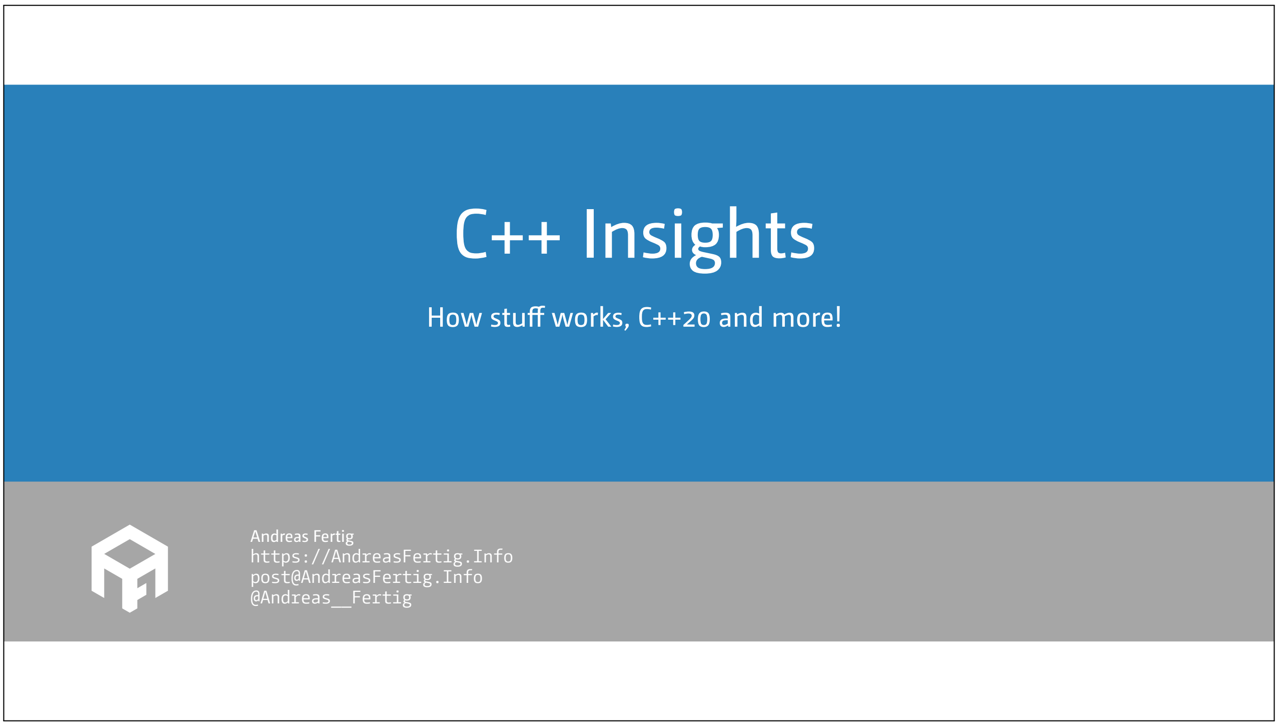

C++ Insights

How stuff works, C++20 and more!

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@Andreas__Fertig

fertig

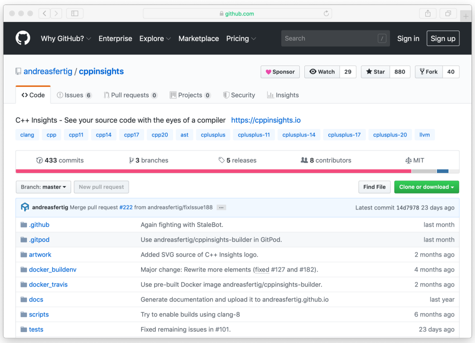
adjective /ˈfɛrtɪç/

finished
ready
complete
completed

C++ Insights

- Show what is going on.
- Make invisible things visible to assist in teaching.
- Create valid code.
- Create code that compiles.
- *Of course, it is open-source.*

https://github.com/andreasfertig/cppinsights/



andreasfertig / cppinsights

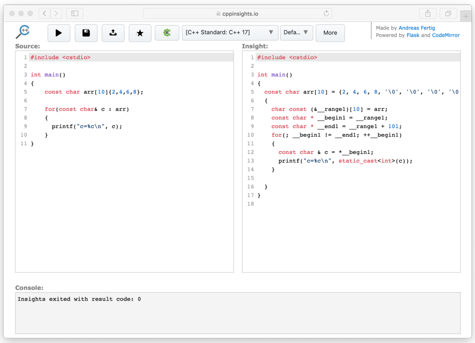
C++ Insights - See your source code with the eyes of a compiler https://cppinsights.io

433 commits · 3 branches · 5 releases · 8 contributors · MIT

andreasfertig Merge pull request #222 from andreasfertig/fixIssue188 … Latest commit 14d7978 23 days ago

.github	Again fighting with StaleBot.	last month
.gitpod	Use andreasfertig/cppinsights-builder in GitPod.	last month
artwork	Added SVG source of C++ Insights logo.	2 months ago
docker_buildenv	Major change: Rewrite more elements (fixed #127 and #182).	4 months ago
docker_travis	Use pre-built Docker image andreasfertig/cppinsights-builder.	2 months ago
docs	Generate documentation and upload it to andreasfertig.github.io	last year
scripts	Try to enable builds using clang-8	6 months ago
tests	Fixed remaining issues in #101.	23 days ago

https://cppinsights.io



Made by Andreas Fertig
Powered by Flask and CodeMirror

Source:

```cpp
#include <cstdio>

int main()
{
    const char arr[10]{2,4,6,8};

    for(const char& c : arr)
    {
      printf("c=%c\n", c);
    }
}
```

Insight:

```cpp
#include <cstdio>

int main()
{
  const char arr[10] = {2, 4, 6, 8, '\0', '\0', '\0', '\0
  {
    char const (&__range1)[10] = arr;
    const char * __begin1 = __range1;
    const char * __end1 = __range1 + 10l;
    for(; __begin1 != __end1; ++__begin1)
    {
      const char & c = *__begin1;
      printf("c=%c\n", static_cast<int>(c));
    }

  }
}

```

Console:

```
Insights exited with result code: 0
```

Implicit Conversions

```cpp

short int max(short int a, short int b)
{
  return (a > b) ? a : b;
}

void Use()
{
  short int          a = 1;
  unsigned short int b = 65’530;

  printf(”max: %d\n”, max(a, b));
}
```

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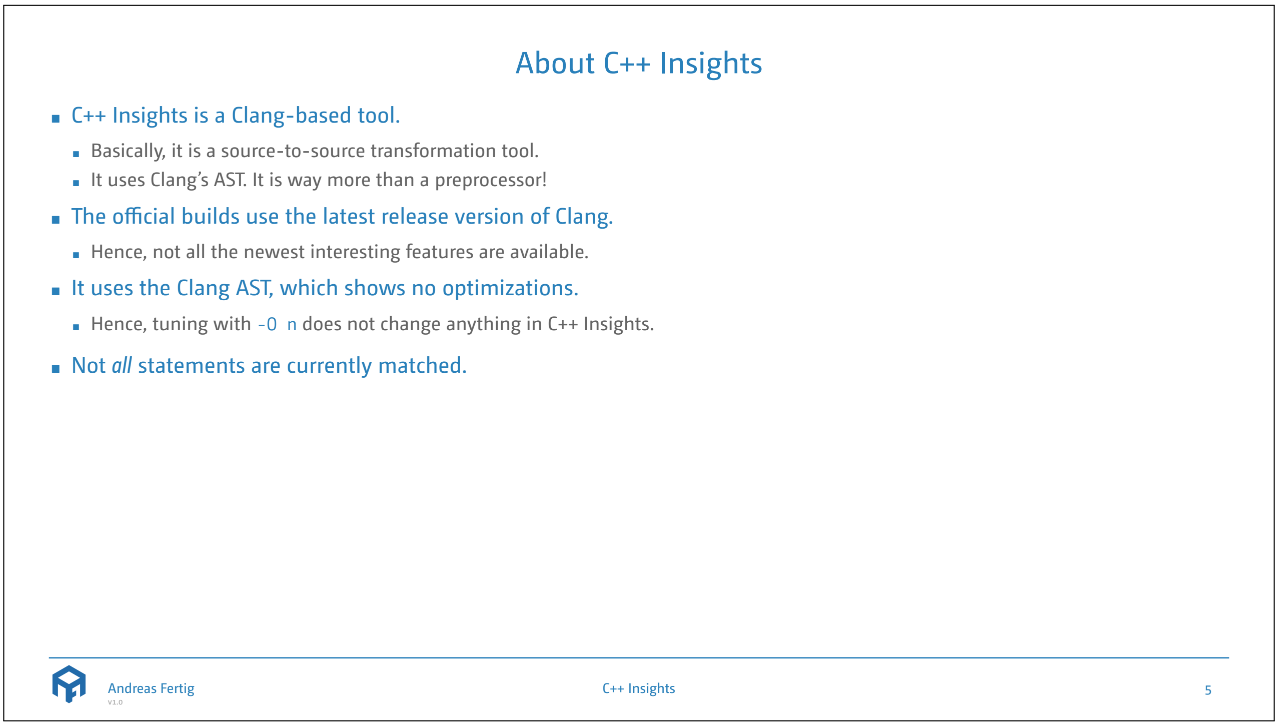
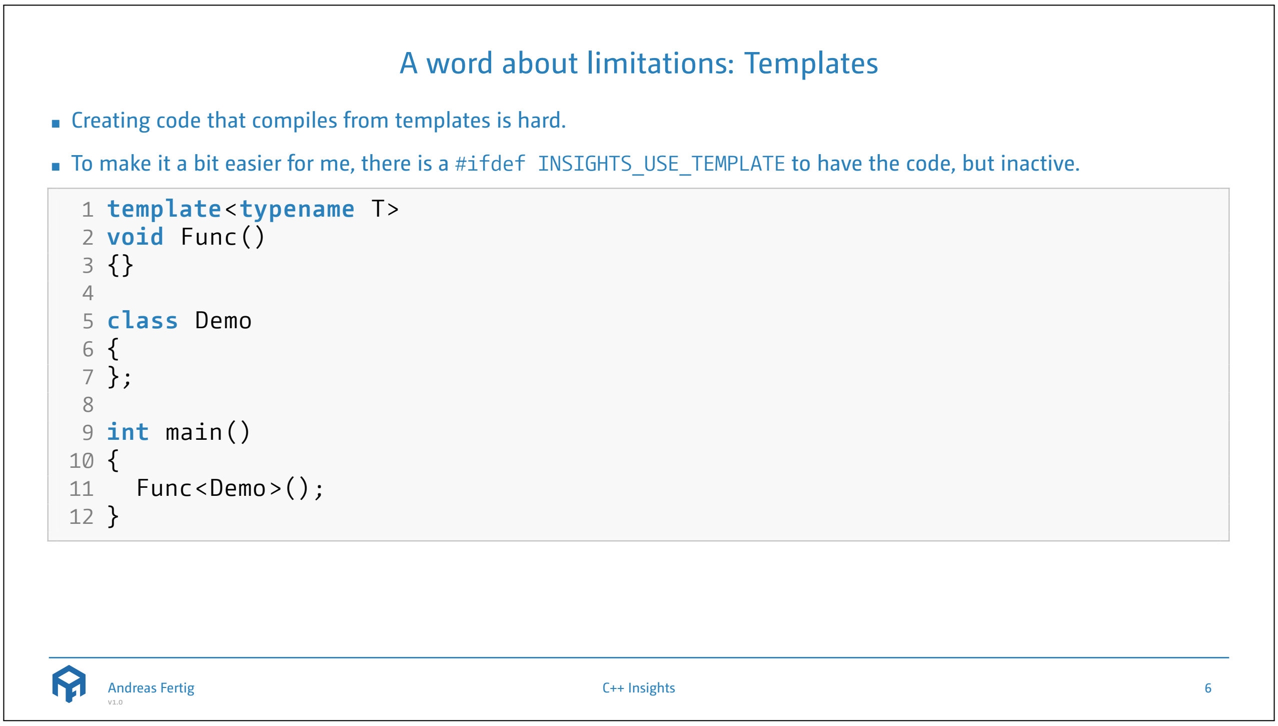


About C++ Insights

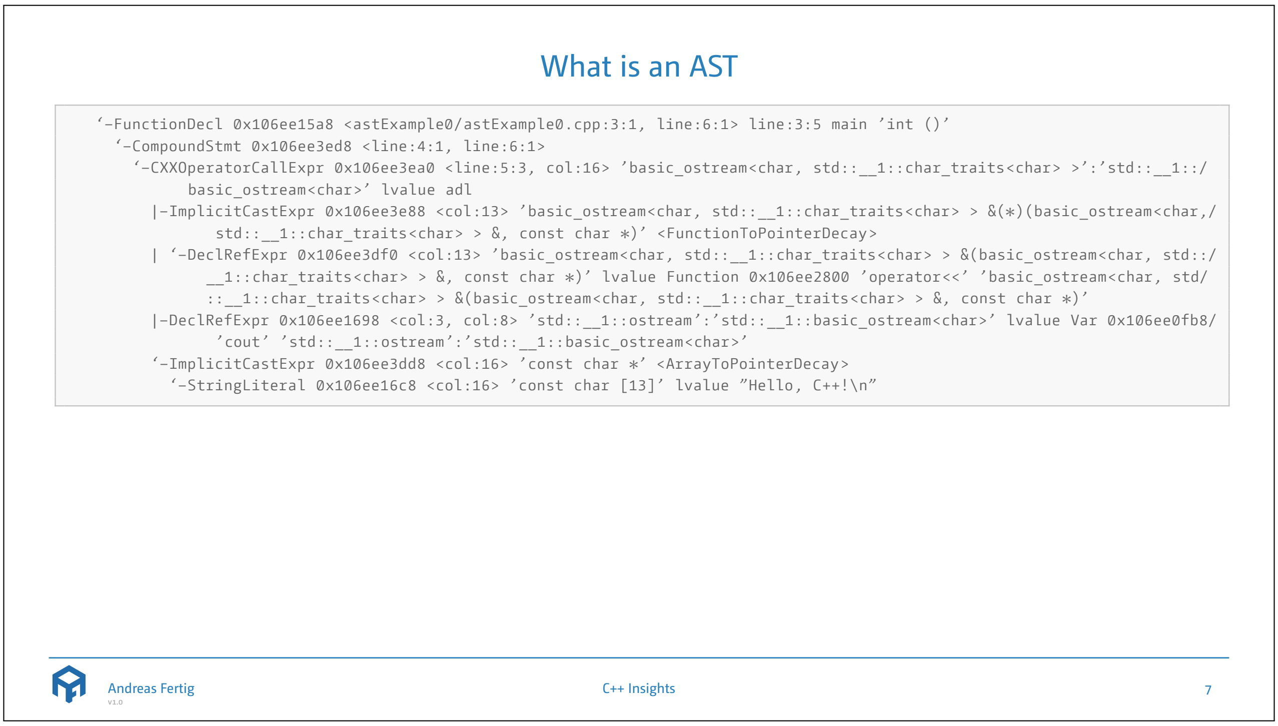
- C++ Insights is a Clang-based tool.
  - Basically, it is a source-to-source transformation tool.
  - It uses Clang's AST. It is way more than a preprocessor!
- The official builds use the latest release version of Clang.
  - Hence, not all the newest interesting features are available.
- It uses the Clang AST, which shows no optimizations.
  - Hence, tuning with `-O n` does not change anything in C++ Insights.
- Not *all* statements are currently matched.



A word about limitations: Templates

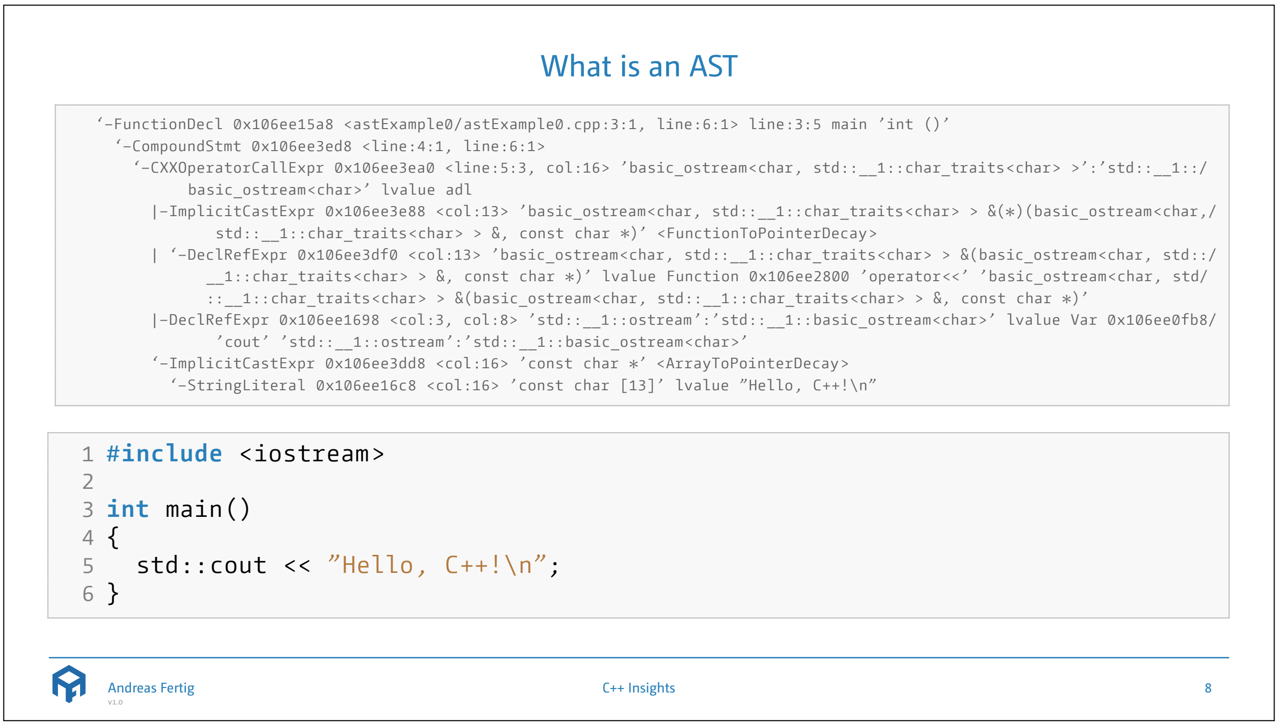
- Creating code that compiles from templates is hard.
- To make it a bit easier for me, there is a `#ifdef INSIGHTS_USE_TEMPLATE` to have the code, but inactive.

```cpp
template<typename T>
void Func()
{}

class Demo
{
};

int main()
{
  Func<Demo>();
}
```



What is an AST

```
‘-FunctionDecl 0x106ee15a8 <astExample0/astExample0.cpp:3:1, line:6:1> line:3:5 main ’int ()’
  ‘-CompoundStmt 0x106ee3ed8 <line:4:1, line:6:1>
    ‘-CXXOperatorCallExpr 0x106ee3ea0 <line:5:3, col:16> ’basic_ostream<char, std::__1::char_traits<char> >’:’std::__1::/
          basic_ostream<char>’ lvalue adl
      |-ImplicitCastExpr 0x106ee3e88 <col:13> ’basic_ostream<char, std::__1::char_traits<char> > &(∗)(basic_ostream<char,/
             std::__1::char_traits<char> > &, const char ∗)’ <FunctionToPointerDecay>
      | ‘-DeclRefExpr 0x106ee3df0 <col:13> ’basic_ostream<char, std::__1::char_traits<char> > &(basic_ostream<char, std::/
            __1::char_traits<char> > &, const char ∗)’ lvalue Function 0x106ee2800 ’operator<<’ ’basic_ostream<char, std/
            ::__1::char_traits<char> > &(basic_ostream<char, std::__1::char_traits<char> > &, const char ∗)’
      |-DeclRefExpr 0x106ee1698 <col:3, col:8> ’std::__1::ostream’:’std::__1::basic_ostream<char>’ lvalue Var 0x106ee0fb8/
             ’cout’ ’std::__1::ostream’:’std::__1::basic_ostream<char>’
      ‘-ImplicitCastExpr 0x106ee3dd8 <col:16> ’const char ∗’ <ArrayToPointerDecay>
        ‘-StringLiteral 0x106ee16c8 <col:16> ’const char [13]’ lvalue ”Hello, C++!\n”
```



What is an AST

```
‘-FunctionDecl 0x106ee15a8 <astExample0/astExample0.cpp:3:1, line:6:1> line:3:5 main ’int ()’
  ‘-CompoundStmt 0x106ee3ed8 <line:4:1, line:6:1>
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          basic_ostream<char>’ lvalue adl
      |-ImplicitCastExpr 0x106ee3e88 <col:13> ’basic_ostream<char, std::__1::char_traits<char> > &(∗)(basic_ostream<char,/
             std::__1::char_traits<char> > &, const char ∗)’ <FunctionToPointerDecay>
      | ‘-DeclRefExpr 0x106ee3df0 <col:13> ’basic_ostream<char, std::__1::char_traits<char> > &(basic_ostream<char, std::/
            __1::char_traits<char> > &, const char ∗)’ lvalue Function 0x106ee2800 ’operator<<’ ’basic_ostream<char, std/
            ::__1::char_traits<char> > &(basic_ostream<char, std::__1::char_traits<char> > &, const char ∗)’
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             ’cout’ ’std::__1::ostream’:’std::__1::basic_ostream<char>’
      ‘-ImplicitCastExpr 0x106ee3dd8 <col:16> ’const char ∗’ <ArrayToPointerDecay>
        ‘-StringLiteral 0x106ee16c8 <col:16> ’const char [13]’ lvalue ”Hello, C++!\n”
```
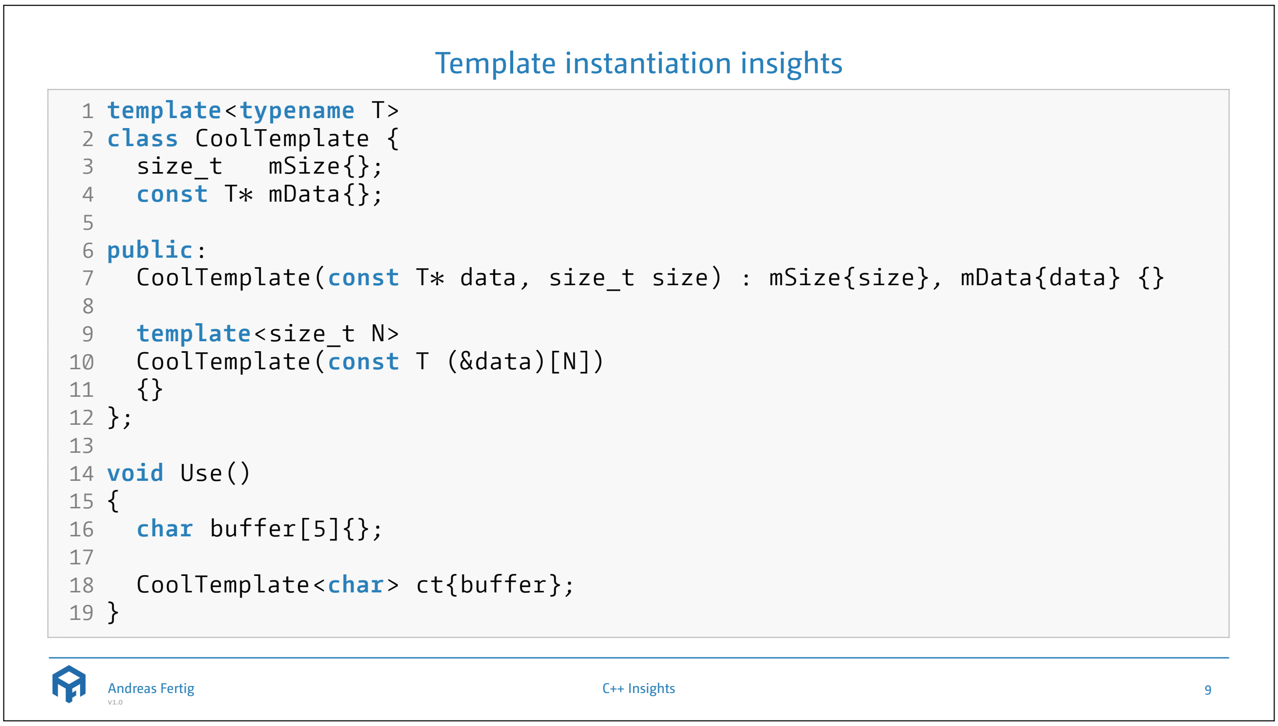
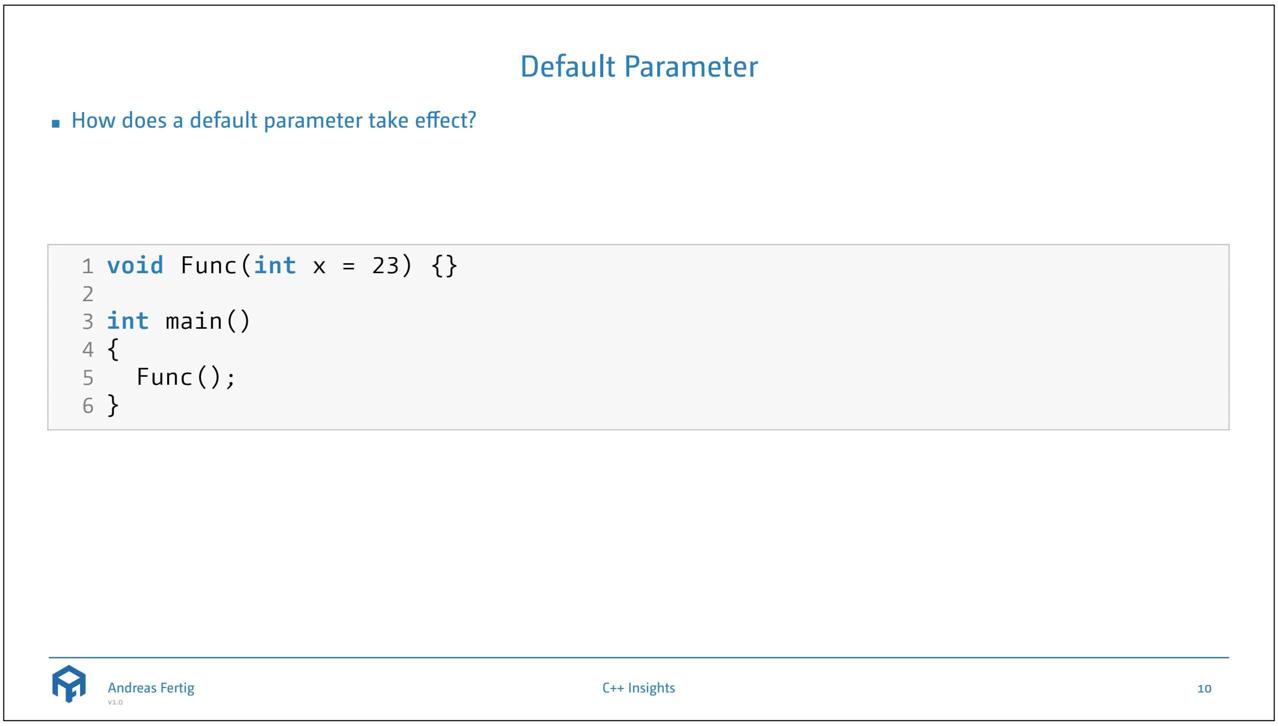

```cpp
#include <iostream>

int main()
{
  std::cout << ”Hello, C++!\n”;
}
```



Template instantiation insights

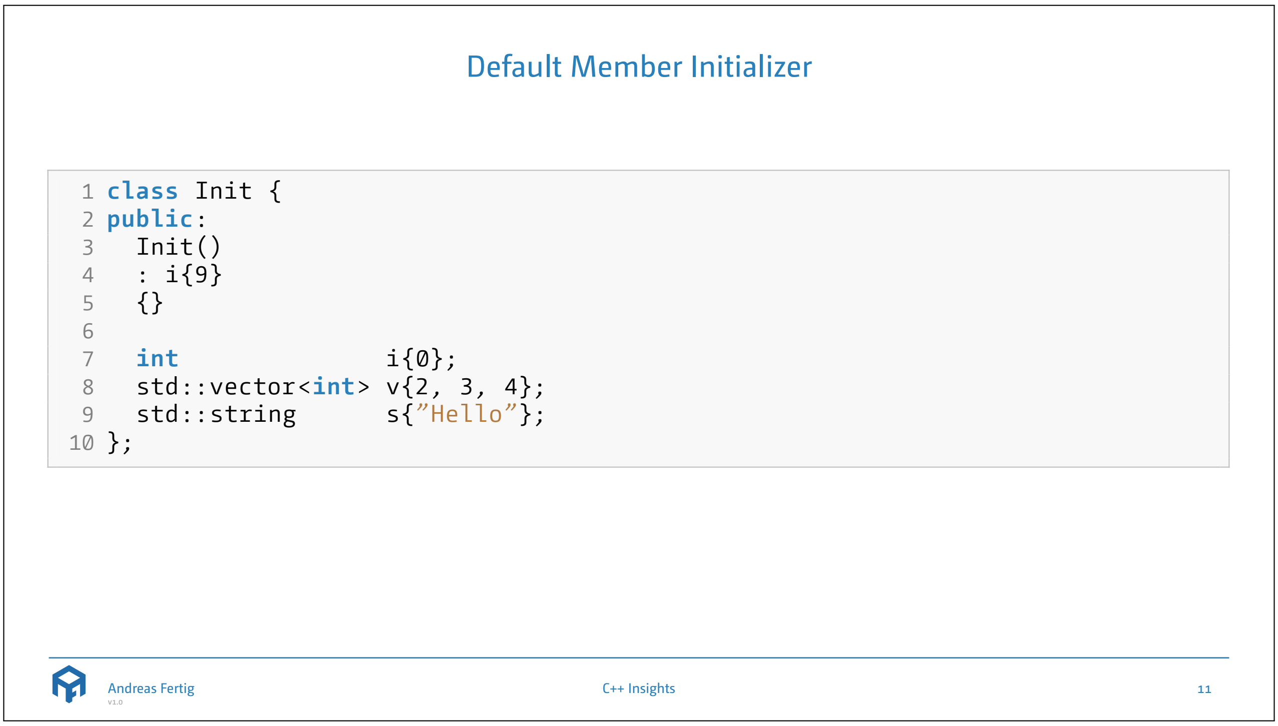
```cpp
template<typename T>
class CoolTemplate {
  size_t   mSize{};
  const T* mData{};

public:
  CoolTemplate(const T* data, size_t size) : mSize{size}, mData{data} {}

  template<size_t N>
  CoolTemplate(const T (&data)[N])
  {}
};

void Use()
{
  char buffer[5]{};

  CoolTemplate<char> ct{buffer};
}
```



Default Parameter

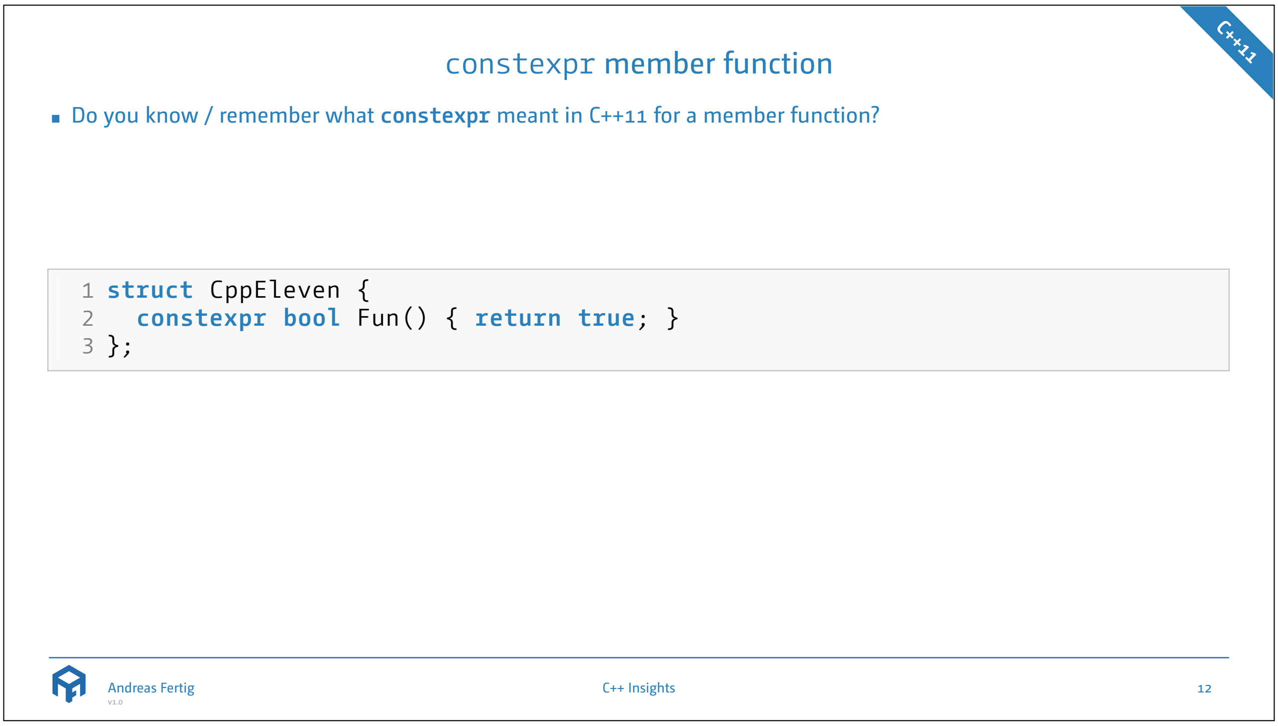
- How does a default parameter take effect?

```cpp
void Func(int x = 23) {}

int main()
{
  Func();
}
```



Default Member Initializer

```cpp
class Init {
public:
  Init()
  : i{9}
  {}

  int              i{0};
  std::vector<int> v{2, 3, 4};
  std::string      s{”Hello”};
};
```

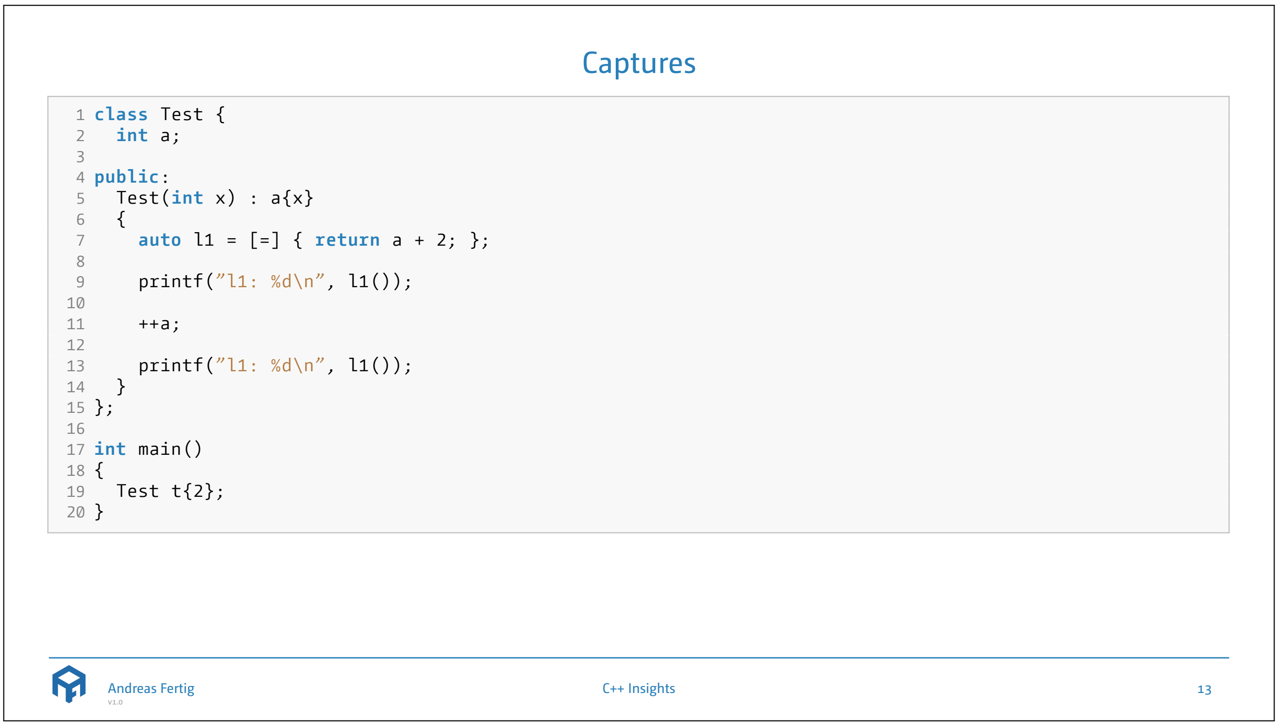


constexpr member function

C++11

- Do you know / remember what **constexpr** meant in C++11 for a member function?

```cpp
struct CppEleven {
  constexpr bool Fun() { return true; }
};
```



Captures

```cpp
class Test {
  int a;

public:
  Test(int x) : a{x}
  {
    auto l1 = [=] { return a + 2; };

    printf(”l1: %d\n”, l1());

    ++a;

    printf(”l1: %d\n”, l1());
  }
};

int main()
{
  Test t{2};
}
```

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C++ Insights

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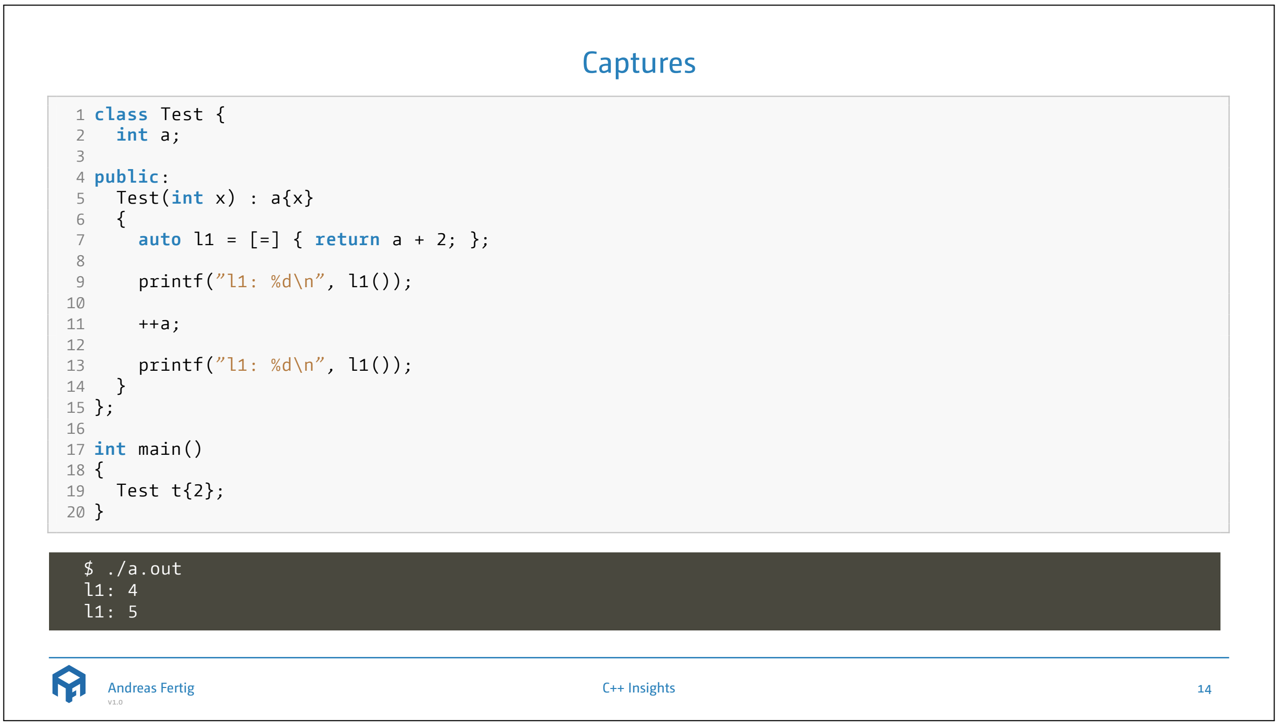

Captures

```cpp
class Test {
  int a;

public:
  Test(int x) : a{x}
  {
    auto l1 = [=] { return a + 2; };

    printf(”l1: %d\n”, l1());

    ++a;

    printf(”l1: %d\n”, l1());
  }
};

int main()
{
  Test t{2};
}
```

```
$ ./a.out
l1: 4
l1: 5
```

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C++ Insights

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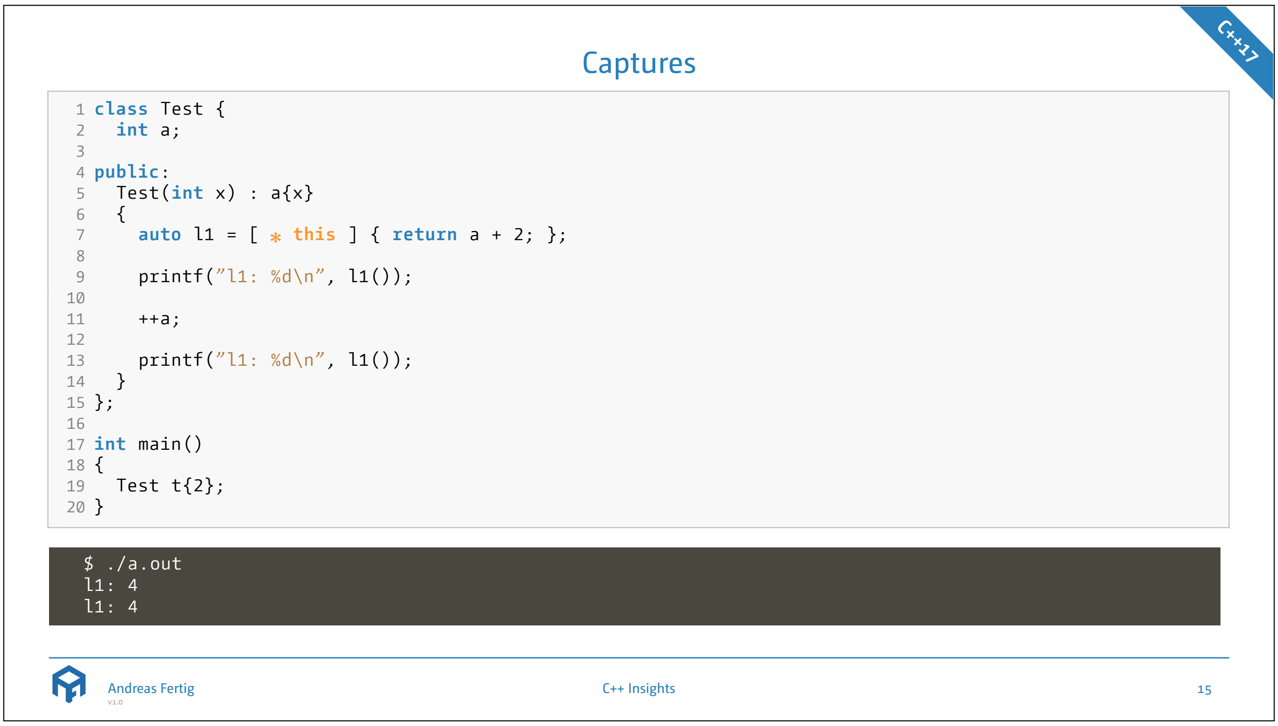
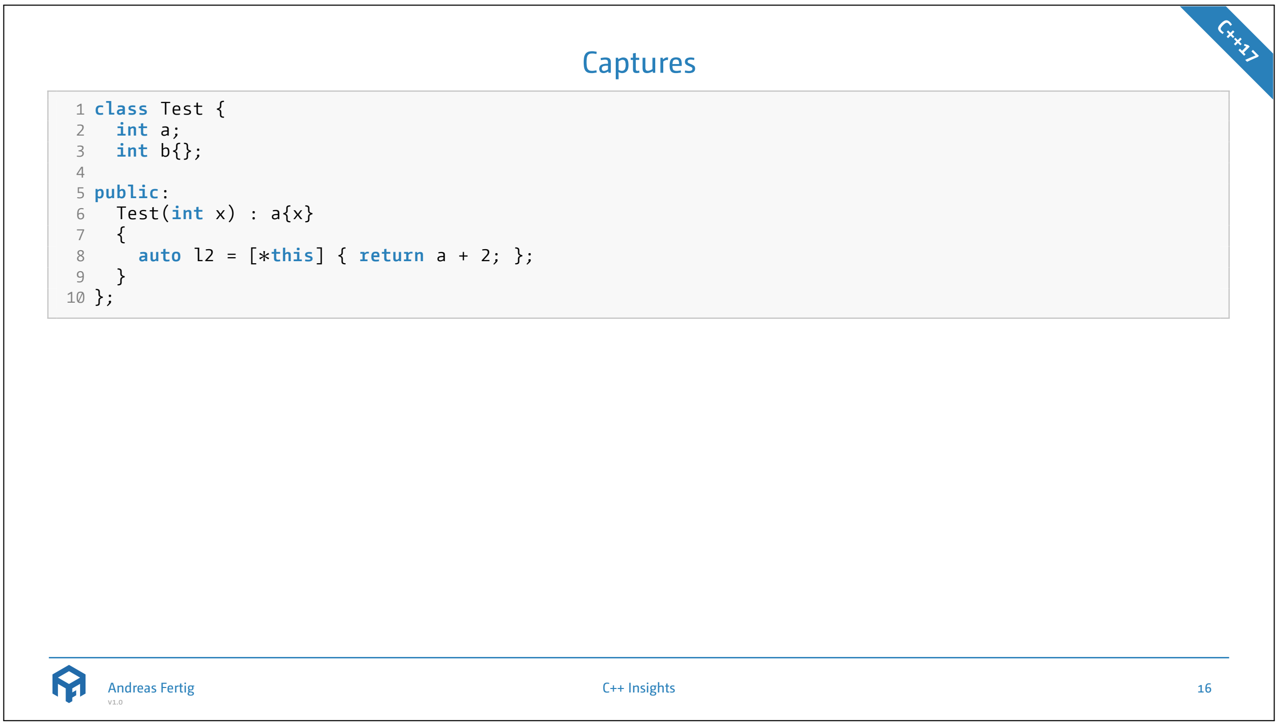


C++17

Captures

```
class Test {
  int a;

public:
  Test(int x) : a{x}
  {
    auto l1 = [ * this ] { return a + 2; };

    printf(”l1: %d\n”, l1());

    ++a;

    printf(”l1: %d\n”, l1());
  }
};

int main()
{
  Test t{2};
}
```

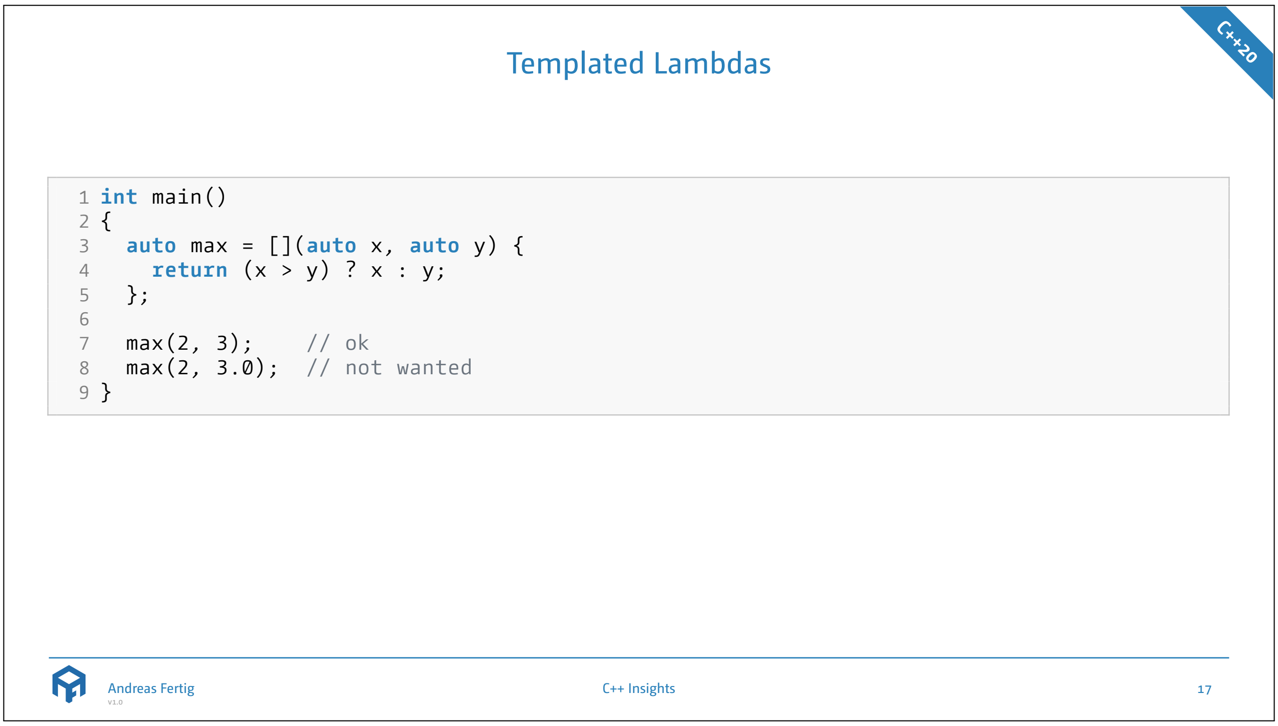
```
$ ./a.out
l1: 4
l1: 4
```



C++17

Captures

```
class Test {
  int a;
  int b{};

public:
  Test(int x) : a{x}
  {
    auto l2 = [*this] { return a + 2; };
  }
};
```



C++20

Templated Lambdas

```cpp
int main()
{
  auto max = [](auto x, auto y) {
    return (x > y) ? x : y;
  };

  max(2, 3);     // ok
  max(2, 3.0);  // not wanted
}
```

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C++ Insights

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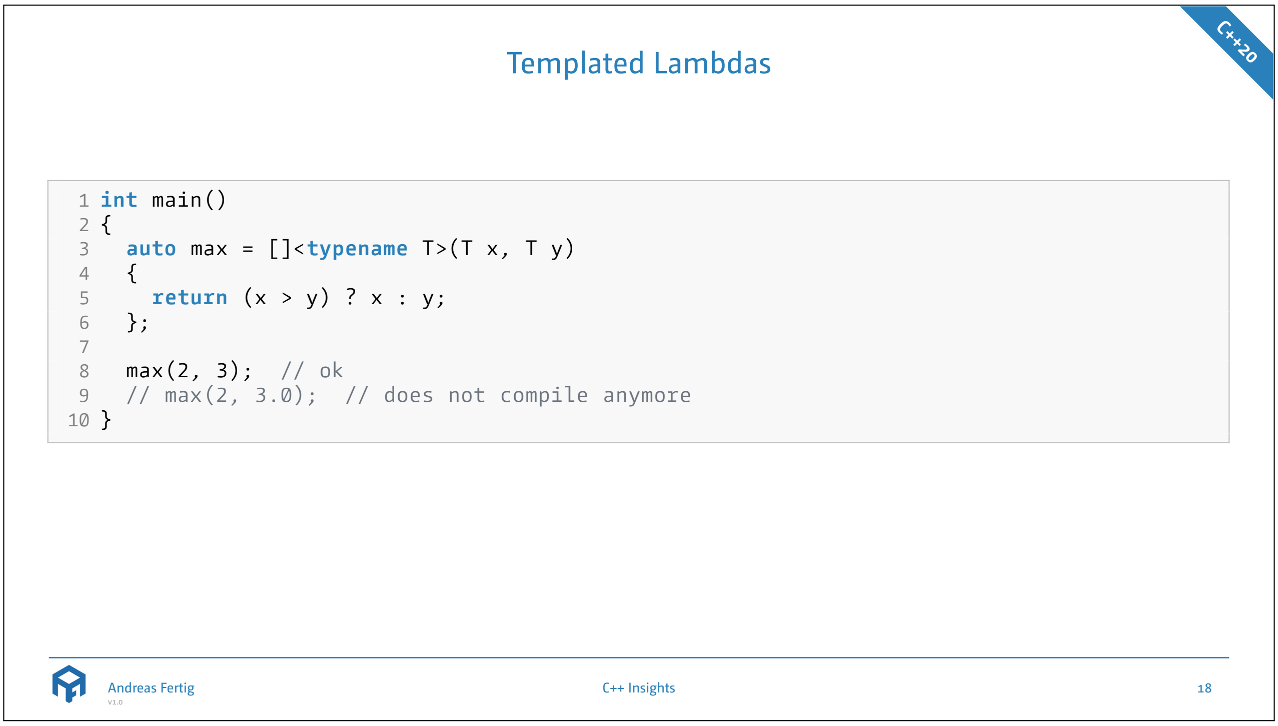

C++20

Templated Lambdas

```cpp
int main()
{
  auto max = []<typename T>(T x, T y)
  {
    return (x > y) ? x : y;
  };

  max(2, 3);  // ok
  // max(2, 3.0);  // does not compile anymore
}
```

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C++ Insights

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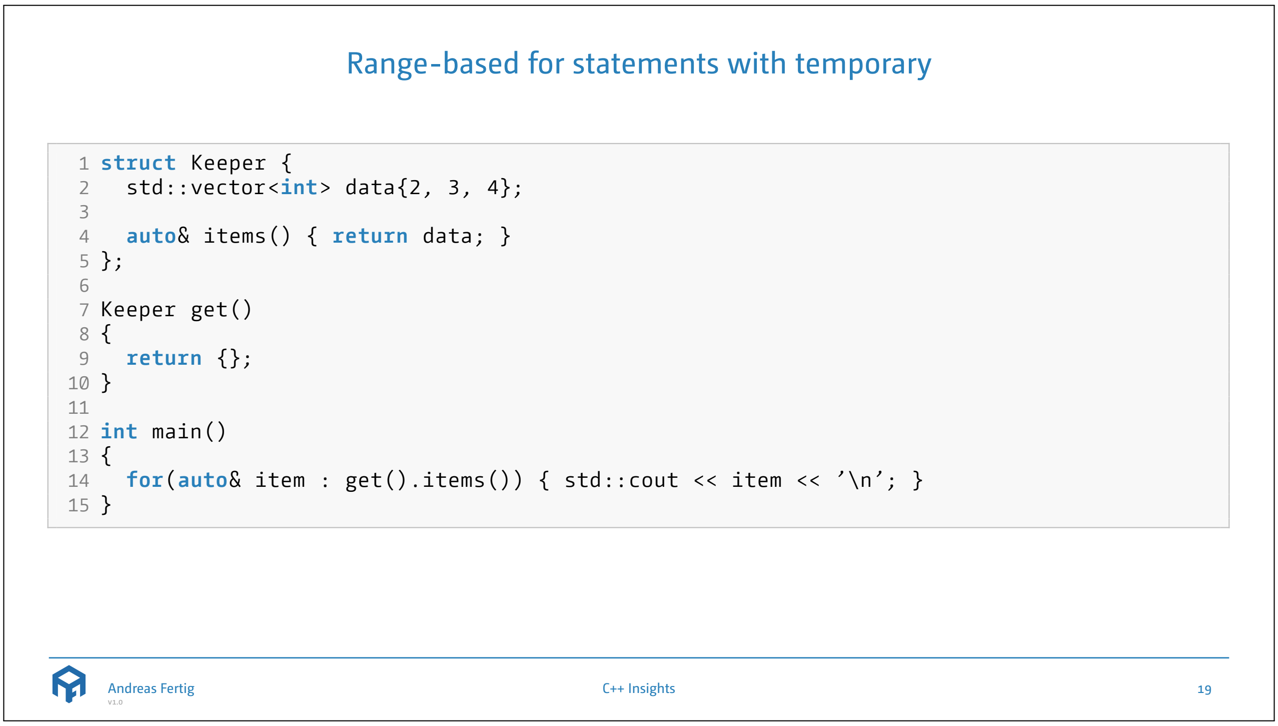


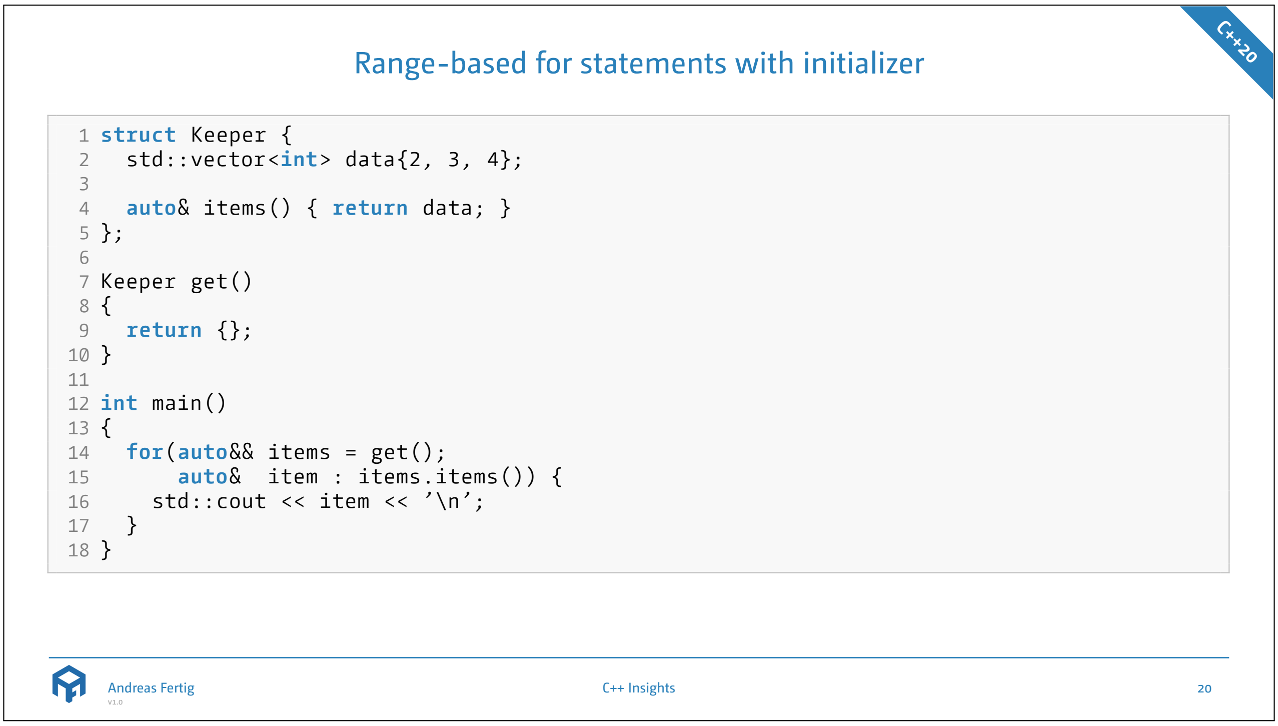
Range-based for statements with temporary

```
struct Keeper {
  std::vector<int> data{2, 3, 4};

  auto& items() { return data; }
};

Keeper get()
{
  return {};
}

int main()
{
  for(auto& item : get().items()) { std::cout << item << ’\n’; }
}
```



C++20

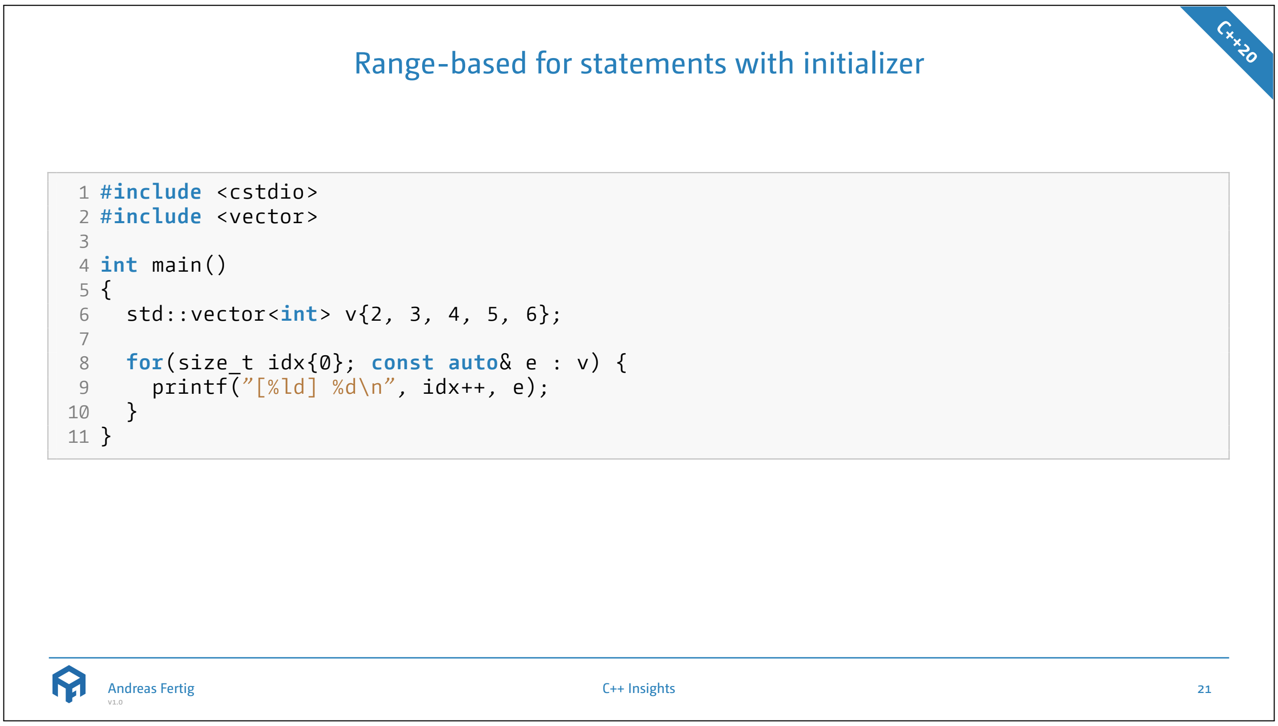
Range-based for statements with initializer

```
struct Keeper {
  std::vector<int> data{2, 3, 4};

  auto& items() { return data; }
};

Keeper get()
{
  return {};
}

int main()
{
  for(auto&& items = get();
      auto&  item : items.items()) {
    std::cout << item << ’\n’;
  }
}
```



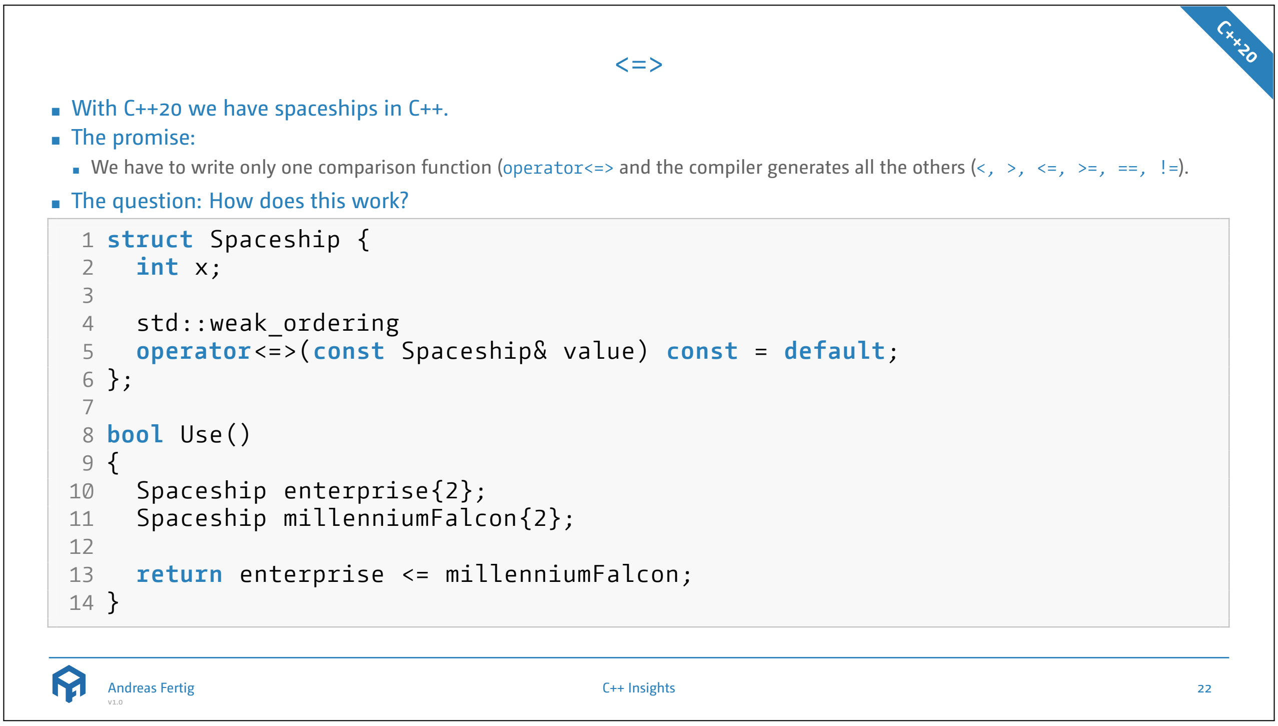
C++20

Range-based for statements with initializer

```cpp
#include <cstdio>
#include <vector>

int main()
{
  std::vector<int> v{2, 3, 4, 5, 6};

  for(size_t idx{0}; const auto& e : v) {
    printf(”[%ld] %d\n”, idx++, e);
  }
}
```



C++20

<=>

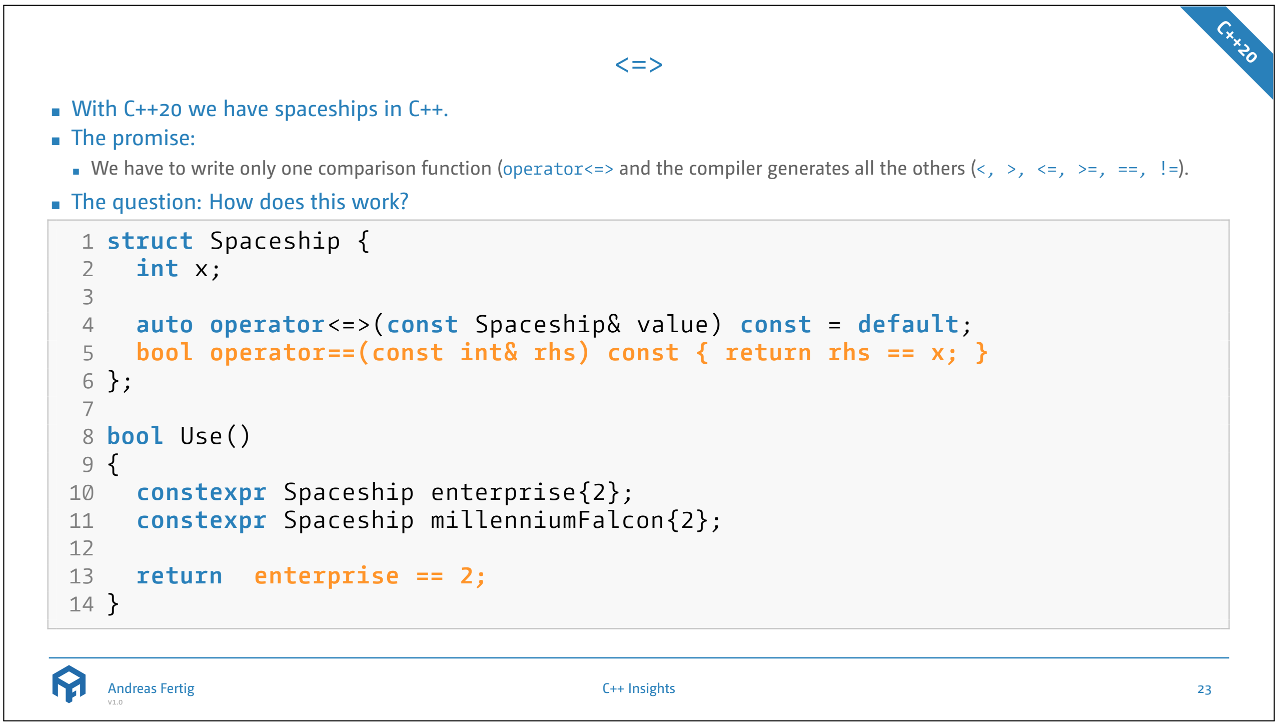
- With C++20 we have spaceships in C++.
- The promise:
  - We have to write only one comparison function (operator<=> and the compiler generates all the others (<, >, <=, >=, ==, !=).
- The question: How does this work?

```cpp
struct Spaceship {
  int x;

  std::weak_ordering
  operator<=>(const Spaceship& value) const = default;
};

bool Use()
{
  Spaceship enterprise{2};
  Spaceship millenniumFalcon{2};

  return enterprise <= millenniumFalcon;
}
```



C++20

<=>

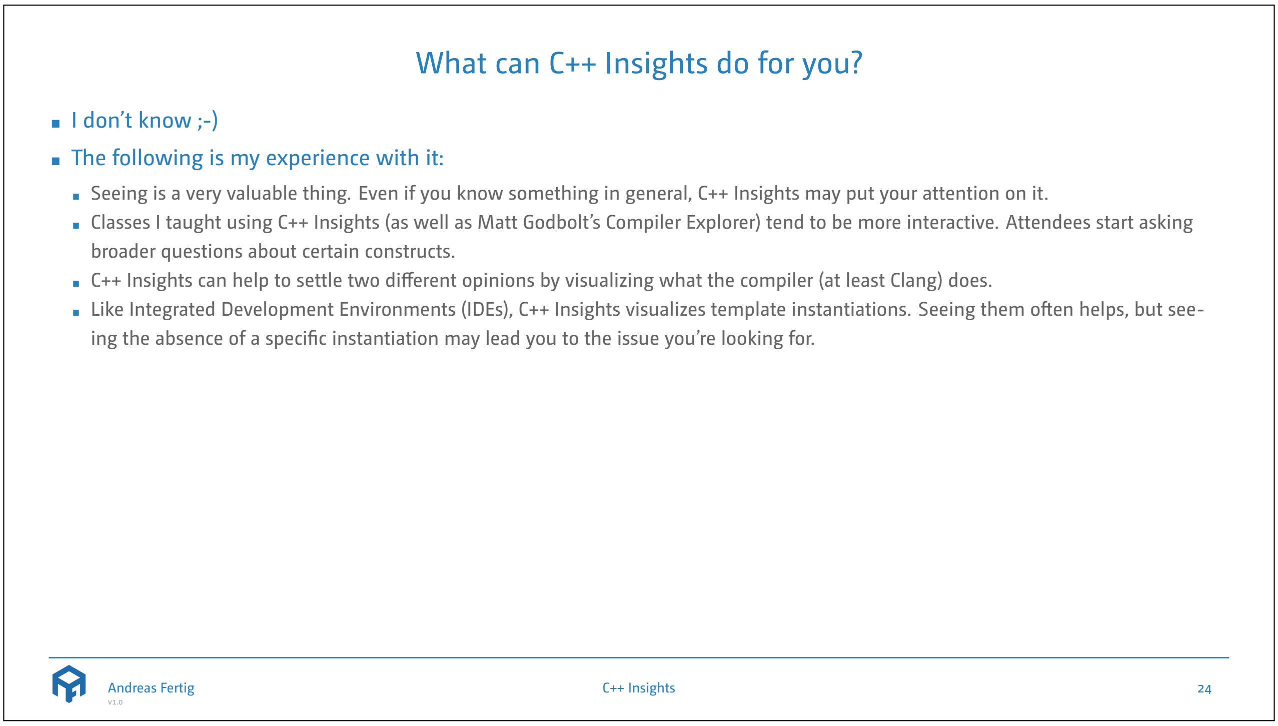
- With C++20 we have spaceships in C++.
- The promise:
  - We have to write only one comparison function (`operator<=>` and the compiler generates all the others (`<, >, <=, >=, ==, !=`).
- The question: How does this work?

```
struct Spaceship {
  int x;

  auto operator<=>(const Spaceship& value) const = default;
  bool operator==(const int& rhs) const { return rhs == x; }
};

bool Use()
{
  constexpr Spaceship enterprise{2};
  constexpr Spaceship millenniumFalcon{2};

  return  enterprise == 2;
}
```



What can C++ Insights do for you?

- I don't know ;-)
- The following is my experience with it:
  - Seeing is a very valuable thing. Even if you know something in general, C++ Insights may put your attention on it.
  - Classes I taught using C++ Insights (as well as Matt Godbolt's Compiler Explorer) tend to be more interactive. Attendees start asking broader questions about certain constructs.
  - C++ Insights can help to settle two different opinions by visualizing what the compiler (at least Clang) does.
  - Like Integrated Development Environments (IDEs), C++ Insights visualizes template instantiations. Seeing them often helps, but seeing the absence of a specific instantiation may lead you to the issue you're looking for.

Support the project

https://github.com/andreasfertig/cppinsights

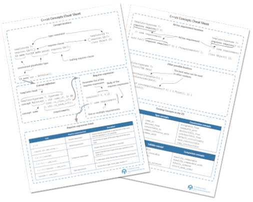
https://www.patreon.com/cppinsights

https://shop.spreadshirt.de/cppinsights

}

I am Fertig.

C++20 Concepts Cheat Sheet



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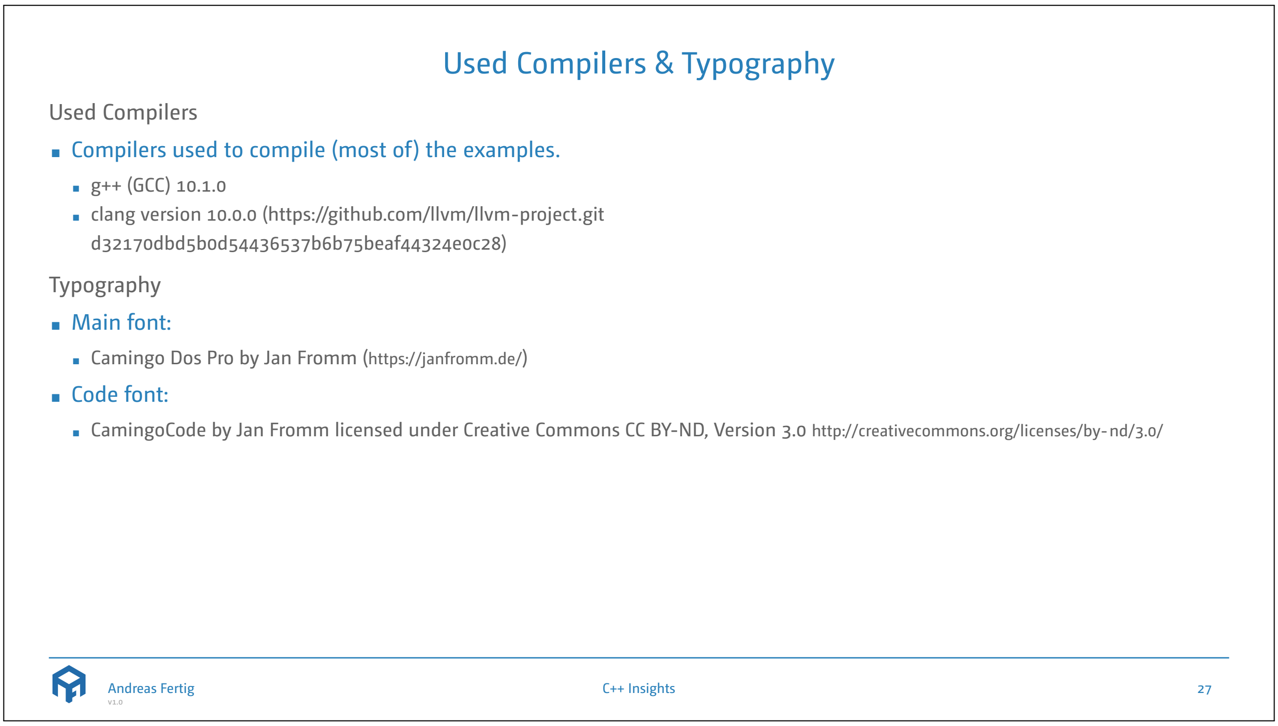


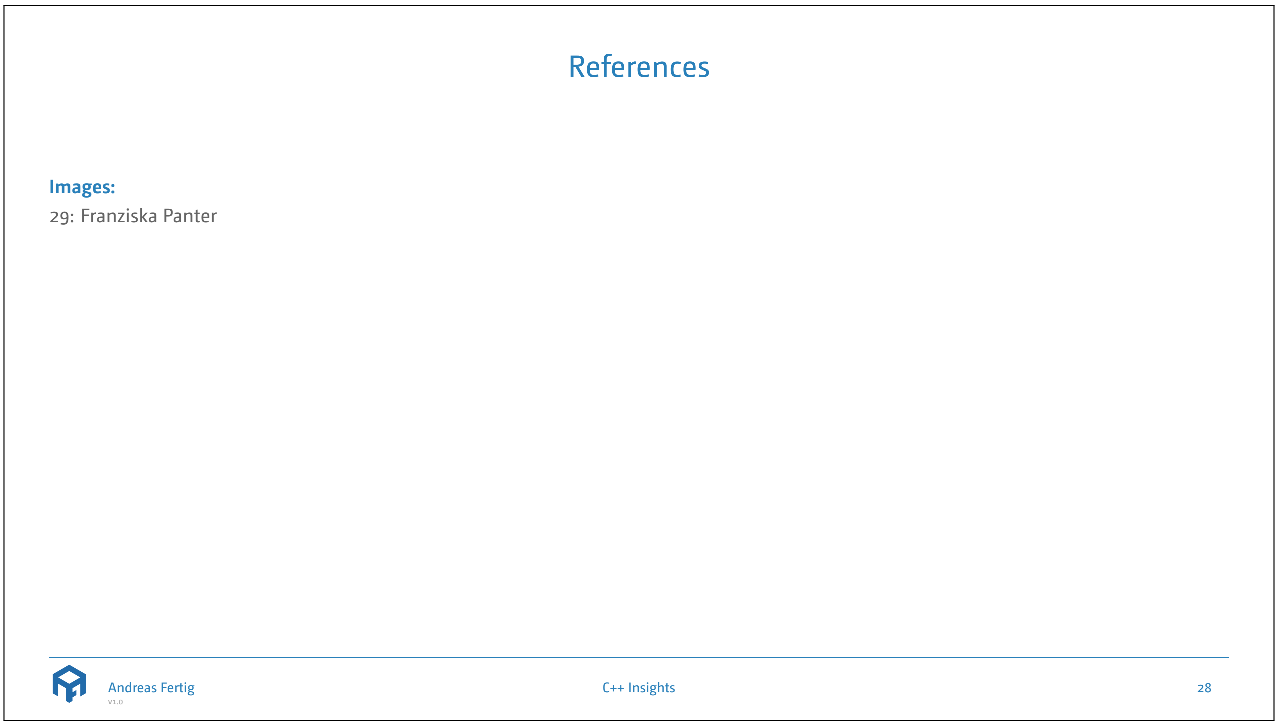
Used Compilers & Typography

Used Compilers

- Compilers used to compile (most of) the examples.
  - g++ (GCC) 10.1.0
  - clang version 10.0.0 (https://github.com/llvm/llvm-project.git d32170dbd5b0d54436537b6b75beaf44324e0c28)

Typography

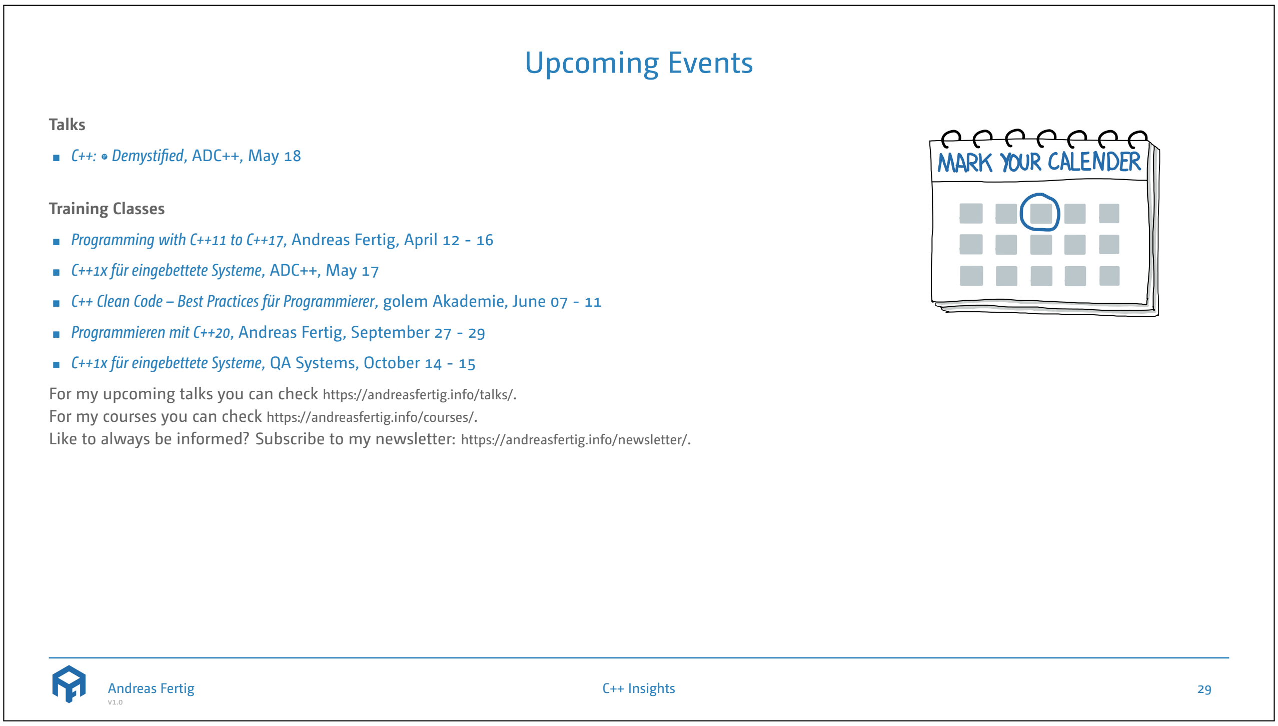
- Main font:
  - Camingo Dos Pro by Jan Fromm (https://janfromm.de/)
- Code font:
  - CamingoCode by Jan Fromm licensed under Creative Commons CC BY-ND, Version 3.0 http://creativecommons.org/licenses/by-nd/3.0/



References

Images:

29: Franziska Panter



Upcoming Events

MARK YOUR CALENDER

Talks

- *C++: ● Demystified*, ADC++, May 18

Training Classes

- *Programming with C++11 to C++17*, Andreas Fertig, April 12 - 16
- *C++1x für eingebettete Systeme*, ADC++, May 17
- *C++ Clean Code – Best Practices für Programmierer*, golem Akademie, June 07 - 11
- *Programmieren mit C++20*, Andreas Fertig, September 27 - 29
- *C++1x für eingebettete Systeme*, QA Systems, October 14 - 15

For my upcoming talks you can check https://andreasfertig.info/talks/.
For my courses you can check https://andreasfertig.info/courses/.
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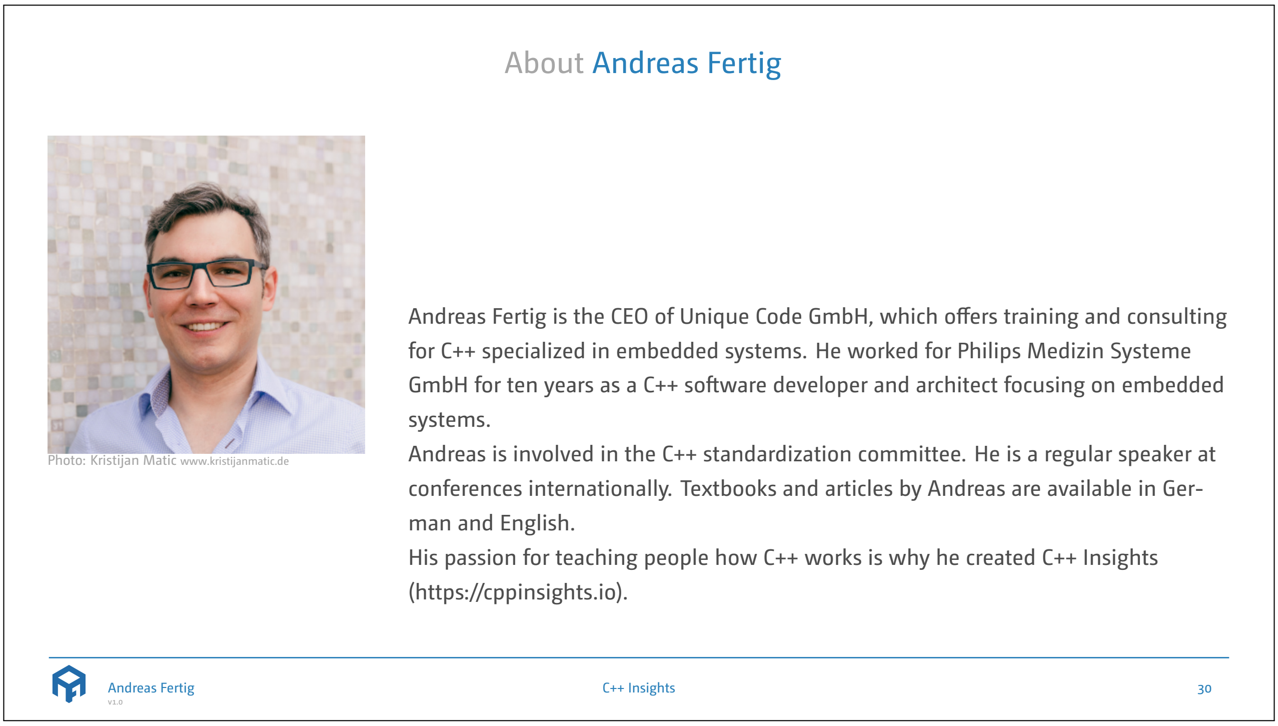

About Andreas Fertig

Photo: Kristijan Matic www.kristijanmatic.de

Andreas Fertig is the CEO of Unique Code GmbH, which offers training and consulting for C++ specialized in embedded systems. He worked for Philips Medizin Systeme GmbH for ten years as a C++ software developer and architect focusing on embedded systems.

Andreas is involved in the C++ standardization committee. He is a regular speaker at conferences internationally. Textbooks and articles by Andreas are available in German and English.

His passion for teaching people how C++ works is why he created C++ Insights (https://cppinsights.io).

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