# C++ ecosystem:
# For better, for worse

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# Agenda

1. The current state of C++ development
2. C++ in top areas. Needs and requests
3. What else is important? Unit testing & code analysis
4. Language evolution and tooling

# The State of Developer Ecosystem

- Yearly: 2017, 2018, 2019
- ~15K respondents total
- 6 languages
- Enough data from all over the world
- Weighting

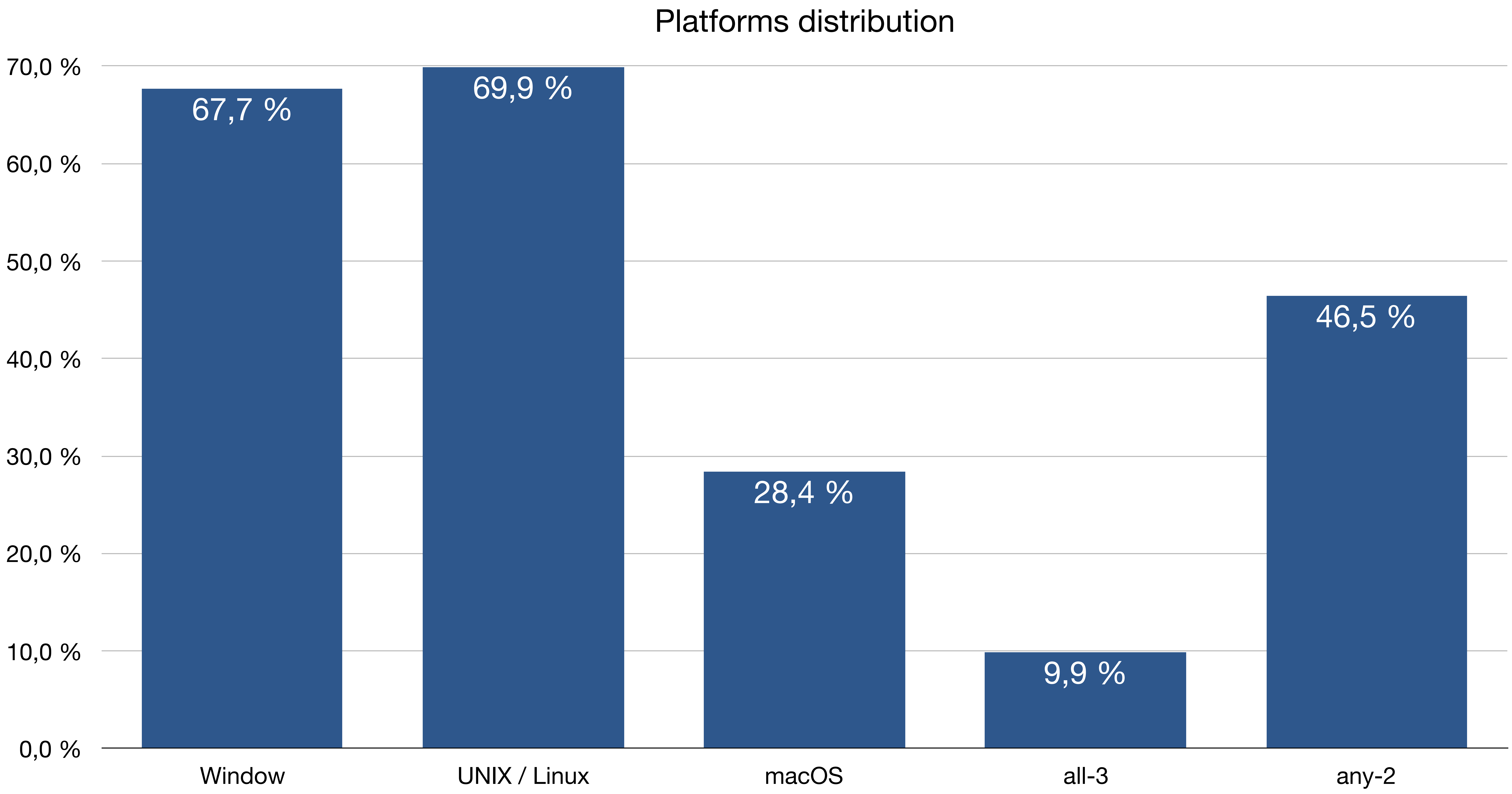
# The State of Developer Ecosystem: C++

- C or C++ used in the last 12 months - **5427**
- C used in the last 12 months - **3410**
- C++ used in the last 12 months - **4148**
- Primary C++ - **1698**

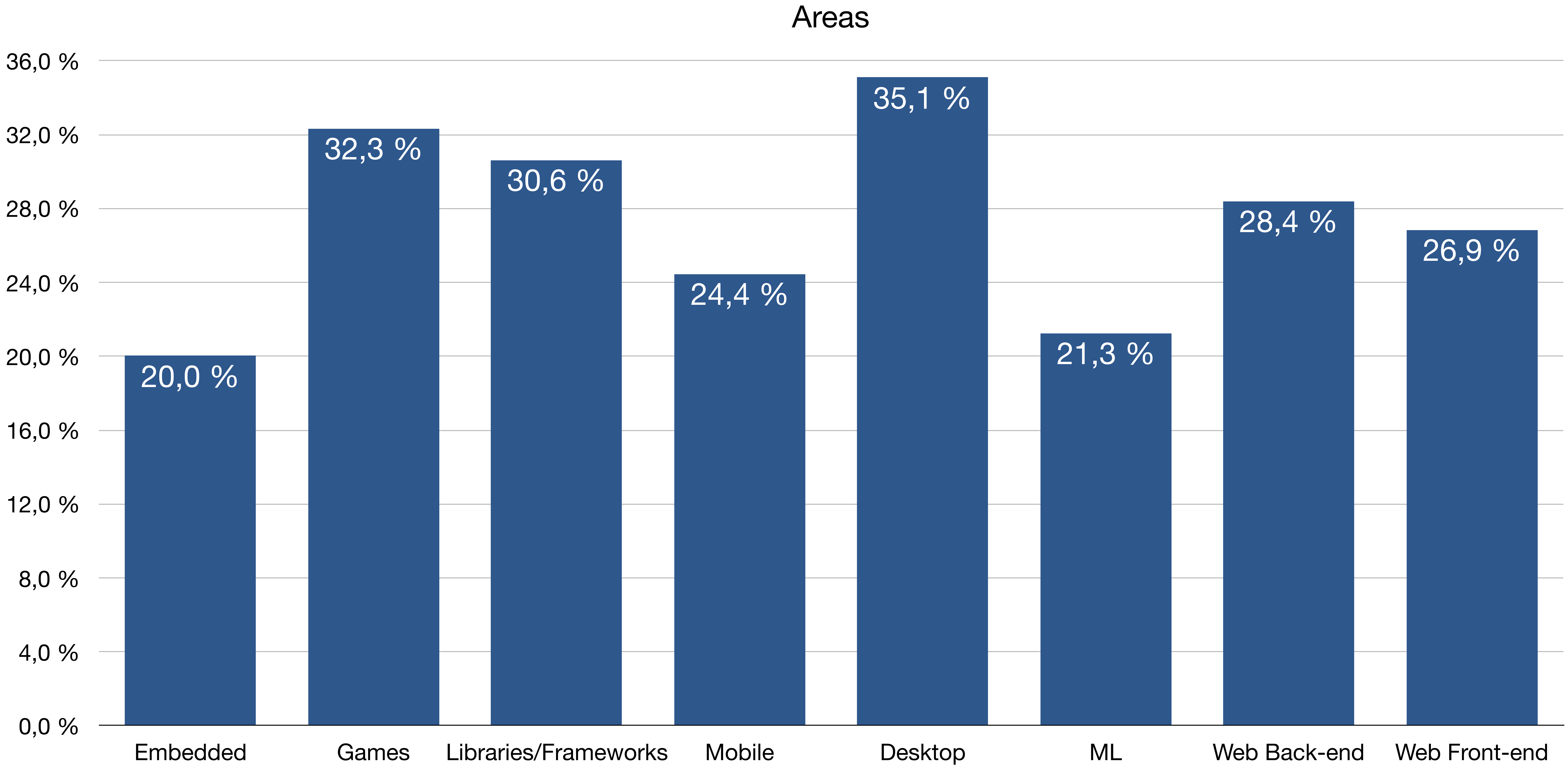
# C++ Developer Survey by CPP Foundation

- 2018
- C++ used at work - 2884
- Hobby/personal - 2380
- >50% have >5 years in C++

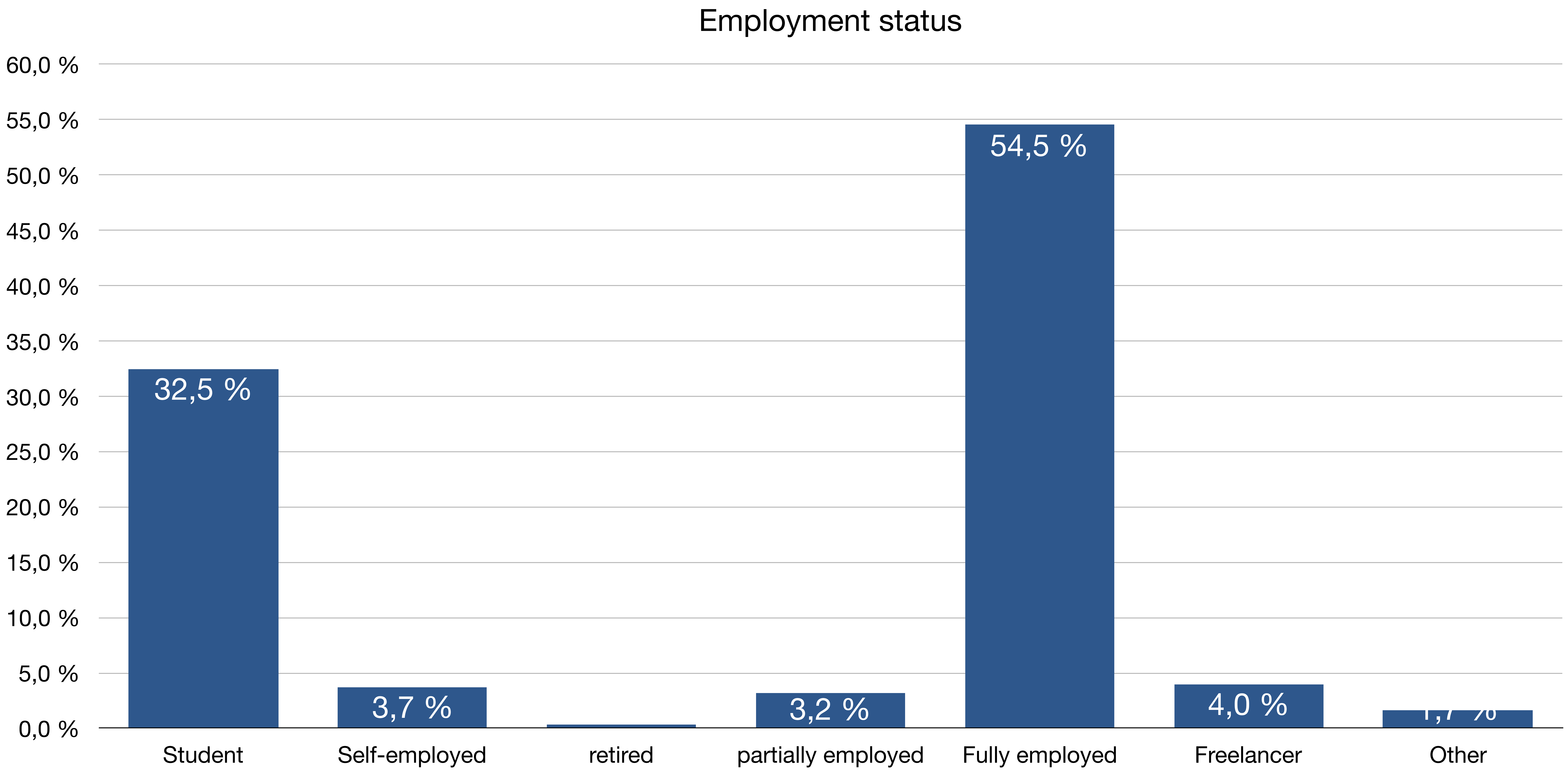
# The State of Developer Ecosystem: C++



# The State of Developer Ecosystem: C++

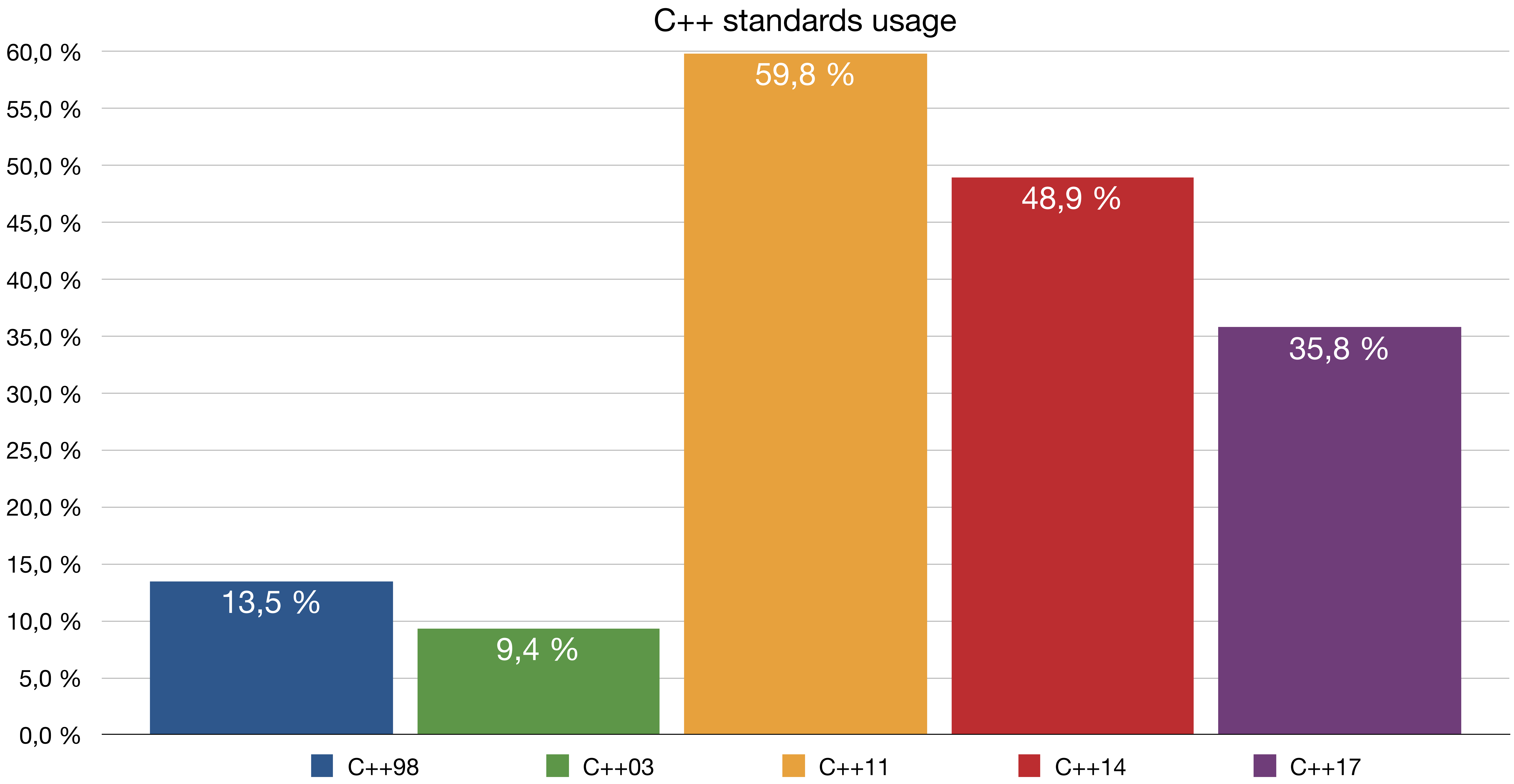


# The State of Developer Ecosystem: C++

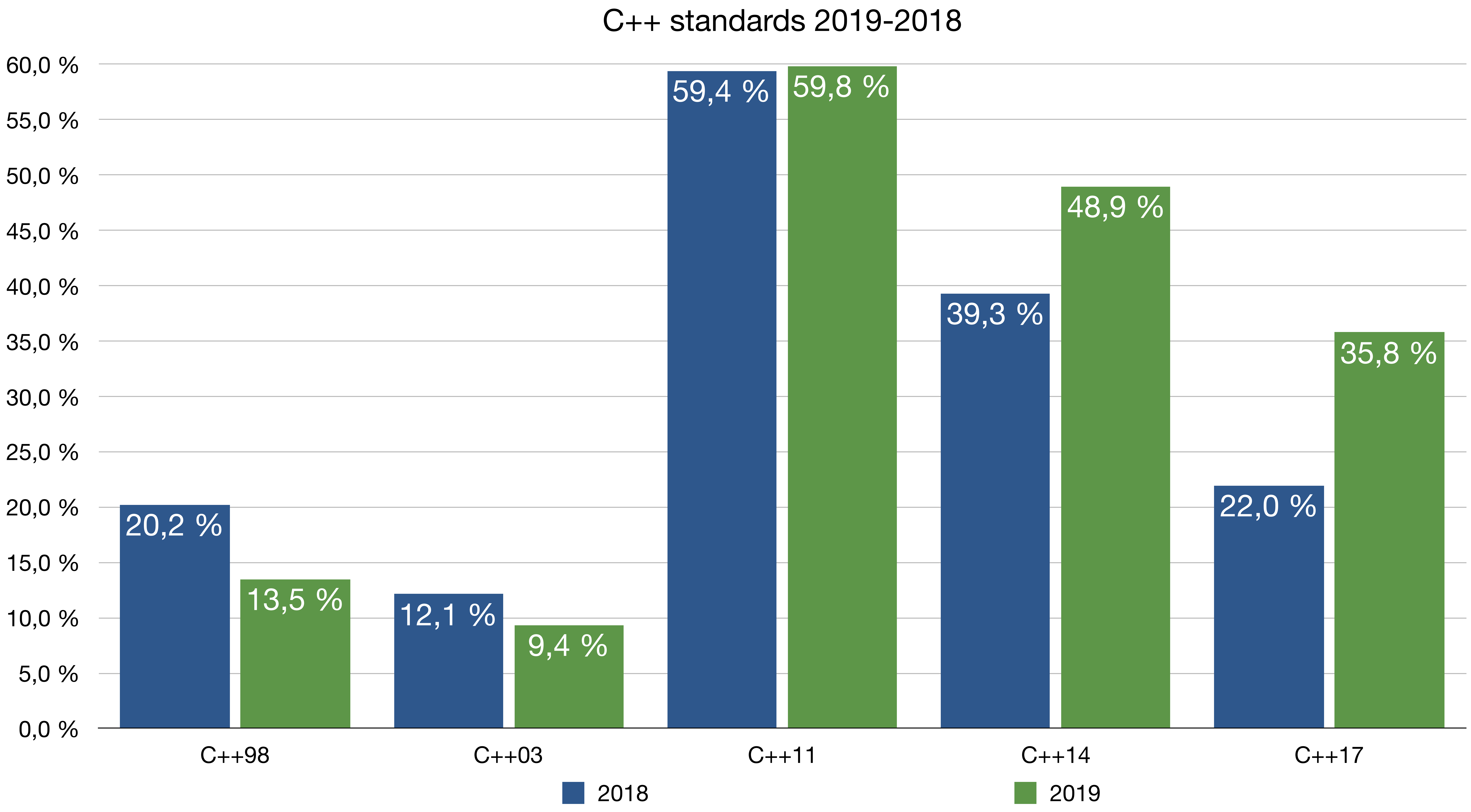


# C++ standards

# C++ standards

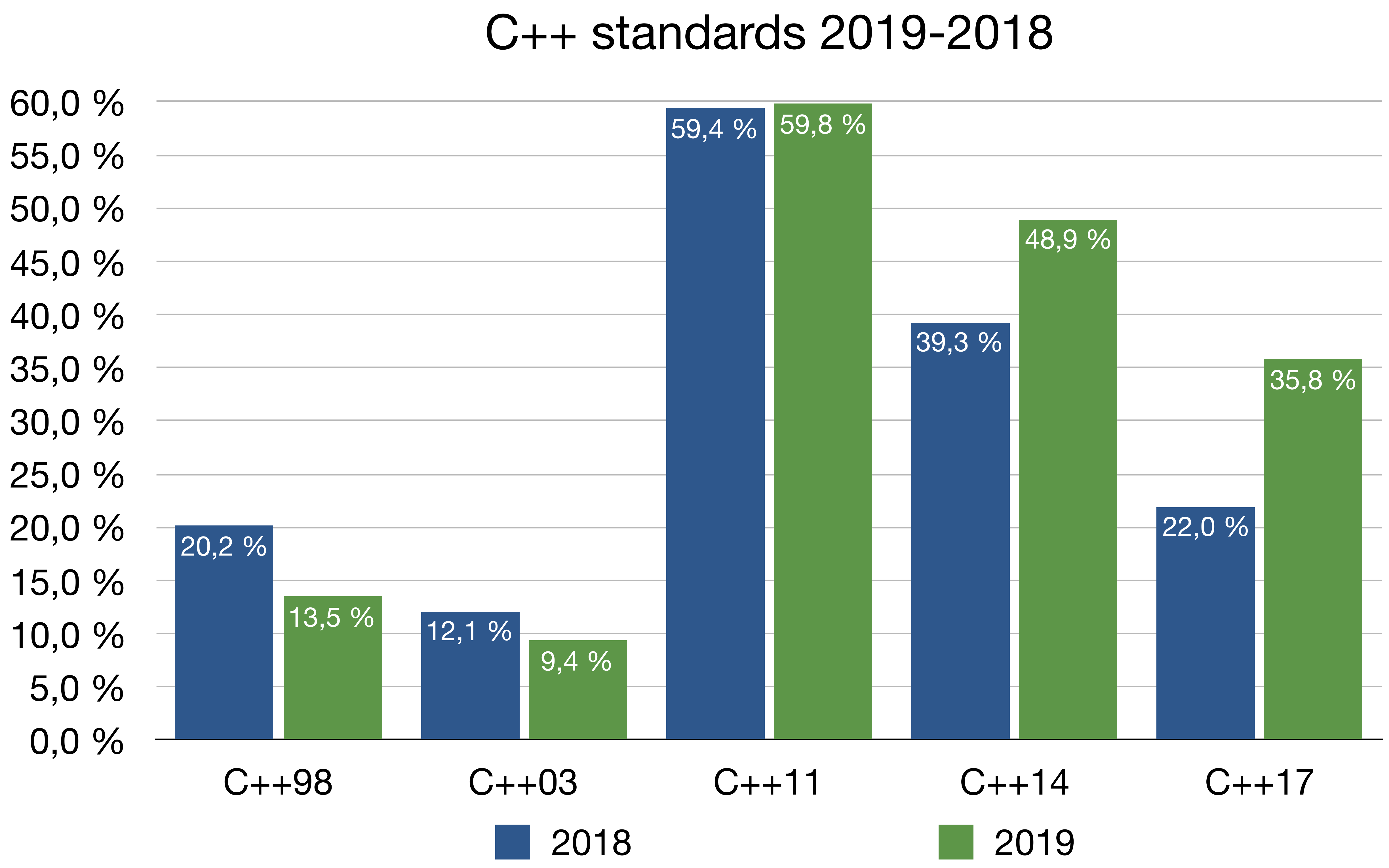

C++ standards usage
60,0 %
55,0 %
50,0 %
45,0 %
40,0 %
35,0 %
30,0 %
25,0 %
20,0 %
15,0 %
10,0 %
5,0 %
0,0 %
13,5 %
9,4 %
59,8 %
48,9 %
35,8 %
C++98
C++03
C++11
C++14
C++17

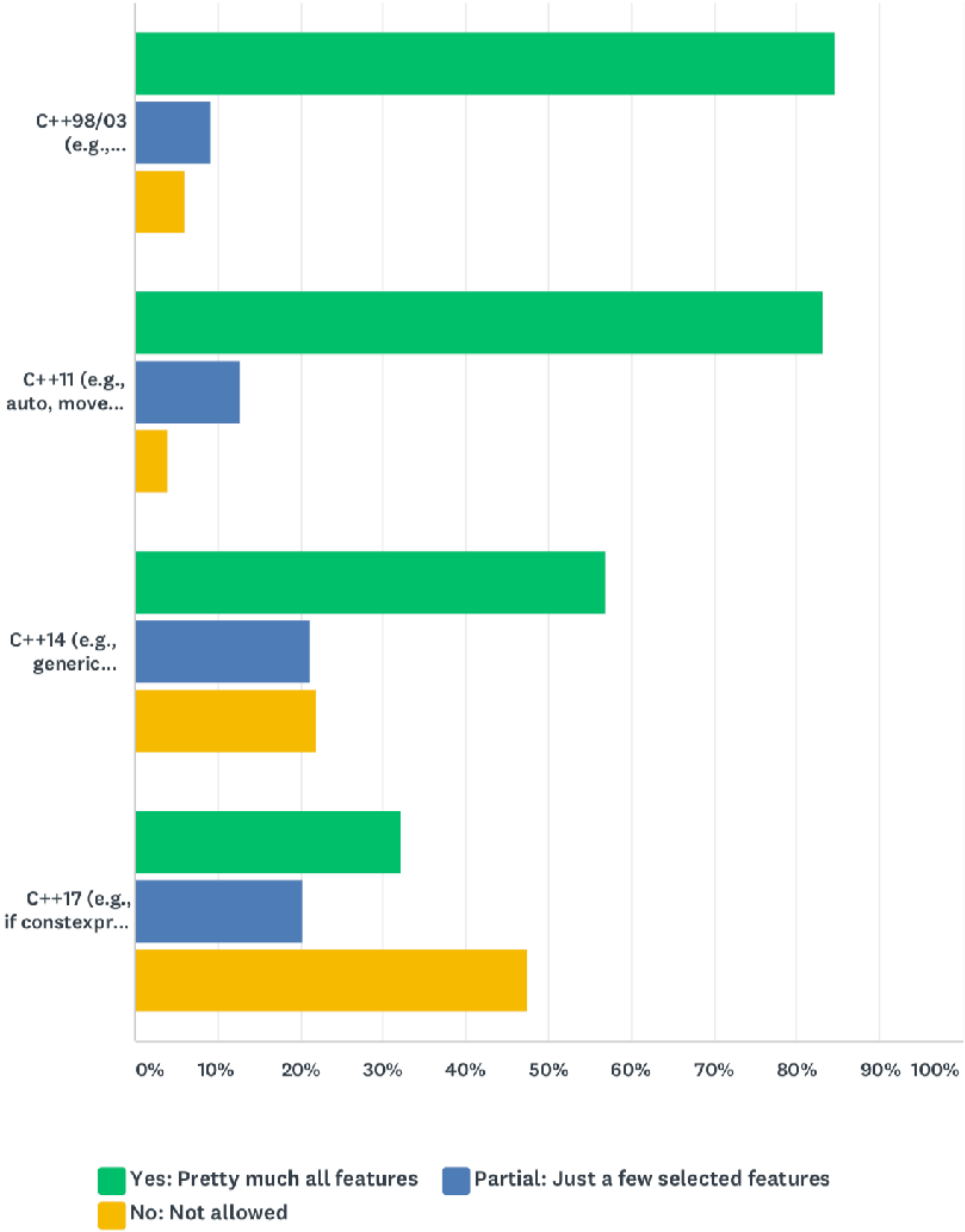
# C++ standards



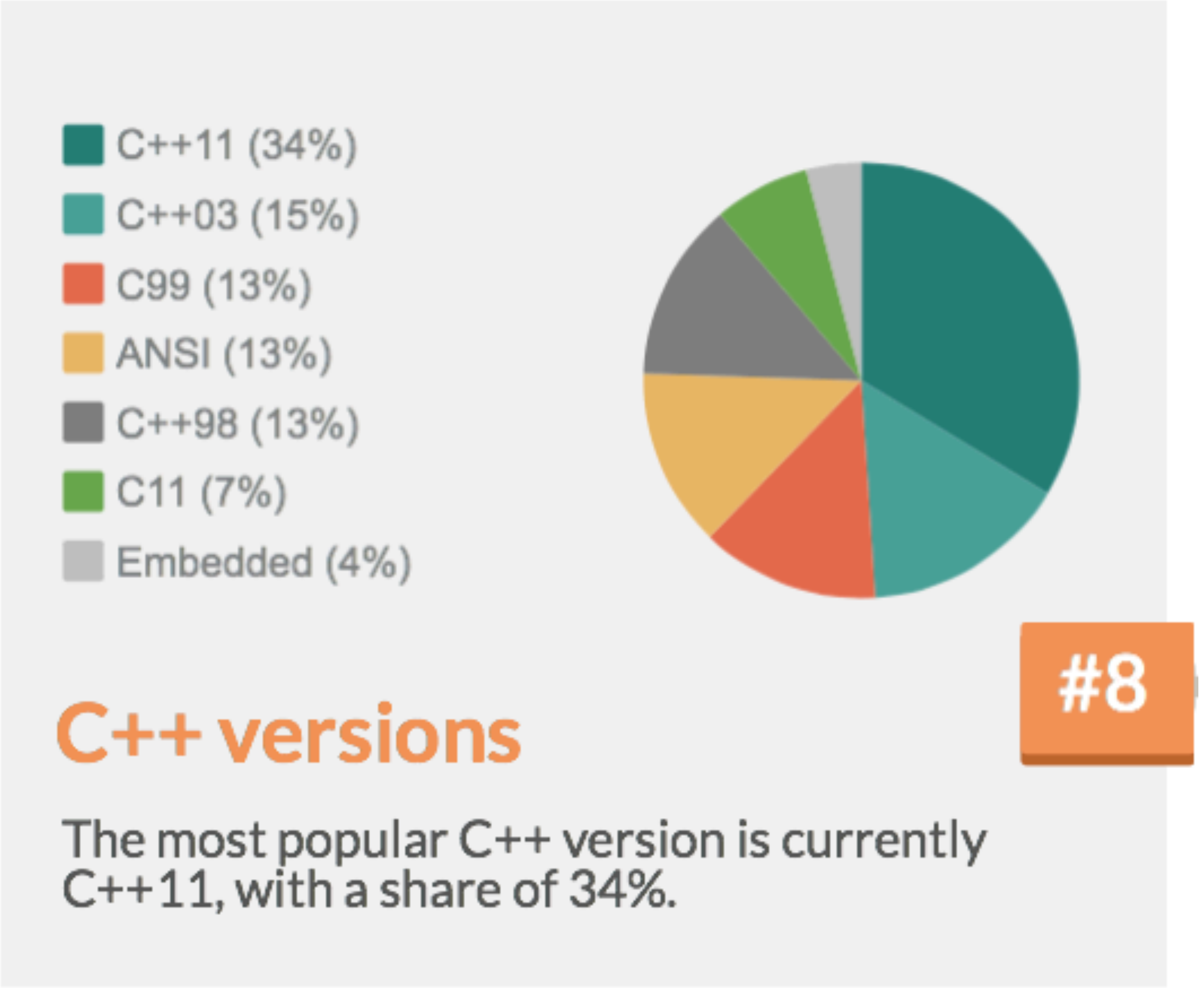
C++ standards 2019-2018
60,0 %
55,0 %
50,0 %
45,0 %
40,0 %
35,0 %
30,0 %
25,0 %
20,0 %
15,0 %
10,0 %
5,0 %
0,0 %
20,2 %
13,5 %
12,1 %
9,4 %
59,4 %
59,8 %
39,3 %
48,9 %
22,0 %
35,8 %
C++98
C++03
C++11
C++14
C++17
2018
2019

# C++ standards


C++ standards 2019-2018
60,0 %
55,0 %
50,0 %
45,0 %
40,0 %
35,0 %
30,0 %
25,0 %
20,0 %
15,0 %
10,0 %
5,0 %
0,0 %
20,2 %
13,5 %
12,1 %
9,4 %
59,4 %
59,8 %
39,3 %
48,9 %
22,0 %
35,8 %
C++98
C++03
C++11
C++14
C++17
2018
2019


C++98/03 (e.g.,...
C++11 (e.g., auto, move...
C++14 (e.g., generic...
C++17 (e.g., if constexpr...
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Yes: Pretty much all features
Partial: Just a few selected features
No: Not allowed

# C++ standards



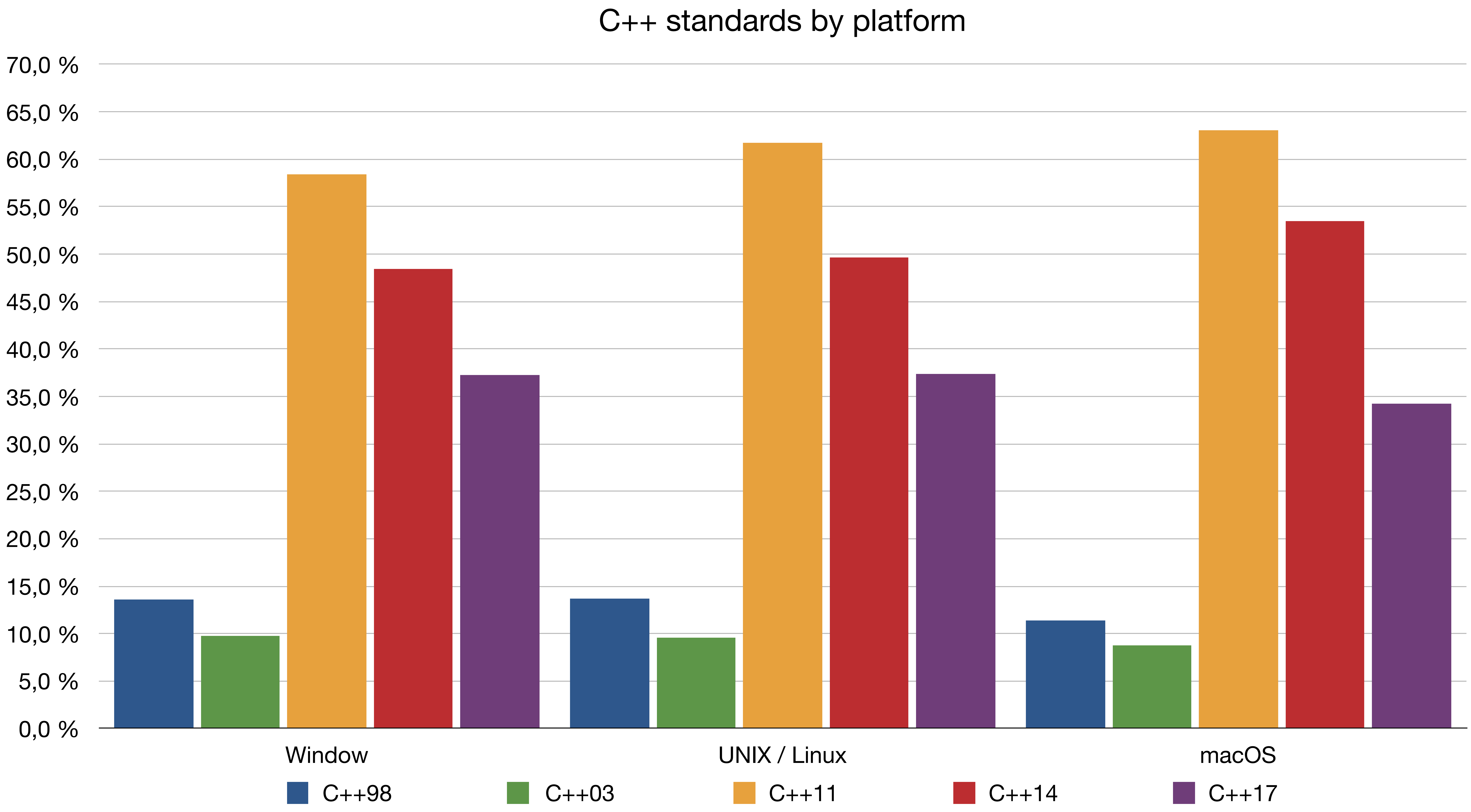
## C++ versions

The most popular C++ version is currently C++11, with a share of 34%.

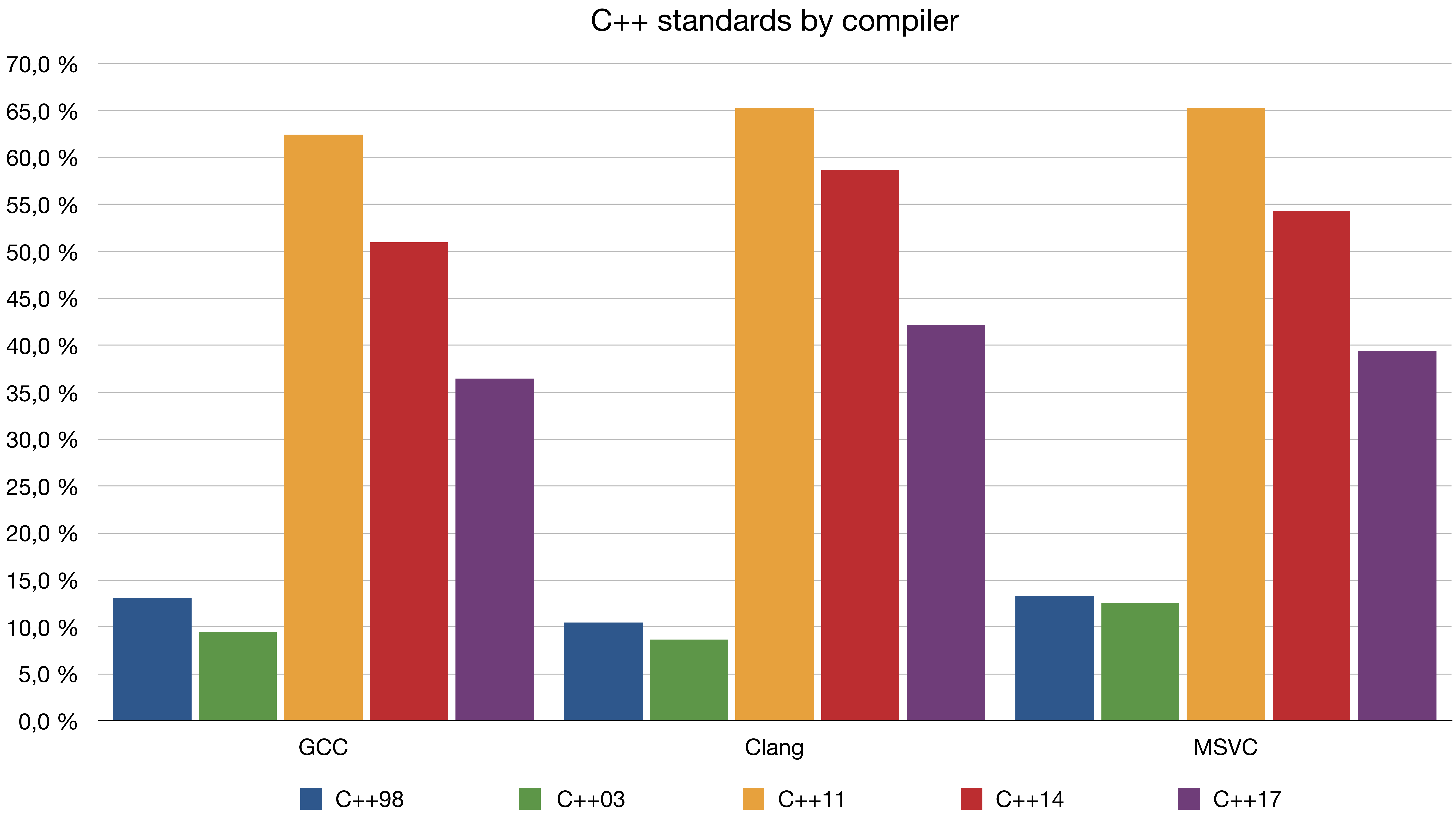
# The State of Developer Ecosystem: C++

- Per platforms distribution
- Per compiler distribution
- Per area of development
- Per employment group

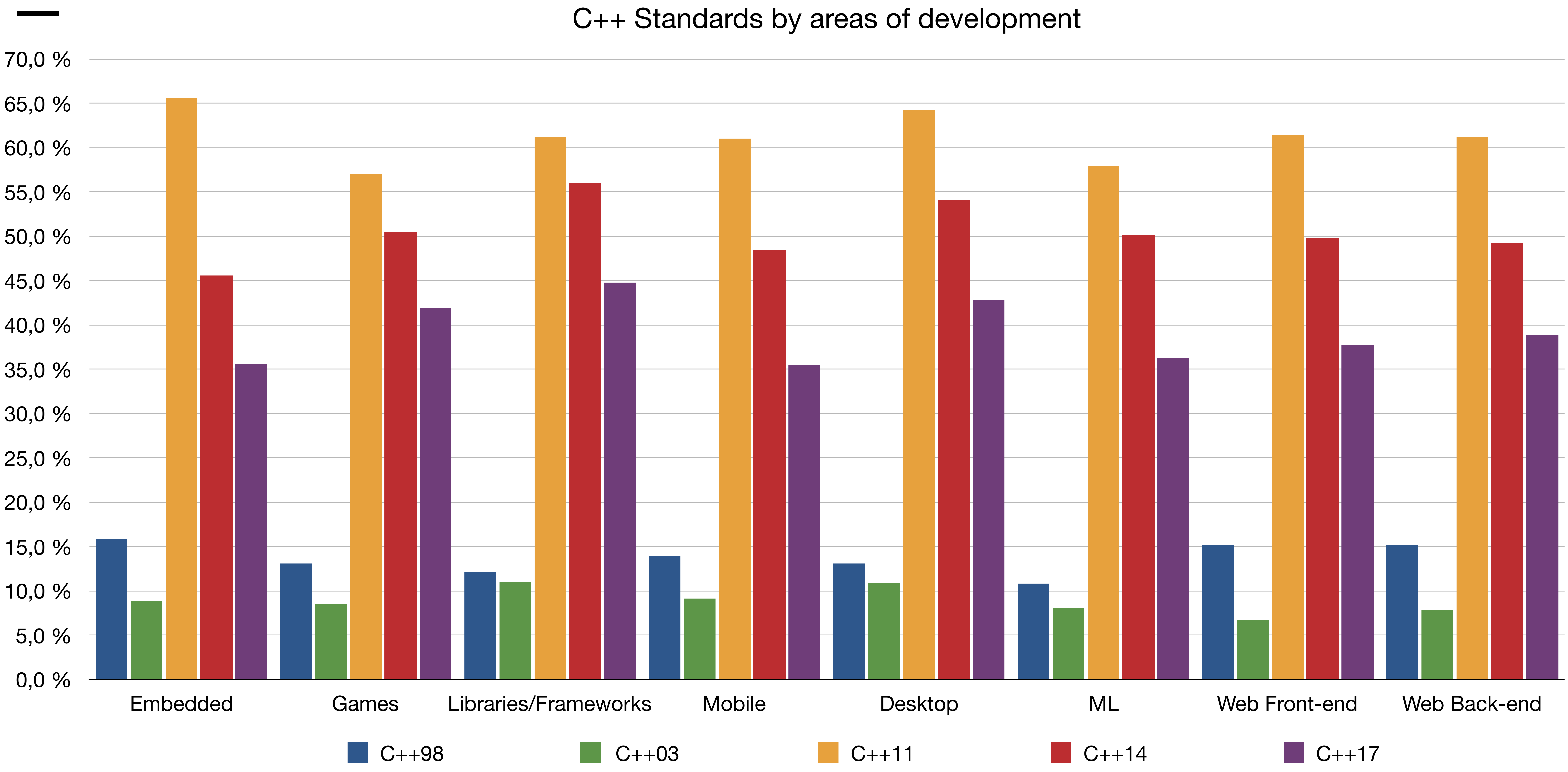
# C++ standards


C++ standards by platform
70,0 %
65,0 %
60,0 %
55,0 %
50,0 %
45,0 %
40,0 %
35,0 %
30,0 %
25,0 %
20,0 %
15,0 %
10,0 %
5,0 %
0,0 %
Window
UNIX / Linux
macOS
C++98
C++03
C++11
C++14
C++17

# C++ standards

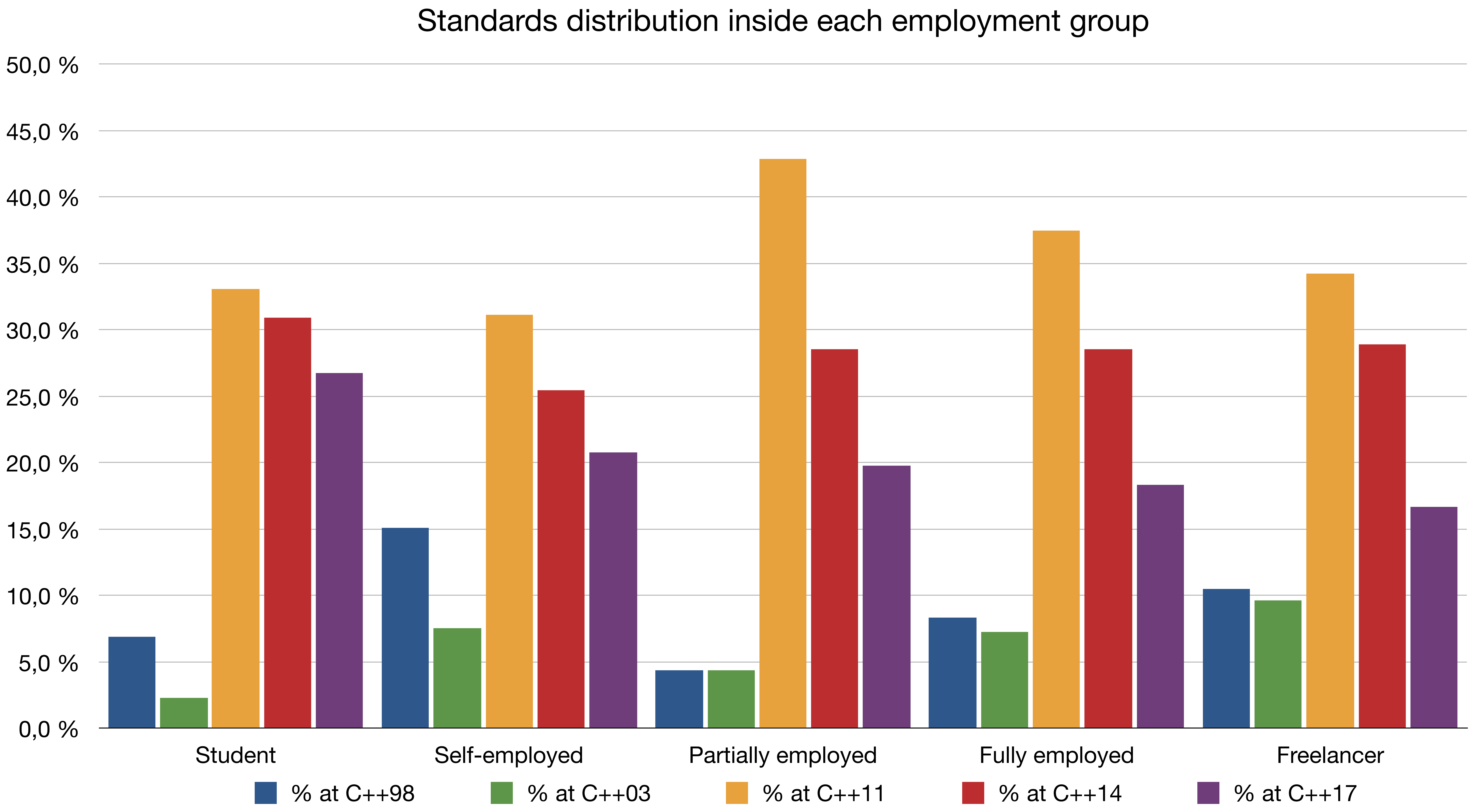

C++ standards by compiler
70,0 %
65,0 %
60,0 %
55,0 %
50,0 %
45,0 %
40,0 %
35,0 %
30,0 %
25,0 %
20,0 %
15,0 %
10,0 %
5,0 %
0,0 %
GCC
Clang
MSVC
C++98
C++03
C++11
C++14
C++17

# C++ standards

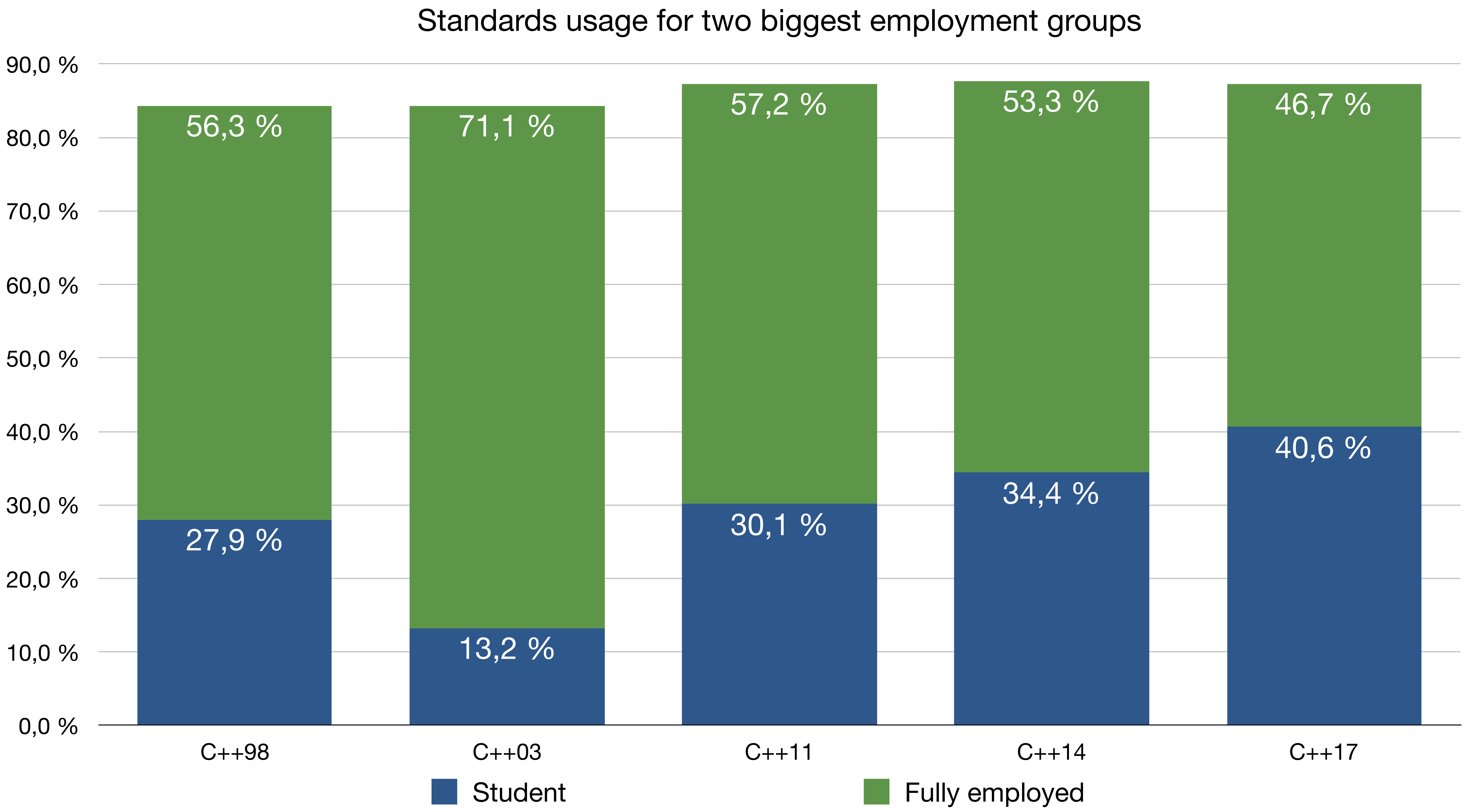


C++ Standards by areas of development

# C++ standards


Standards distribution inside each employment group
50,0 %
45,0 %
40,0 %
35,0 %
30,0 %
25,0 %
20,0 %
15,0 %
10,0 %
5,0 %
0,0 %
Student
Self-employed
Partially employed
Fully employed
Freelancer
% at C++98
% at C++03
% at C++11
% at C++14
% at C++17

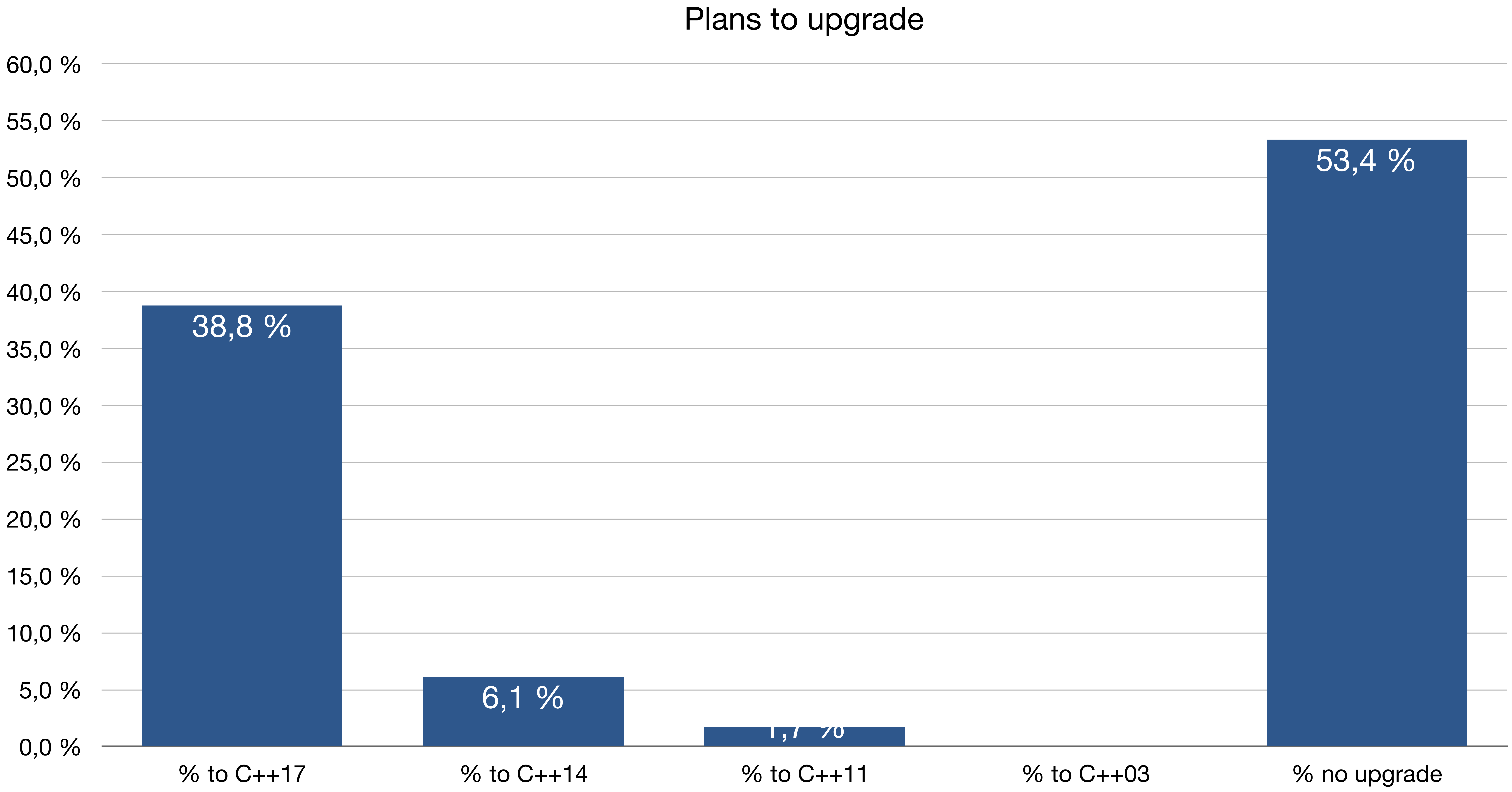
# C++ standards


Standards usage for two biggest employment groups
90,0 %
80,0 %
70,0 %
60,0 %
50,0 %
40,0 %
30,0 %
20,0 %
10,0 %
0,0 %
56,3 %
27,9 %
71,1 %
13,2 %
57,2 %
30,1 %
53,3 %
34,4 %
46,7 %
40,6 %
C++98
C++03
C++11
C++14
C++17
Student
Fully employed

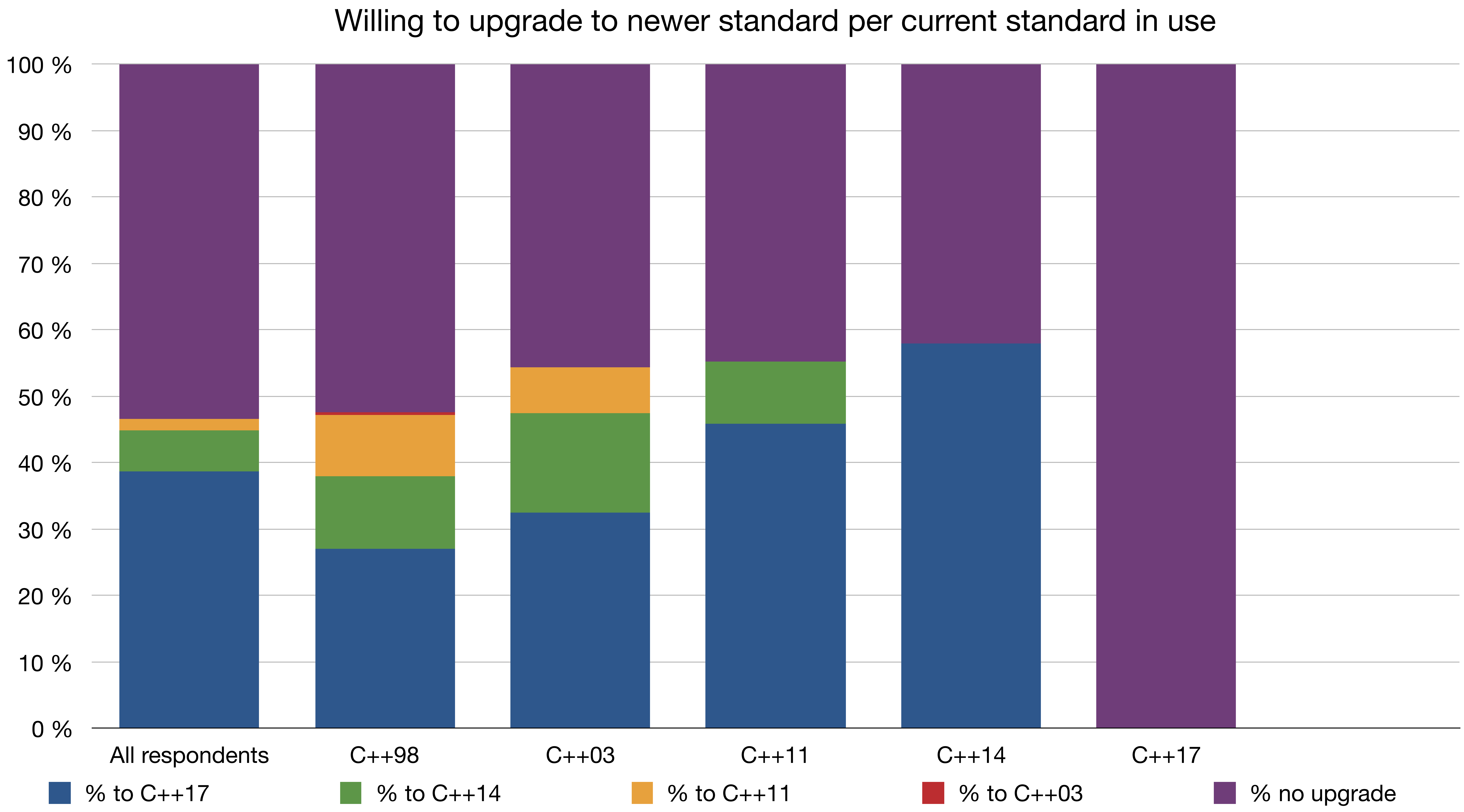
## Throwing a ball

# Upgrading

# C++ standards: upgrade



# C++ standards: upgrade



## Throwing a ball

# C++ per areas

## C++ per areas

- Finances / Banking / Trading
- Embedded
- Games

# C++ in Banking and Trading

# C++ in Banking and Trading

- Language choices:
  - **Java** for the big enterprise systems, back end trading platforms etc.
  - **C++** for the low latency / high performance stuff
  - **C#** for front-end / desktop apps
  - **Python** for various scripting
- C++ is a primary choice
- Especially low latency trading and quantitive analytics
- Performance

# C++ in Banking and Trading

Performance:

- Low latency, not quick throughput
- And safety
- Requires understanding of the compiler output

Carl Cook “When a Microsecond Is an Eternity: High Performance Trading Systems in C++” (CppCon 2017)

# C++ in Banking and Trading

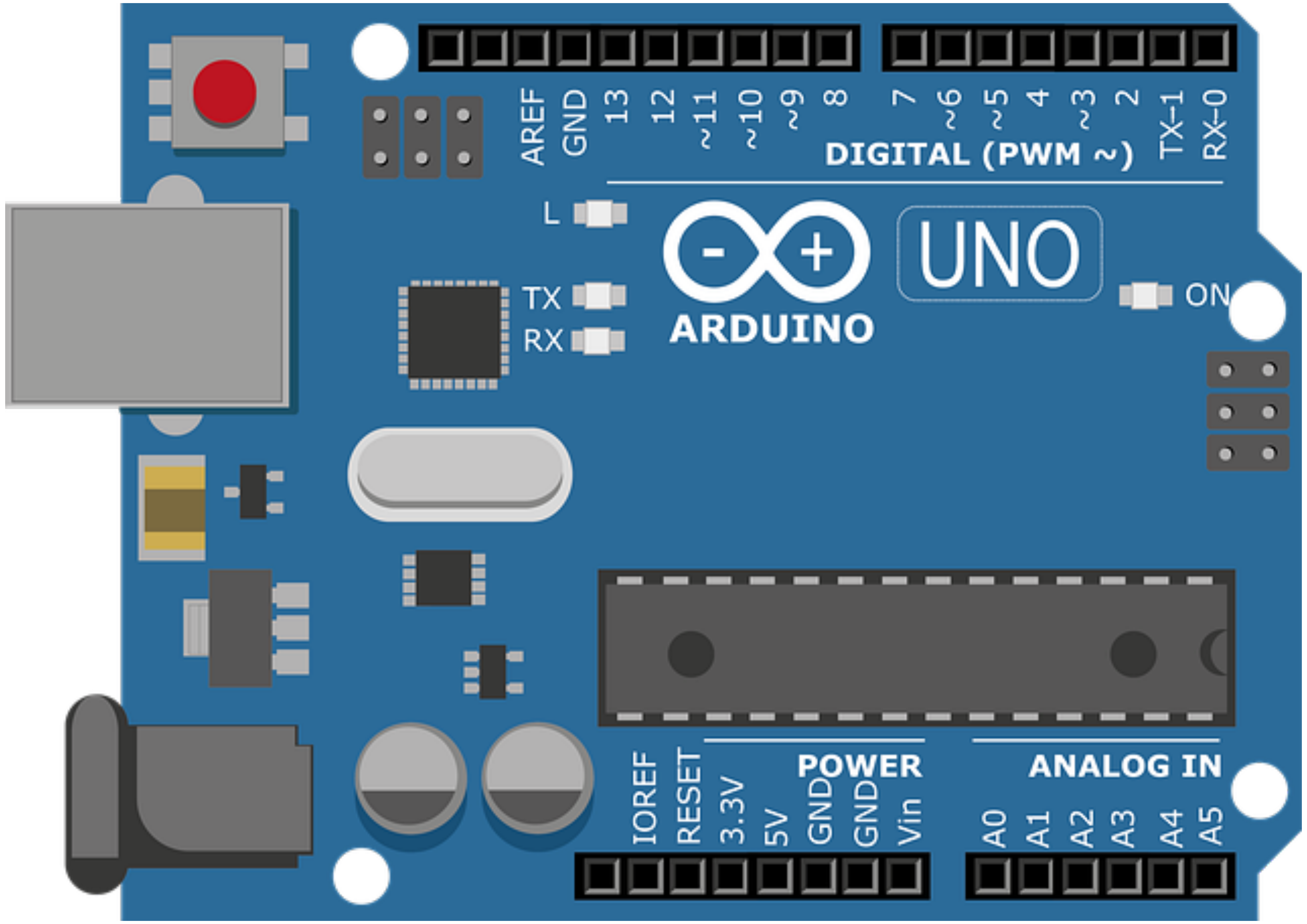
C++ usage:

- Allocations are important
- Exceptions are fine, if they don’t throw and not in the control flow
- Templates over virtual functions and branches
- Usage of low-level CPU instructions

Related ecosystem:

- Huge infrastructure, learning materials, wide expertise
- Lots of SDKs (CUDA, QuantLib)
- High cost of moving to the new technologies
- Affects clients

# C++ in Embedded



# C++ in Embedded

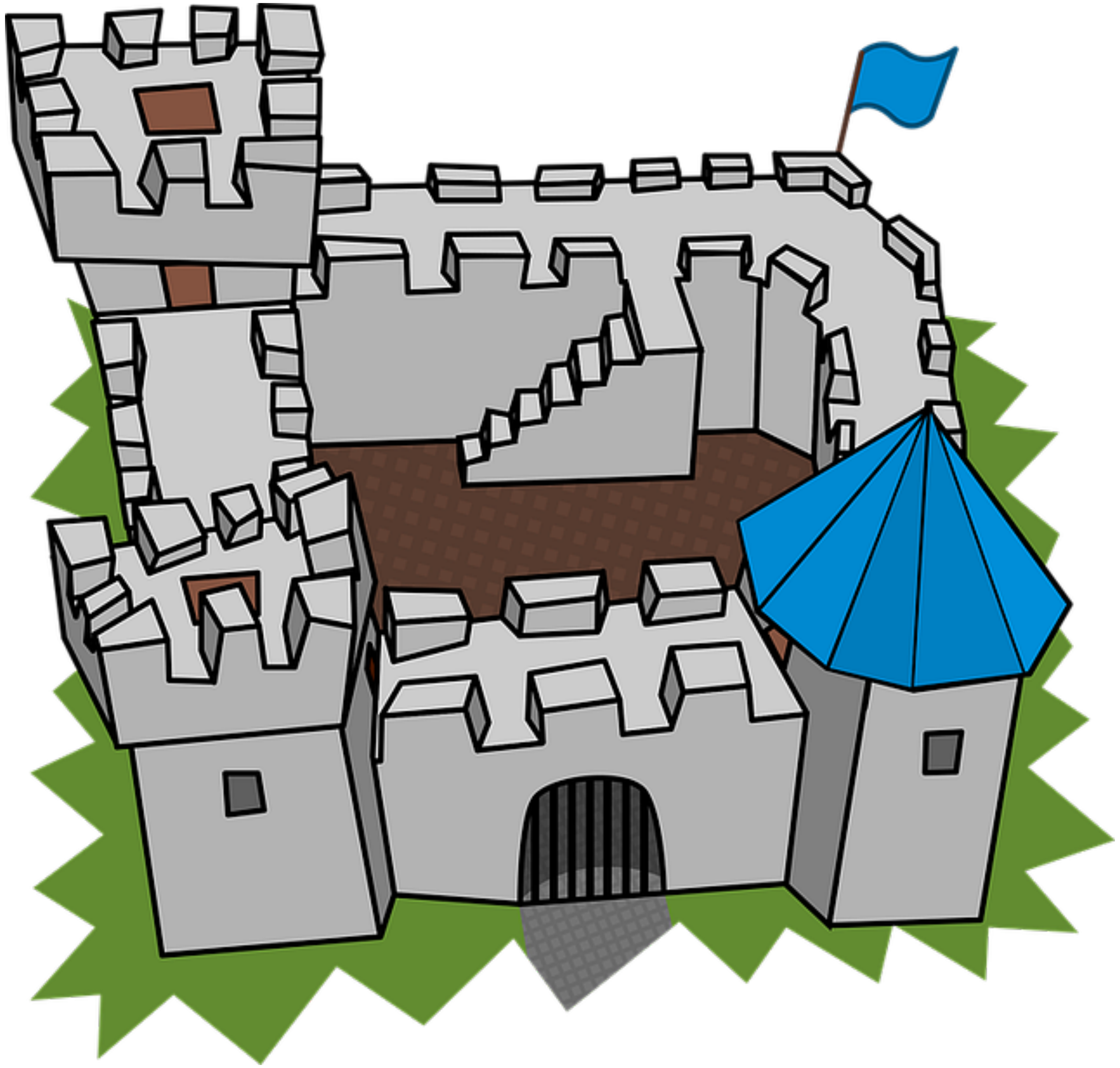
- Controlled by MCUs vendors
- Testing / Standards compliance / Certification tools
- Language choices:
  - C and C++, often more C than C++
  - Python, Lua, etc. for scripting, configurations, etc.
- Vendor’s compilers / debuggers / etc.

# C++ in Embedded

C++ usage:

- Classes are C structs with function pointers
- Macros are everywhere
- Direct memory/registers access
- Data structures in memory are specifically packed

# C++ in Games



# C++ in Games

- Language choices:
  - Unity/C# takes the biggest part of the market
  - AAA is mostly C++, Unreal Engine, Lumberyard, CryEngine and custom in-house engines
  - Rendering is mostly in C
- Console SDKs in binaries
- Performance (latency)

# C++ in Games

C++ usage

- C++03 and C++11
- In-house reflection implementations
- No Boost or STL because of the allocations
- Minimal template usage
- No exceptions because of their cost

# C++ in Games

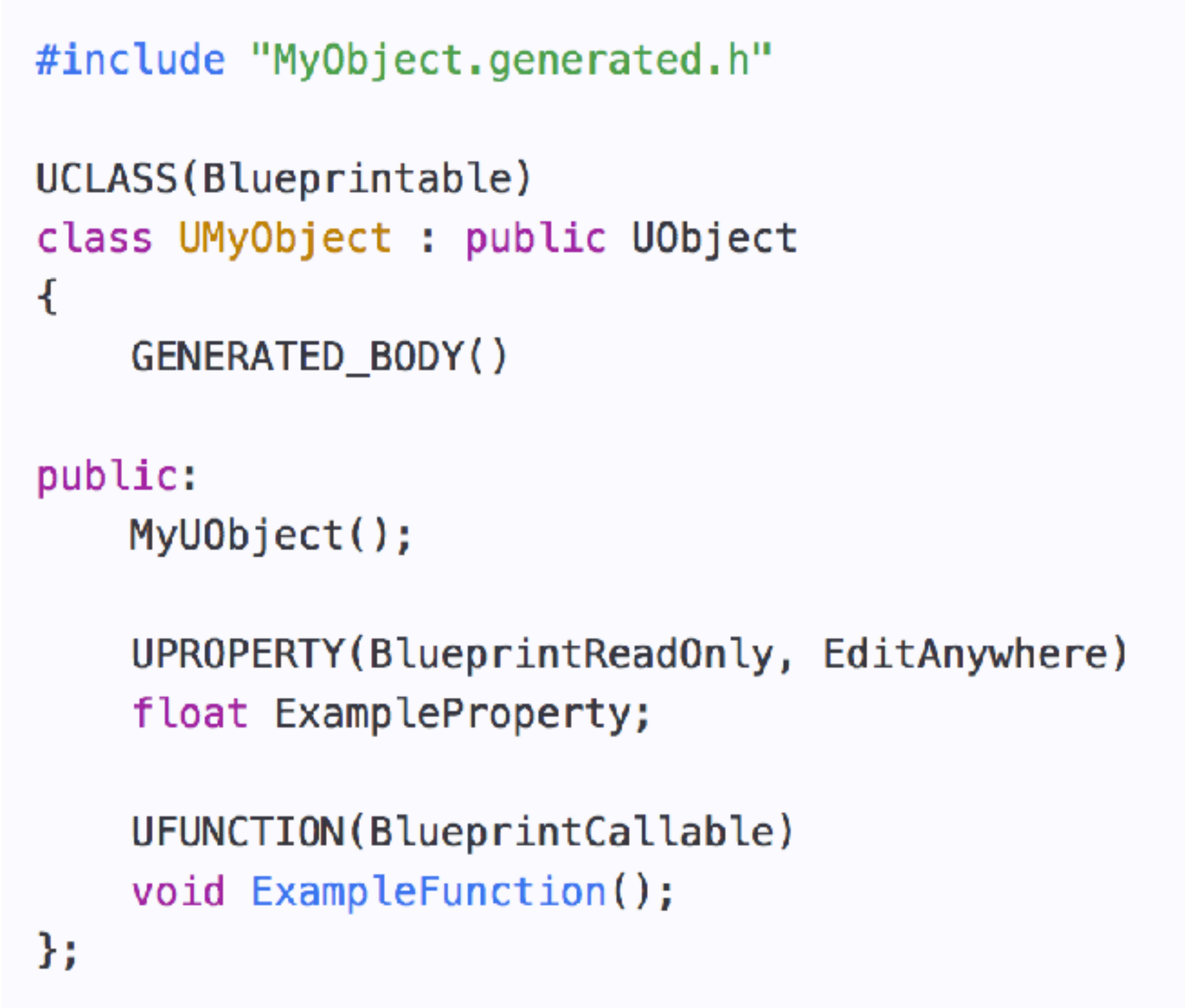
Reflection

- For serialization
- For GC
- For network replication
- For various characteristics

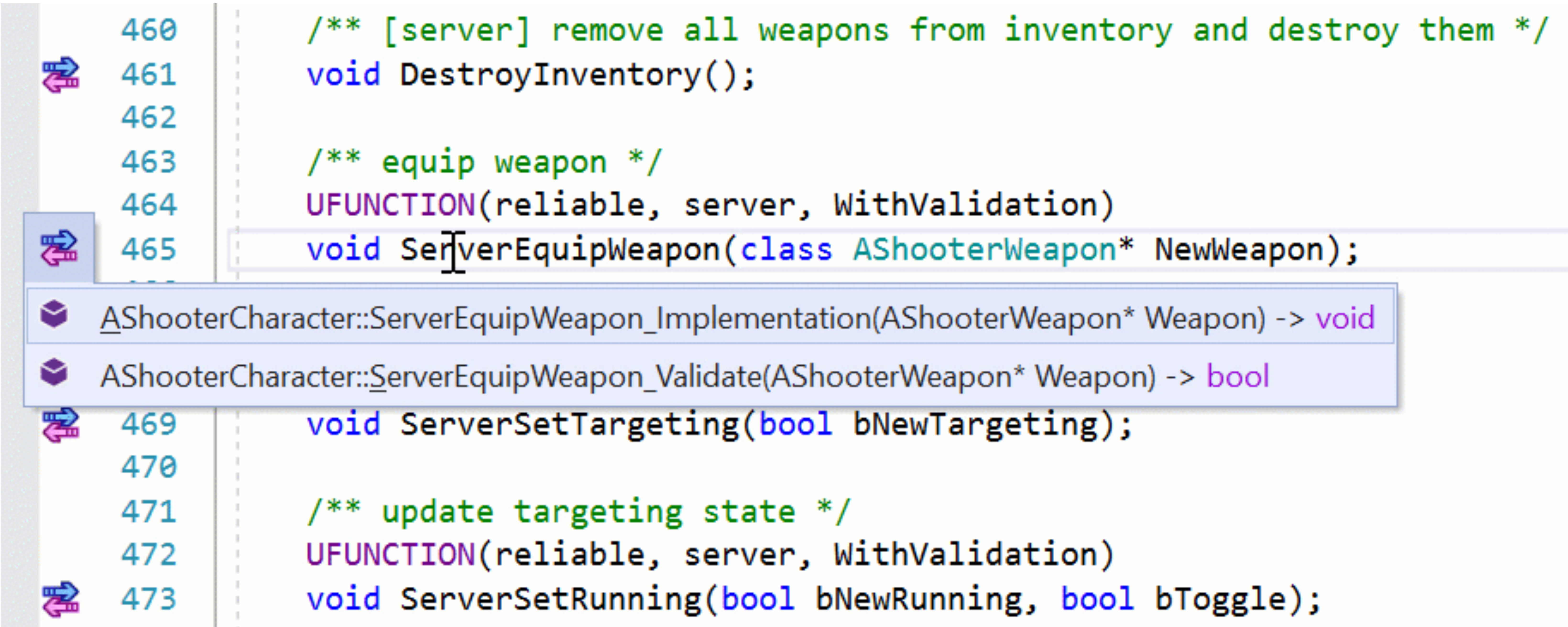
# C++ in Games

Reflection in Unreal Engine:

- Serves for interaction between C++/Blueprint
- Implemented with macros
- RPC methods



```cpp
#include "MyObject.generated.h"

UCLASS(Blueprintable)
class UMyObject : public UObject
{
    GENERATED_BODY()

public:
    MyUObject();

    UPROPERTY(BlueprintReadOnly, EditAnywhere)
    float ExampleProperty;

    UFUNCTION(BlueprintCallable)
    void ExampleFunction();
};
```



```cpp
/** [server] remove all weapons from inventory and destroy them */
void DestroyInventory();

/** equip weapon */
UFUNCTION(reliable, server, WithValidation)
void ServerEquipWeapon(class AShooterWeapon* NewWeapon);
```

```
AShooterCharacter::ServerEquipWeapon_Implementation(AShooterWeapon* Weapon) -> void
AShooterCharacter::ServerEquipWeapon_Validate(AShooterWeapon* Weapon) -> bool
```

```cpp
void ServerSetTargeting(bool bNewTargeting);

/** update targeting state */
UFUNCTION(reliable, server, WithValidation)
void ServerSetRunning(bool bNewRunning, bool bToggle);
```

# C++ in Games

Custom STL & Allocations

- No STL, custom structures, plain arrays
- Non-default memory alignment requirements
- Newly constructed or reset container allocates no memory
- Avoiding heap
- Temporal allocators with the life-time of the frame

Sample: InplaceArray<ubi32, 8>

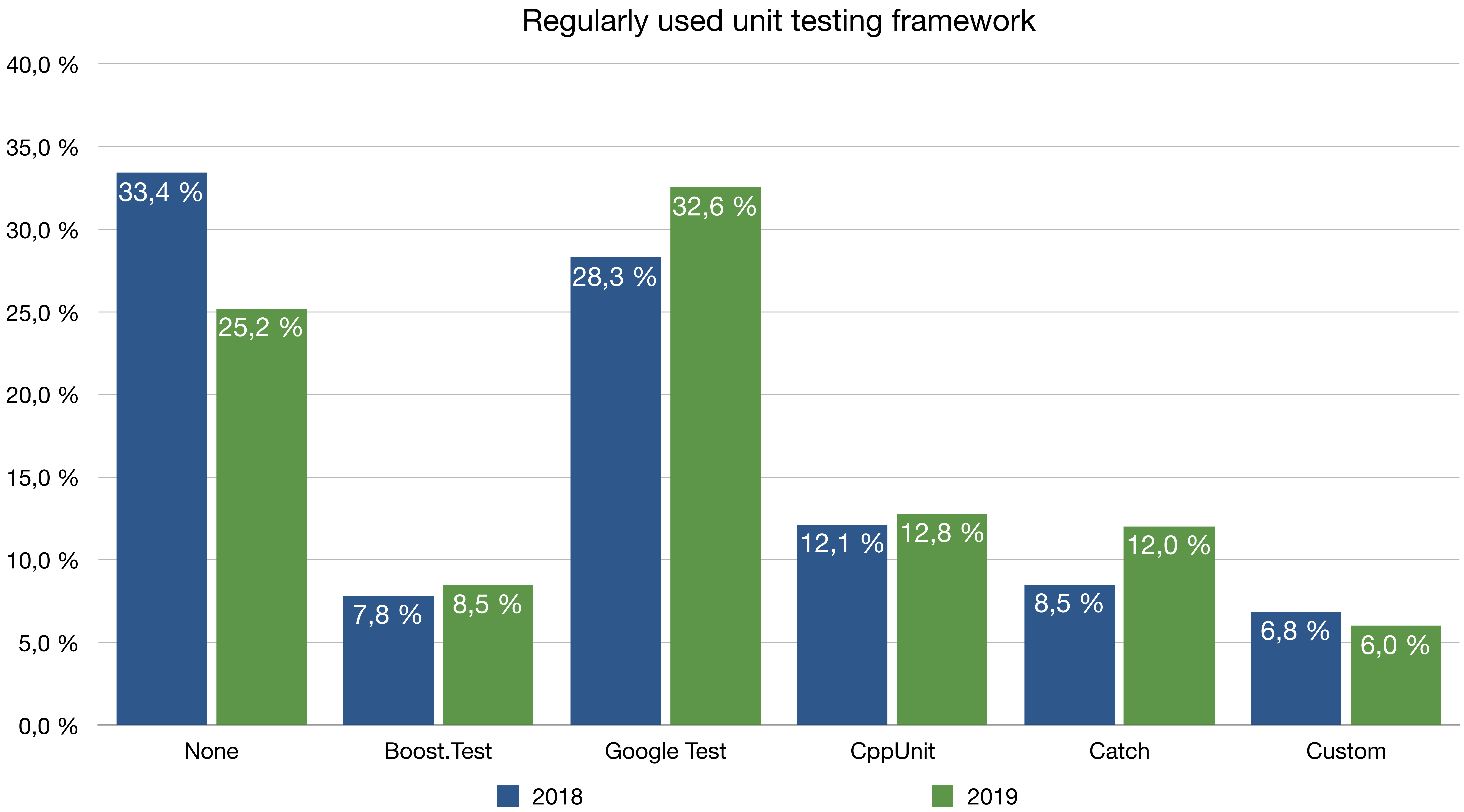
Nicolas Fleury "C++ in Huge AAA Games” (CppCon 2014)
Scott Wardle "Memory and C++ debugging at Electronic Arts” (CppCon 2015)
EASTL – Electronic Arts Standard Template Library

*"Among game developers the most fundamental weakness [of the STL] is the std allocator design, and it is this weakness that was the largest contributing factor to the creation of EASTL.”*

## Throwing a ball

# Unit testing

# Unit testing



# Unit testing

- ~70 in the list: https://en.wikipedia.org/wiki/List_of_unit_testing_frameworks#C++
- Reddit discussions:
  - Most Popular C++ Unit Testing Frameworks
    https://www.reddit.com/r/cpp/comments/4e9afx/most_popular_c_unit_testing_frameworks/
  - Best way to do unit testing in c++?
    https://www.reddit.com/r/cpp/comments/36pru0/best_way_to_do_unit_testing_in_c/
  - Is there a de-facto standard "framework" for unit testing in C++?
    https://www.reddit.com/r/cpp/comments/1zh0p1/is_there_a_defacto_standard_framework_for_unit/
- Recommendations: Google Test (with Google Mock), Catch

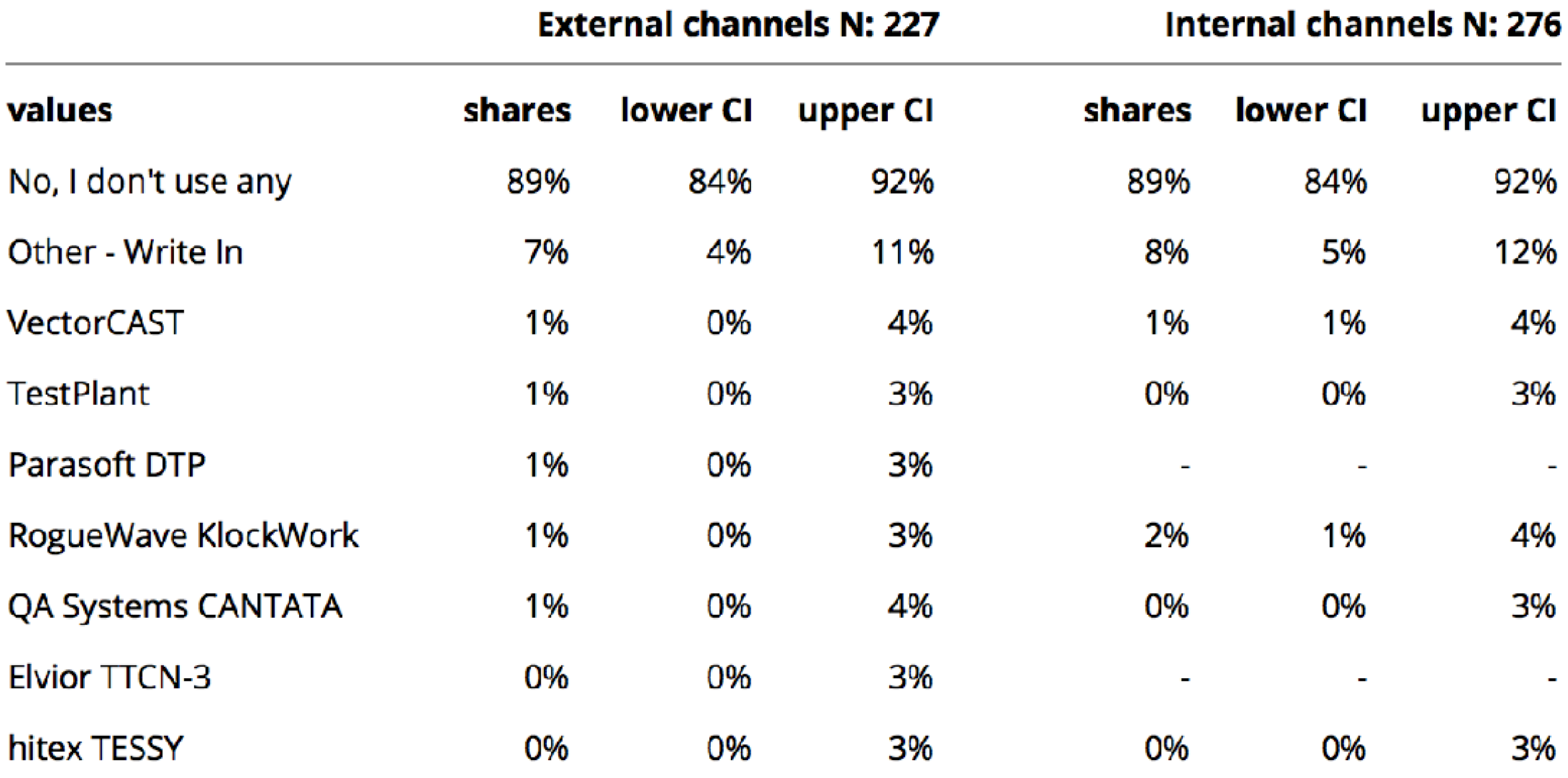
# Unit testing

| Criteria | Framework |
|---|---|
| Feature rich | Google Test, Boost.Test |
| Easy-to-start | Catch |
| Integrations | Google Test |

# Unit testing

Embedded market:

- tests running on hardware
- tests are required for certifications according to the standards
- no home-made products because of the certification
- no integration into IDEs (Eclipse)
- pricy

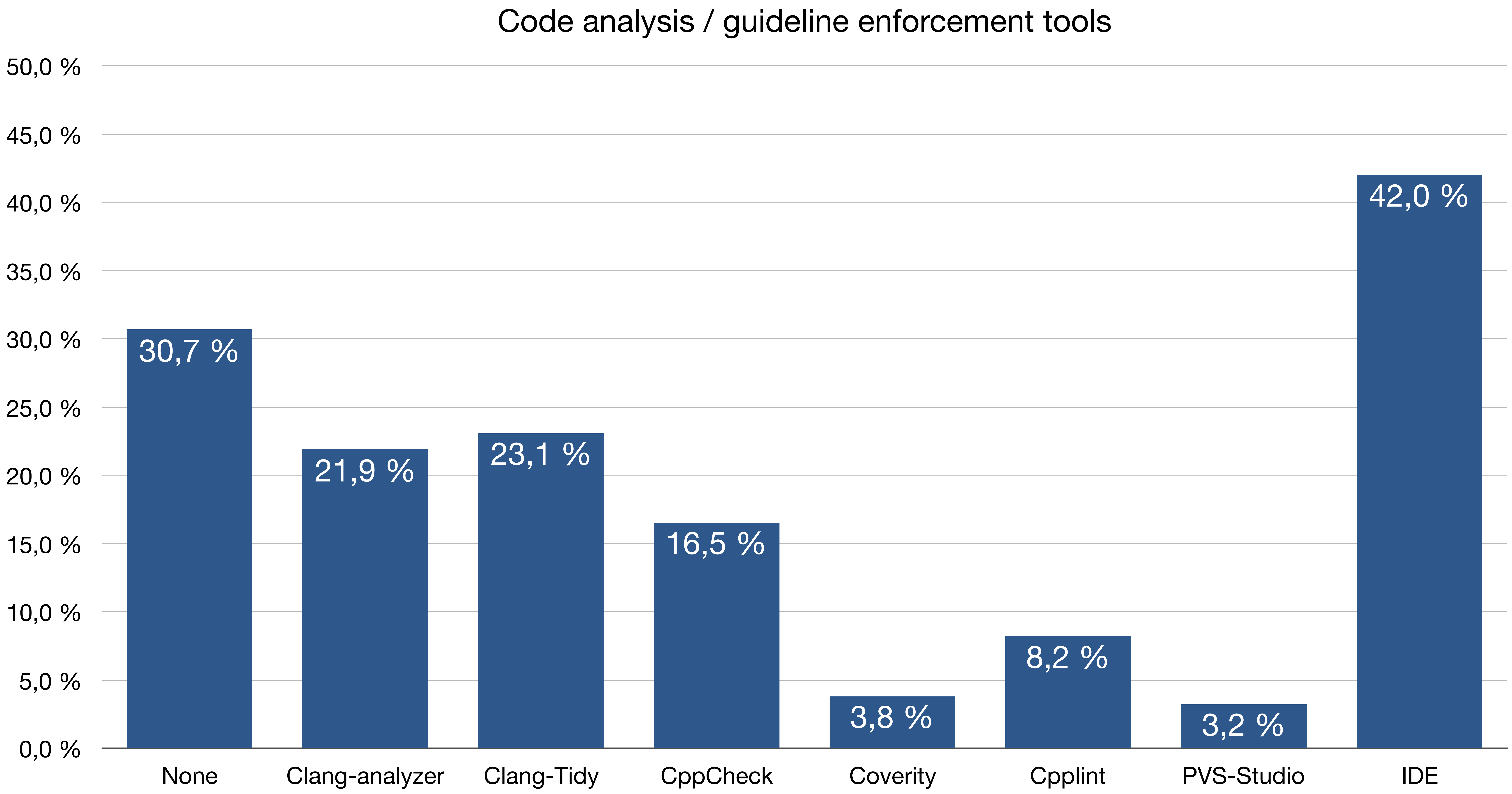


| | External channels N: 227 | | | Internal channels N: 276 | | |
|---|---|---|---|---|---|---|
| **values** | **shares** | **lower CI** | **upper CI** | **shares** | **lower CI** | **upper CI** |
| No, I don't use any | 89% | 84% | 92% | 89% | 84% | 92% |
| Other - Write In | 7% | 4% | 11% | 8% | 5% | 12% |
| VectorCAST | 1% | 0% | 4% | 1% | 1% | 4% |
| TestPlant | 1% | 0% | 3% | 0% | 0% | 3% |
| Parasoft DTP | 1% | 0% | 3% | - | - | - |
| RogueWave KlockWork | 1% | 0% | 3% | 2% | 1% | 4% |
| QA Systems CANTATA | 1% | 0% | 4% | 0% | 0% | 3% |
| Elvior TTCN-3 | 0% | 0% | 3% | - | - | - |
| hitex TESSY | 0% | 0% | 3% | 0% | 0% | 3% |

Throwing a ball

# Code analysis / guidelines enforcement

# Code analysis



## Not throwing a ball

# How C++ committee and tooling can help?

# Language evolution & tooling

Compatibility and reduced cost of the integration

- C++ mostly never breaks the compatibility
- Redesigning modules
- New exceptions

# Language evolution & tooling

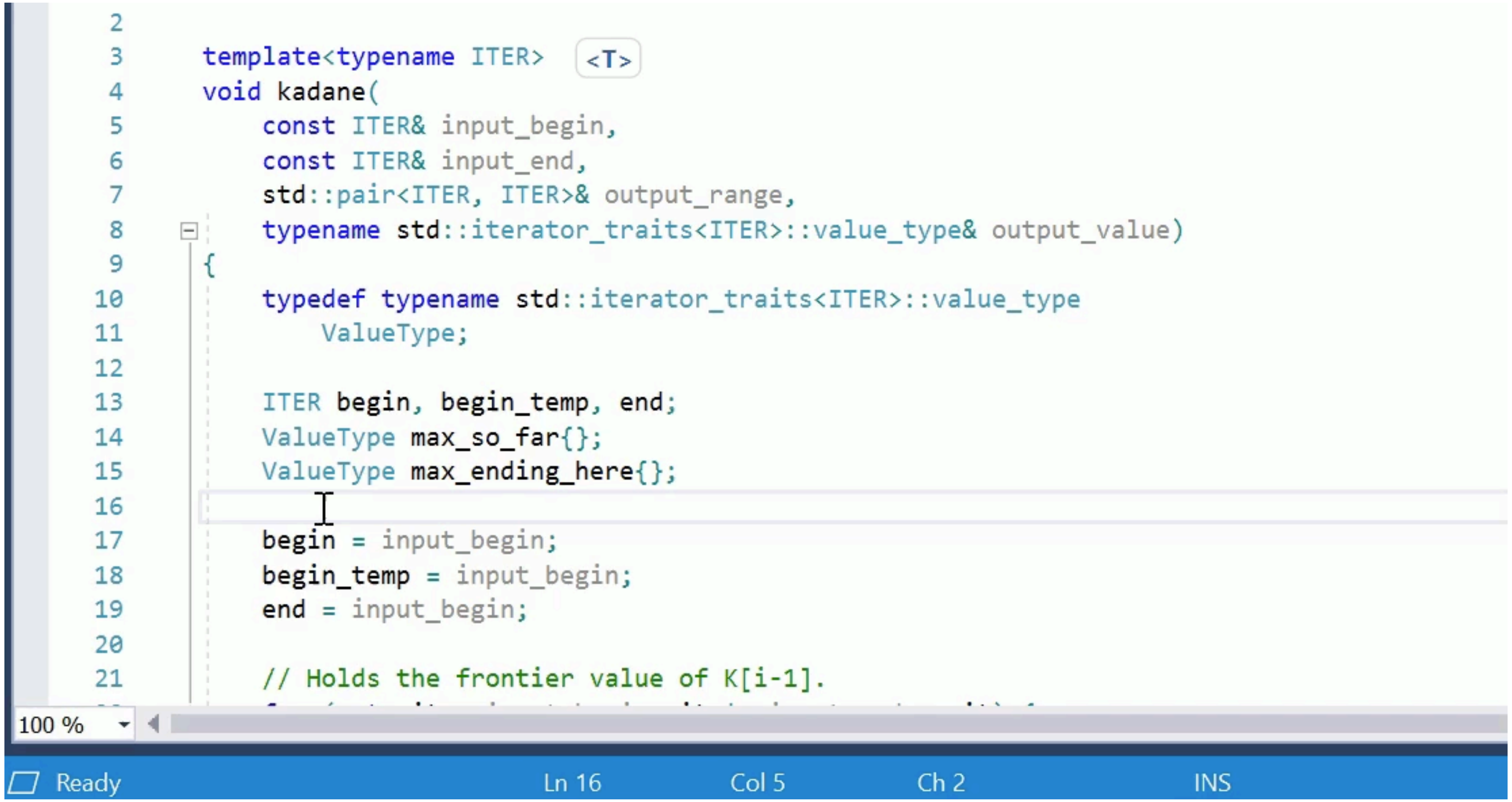
Support in tooling

- Compilers adopting new features quickly
- IDEs providing support for features
- Features are toolable

# Language evolution & tooling

Example:
Templates intellisense

Visual Studio



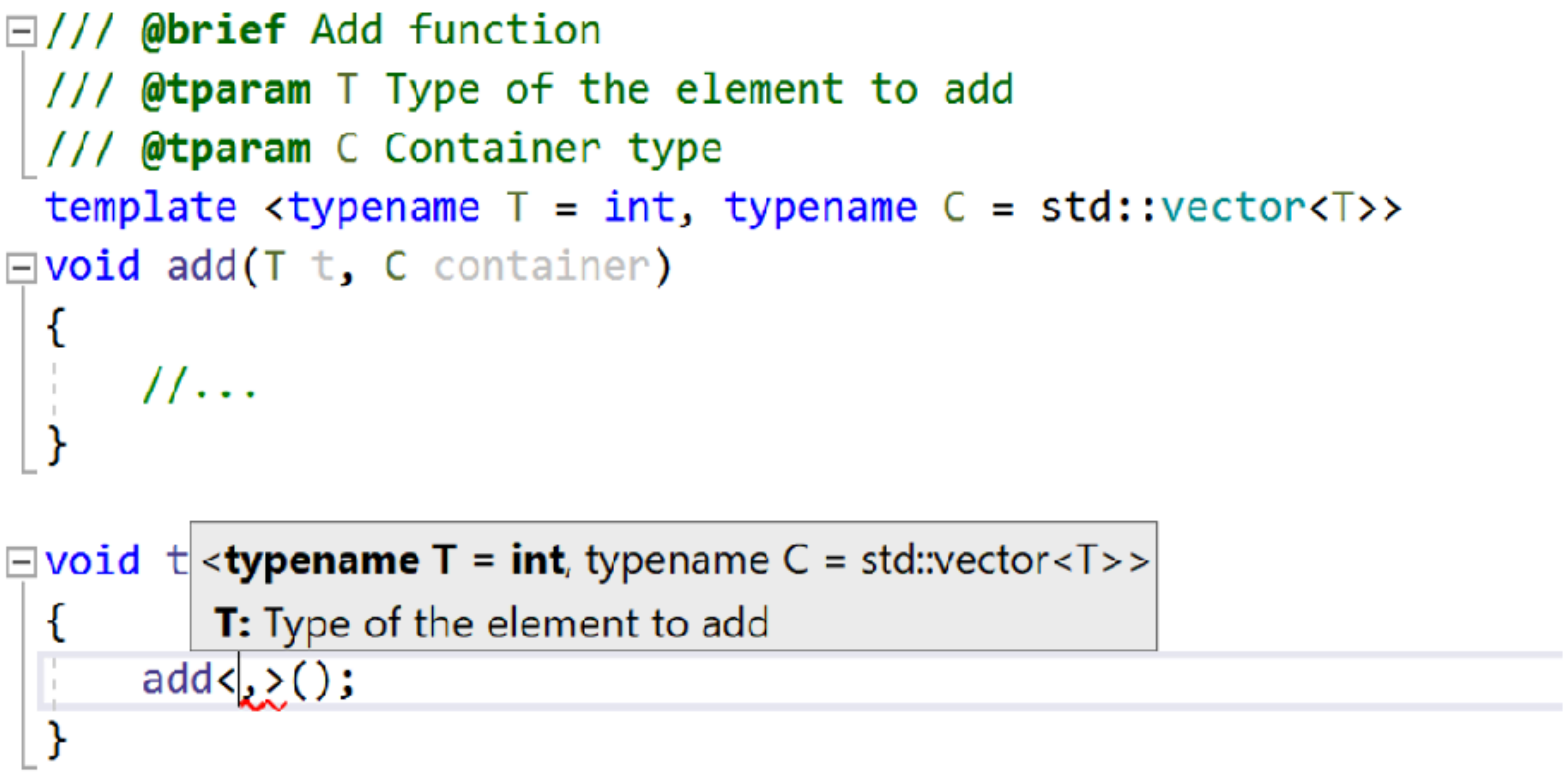
```
template<typename ITER>
void kadane(
    const ITER& input_begin,
    const ITER& input_end,
    std::pair<ITER, ITER>& output_range,
    typename std::iterator_traits<ITER>::value_type& output_value)
{
    typedef typename std::iterator_traits<ITER>::value_type
        ValueType;

    ITER begin, begin_temp, end;
    ValueType max_so_far{};
    ValueType max_ending_here{};

    begin = input_begin;
    begin_temp = input_begin;
    end = input_begin;

    // Holds the frontier value of K[i-1].
```

Ready Ln 16 Col 5 Ch 2 INS

# Language evolution & tooling

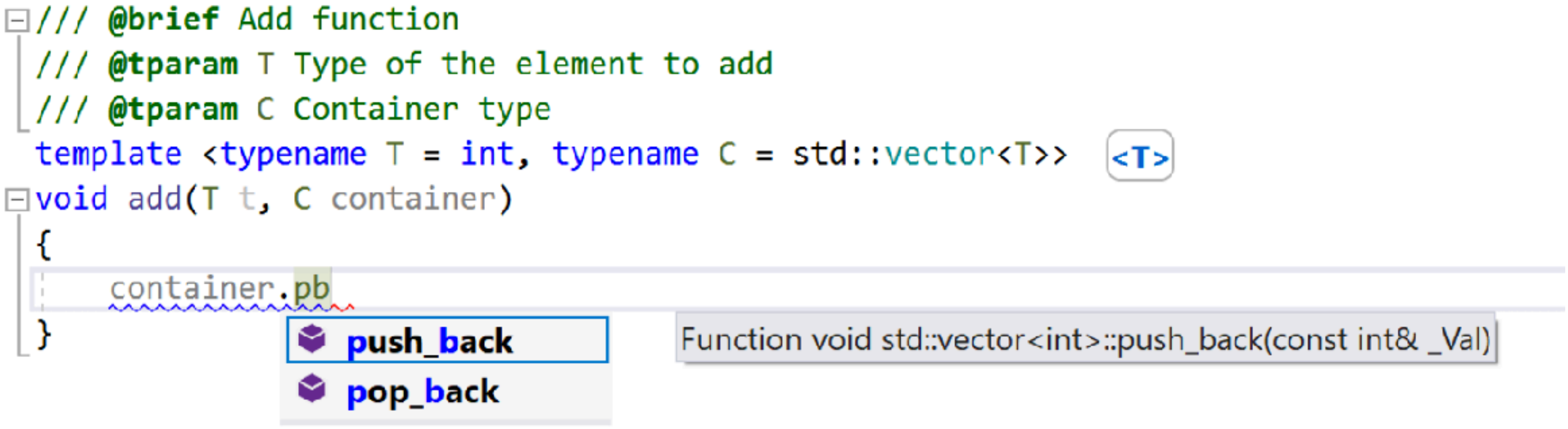
Example:
Templates intellisense

ReSharper C++



```
/// @brief Add function
/// @tparam T Type of the element to add
/// @tparam C Container type
template <typename T = int, typename C = std::vector<T>>
void add(T t, C container)
{
    //...
}

void t
{
    add<,>();
}
```

<typename T = int, typename C = std::vector<T>>
T: Type of the element to add



```
/// @brief Add function
/// @tparam T Type of the element to add
/// @tparam C Container type
template <typename T = int, typename C = std::vector<T>>
void add(T t, C container)
{
    container.pb
}
```

Function void std::vector<int>::push_back(const int& _Val)

# References

- C++ Foundation Developer Survey
  - [2018-2] https://isocpp.org/files/papers/CppDevSurvey-2018-02-summary.pdf
- The State of Developer Ecosystem Survey
  - [2017] https://www.jetbrains.com/research/devecosystem-2017/cpp/
  - [2018] https://www.jetbrains.com/research/devecosystem-2018/cpp/
  - [2019] https://www.jetbrains.com/research/devecosystem-2019 – results are not yet available!
- C/C++ Infographics
  - [collected 2013] https://blog.jetbrains.com/clion/2015/07/infographics-cpp-facts-before-clion/
- Nicolas Fleury "C++ in Huge AAA Games"
  - [CppCon 2014] https://www.youtube.com/watch?v=qYN6eduU06s
- Scott Wardle “Memory and C++ debugging at Electronic Arts”
  - [CppCon 2015] https://www.youtube.com/watch?v=8KIvWJUYbDA
- EASTL - Electronic Arts Standard Template Library
  - [2007] http://www.open-std.org/jtc1/sc22/wg21/docs/papers/2007/n2271.html
  - [GitHub] https://github.com/electronicarts/EASTL
- Carl Cook “When a Microsecond Is an Eternity: High Performance Trading Systems in C++”
  - [CppCon 2017] https://www.youtube.com/watch?v=NH1Tta7purM

# Thank you
for your attention

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Questions?