`std::format` *and* `{fmt}` – *an overview*

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What is {fmt}?

- The fmt library, styled {fmt}, authored largely by Victor Zverovich
- Solves the problem of formatting text, a la sprintf, et. al
- Formats all basic types consistently cross-platform
- Extensible for user types

Goals of {fmt}

- Safety
  - Type checking
  - Argument counting
  - Memory safe
- Compact generated code
- Portability
  - Versions 5.x and 6.x work on any C++11 compiler
  - Version 4.x continues to be maintained at C++98
  - No external dependencies
- Reuse tested formatting conventions from Python/Rust
- Speed
  - Benchmarks among the fastest for non-locale

The competition – `printf`

- Widely available
- Generally fast

- No safety at all
- No extensibility
- C-specific

The competition – `iostream`

- Widely available
- Safe
- Extensible

- Extremely verbose – “chevron hell”
- E.g.,

```
std::cout << std::setprecision(2) << std::fixed << 1.23456 << "\n";
```

vs.

```
printf("%.2f\n", 1.23456);
```

- Painfully slow number conversions

The competition – Boost Format

- Powerful
- Safe
- Extensible

- Slow performance
- Bloated generated code

Using `format()`

- No compiler I've found has it in the C++20 feature set, yet.
- `fmtlib`, also styled as `{fmt}`, is available under a very liberal license (MIT-style for open source, effectively unlimited for redistribution of compiled objects)
- Available in vcpkg, HomeBrew, GitHub, and others
- Also available in the list of libraries on godbolt.org
- Compiled library + headers; also can be used as header-only

{fmt} Hello world

```
#include <iostream>
#include "fmt/format.h"

int main()
{
    std::cout << fmt::format("Hello {}.",
                             "world");
    return 0;
}
```

C++20 Hello world

```cpp
#include <iostream>
#include <format>

int main()
{
    std::cout << std::format("Hello {}.",
                             "world");
    return 0;
}
```

C++20 Hello world

```cpp
#include <iostream>
#include <format>

int main()
{
    std::cout << std::format("Hello {}.",
                             "world");
    return 0;
}
```

An even easier {fmt} version, but not coming in C++20

```cpp
#include <iostream>

int main()
{
    fmt::format("Hello {}.", "world");
    return 0;
}
```

Demo code

- `01_hello_world.cpp` – `{fmt}` hello world
- `02_hello_word_std.cpp` – C++20 hello world
- `03_hello_world_fmt.cpp` – `{fmt}` hello world minus iostream
- `04_basic_types.cpp` – support for basic C++ types
- `05_format_string.cpp` – various format string specs
- `06_output_iterator.cpp` – output to an iterator instead of `std::string`
- `07_formatter_specialization.cpp` – add support for custom types
- `08_error_handling.cpp` – catching type errors

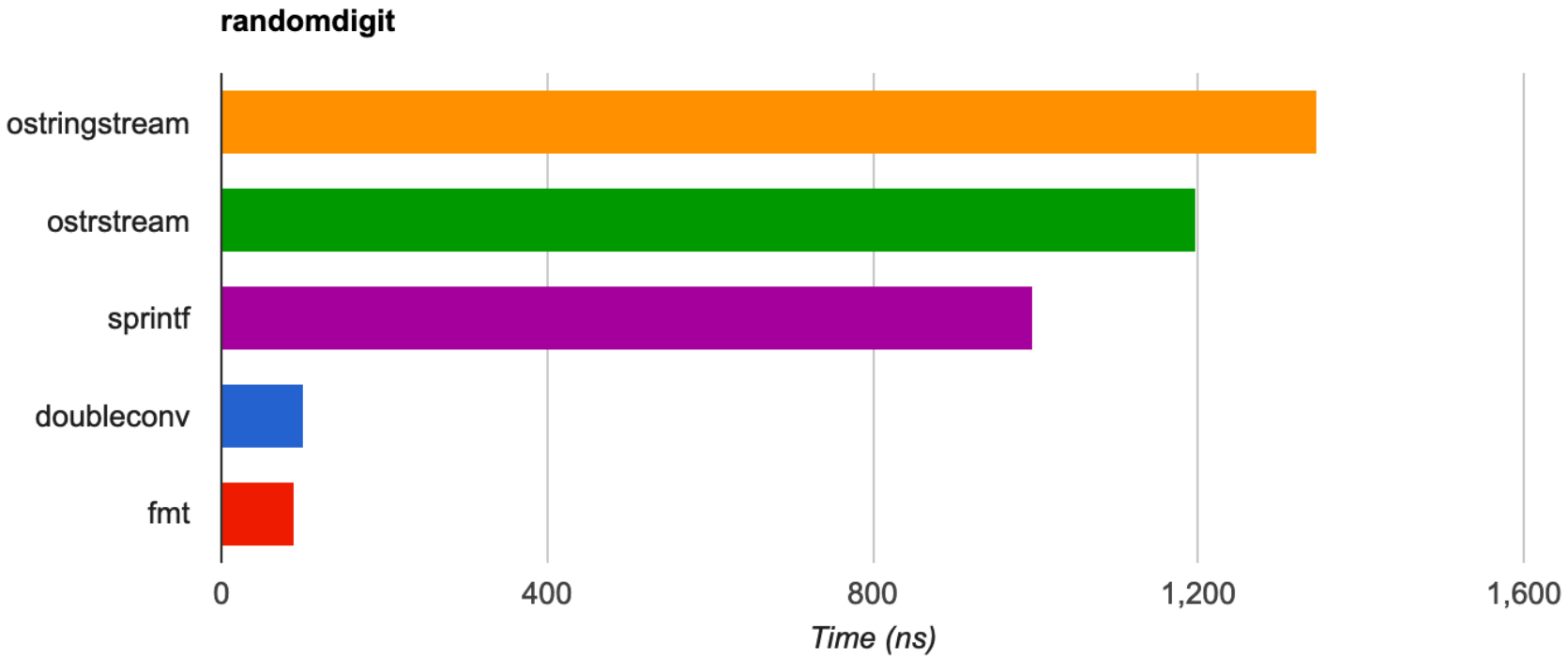
Benchmarks – performance

Times run over a variety of format types, macOS
Source: `{fmt}` readme

Library	Method	Run Time, s
libc	printf	1.03
libc++	std::ostream	2.98
{fmt} 4de41a	fmt::print	0.76
Boost Format 1.67	boost::format	7.24
Folly Format	folly::format	2.23

Benchmarks – performance

Milo Yip's d2a Benchmark – https://github.com/miloyip/dtoa-benchmark
Source: `{fmt}` readme



Benchmarks – compiler, -O3

Times run over a variety of format types, macOS
Source: `{fmt}` readme

Method	Compile Time, s	Executable size, KiB	Stripped size, KiB
printf	2.6	29	26
printf+string	16.4	29	26
iostreams	31.1	59	55
{fmt}	19.0	37	34
Boost Format	91.9	226	203
Folly Format	115.7	101	88

Benchmarks – compiler, `-O0`

Times run over a variety of format types, macOS
Source: `{fmt}` readme

Method	Compile Time, s	Executable size, KiB	Stripped size, KiB
printf	2.2	33	30
printf+string	16.0	33	30
iostreams	28.3	56	52
{fmt}	18.2	59	50
Boost Format	54.1	365	303
Folly Format	79.9	445	430

The chrono question

- C++20 includes significantly updated chrono formatting and scanning functionality
- http://www.open-std.org/jtc1/sc22/wg21/docs/papers/2018/p0355r7.html

- The chrono proposal interacts with the formatting proposal by adding a chrono-specific `std::formatter`

- https://en.cppreference.com/w/cpp/chrono/system_clock/formatter
- https://en.cppreference.com/w/cpp/utility/format/formatter

- `{fmt}` has time formatting in "`fmt/chrono.h`", but it's not anything like the C++20 proposal
- https://isocpp.org/files/papers/P1361R1.pdf

What we aren't getting in C++20

- fmt::print – a printing function
- Compile-time type checking

```
std::string s = format(fmt("{:d}"), "foo");
```

- Literal support

```
using namespace fmt::literals;
std::string message = "The answer is {}"_format(42);
```

- Named positions

```
auto msg = fmt::format("{key2}: {key1}", fmt::arg("key1", 1),
                                         fmt::arg("key2", "abc"));
```

Links

- `{fmt}` info
  - https://fmt.dev/
  - https://github.com/fmtlib/fmt
  - https://youtu.be/ptba_AqFYCM (Zverovich's CppCon 2017 talk)

- More on integer and FP to text conversions
  - https://www.zverovich.net/2019/02/11/formatting-floating-point-numbers.html
  - https://github.com/miloyip/itoa-benchmark
  - https://github.com/miloyip/dtoa-benchmark
  - https://youtu.be/4P_kbF0EbZM (CppCon 2019 talk on <charconv>)