



# The Tragedy of C++ Acts One & Two

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Bē

Artwork by MUE Studio



# Prologue



# Act One - *The Power of C++*



# C++ History

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- Born of a marriage between Simula and C

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- Born of a marriage between Simula and C
- A History of C++: 1979– 1991
- Evolving a language in and for the real world: C++ 1991-2006
- Thriving in a crowded and changing world: C++ 2006–2020



# C++ History

- Born of a marriage between Simula and C
- [A History of C++: 1979– 1991](#)
- [Evolving a language in and for the real world: C++ 1991-2006](#)
- [Thriving in a crowded and changing world: C++ 2006–2020](#)
- [The Design and Evolution of C++](#)



# The Obvious



# The Obvious

- Performance



# The Obvious

- Performance
- Platform support



# The Obvious

- Performance
- Platform support
- Tooling

# The Obvious

- Performance
- Platform support
- Tooling
- High-level



# The Obvious

- Performance
- Platform support
- Tooling
- High-level
- Available libraries

# C Interop

- You don't have to thunk to C
  - For the most part, include a C++ header and use it



# Standard

# Standard

- Specification



# Standard

- Specification
- Multiple implementations

# Standard

- Specification
- Multiple implementations
- Committee process



# Community

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- Brilliant minds

# Community

- Brilliant minds
- Generally helpful



# Community

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- Generally helpful
- Active

# Generic Programming

- The STL

# Mutable Value Semantics

- User-defined types can behave like built-in types



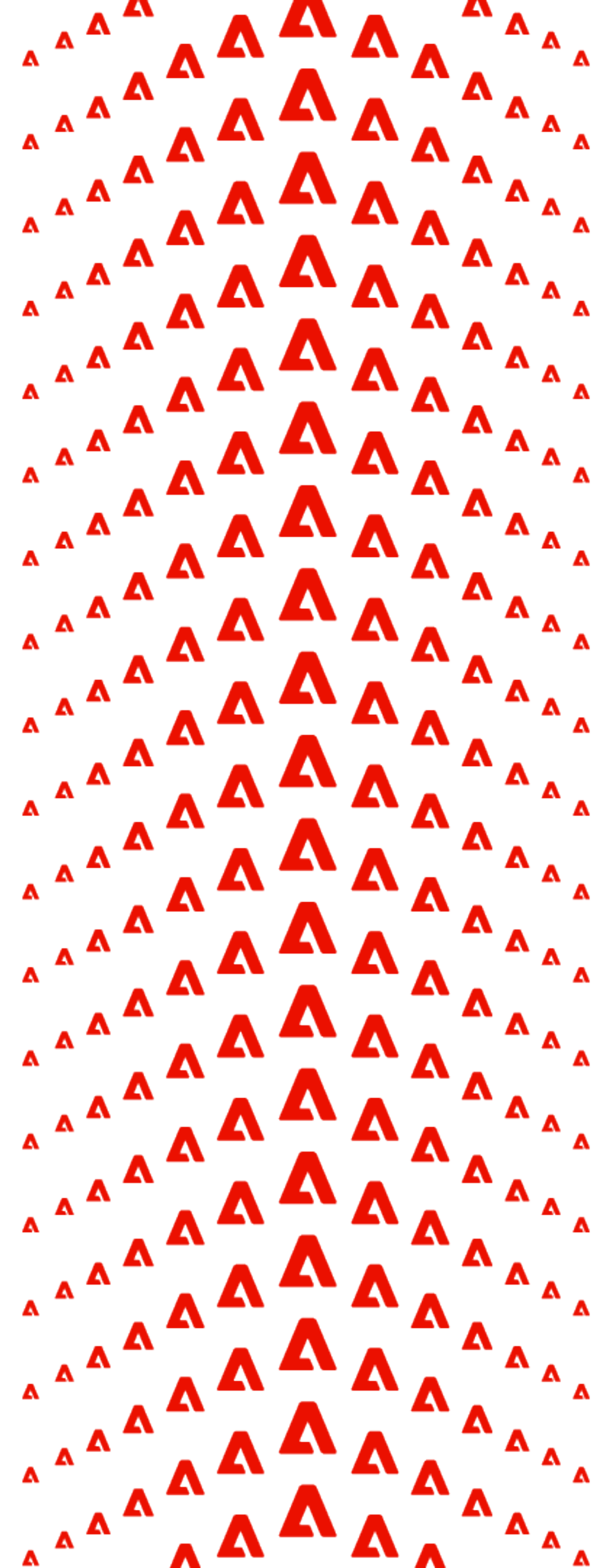
**C++**

***Flexible abstraction & efficient by definition.***

# Act Two - *The Health of C++*



**Beauty**



# C++ Standard

- C++98 Standard
  - 757 Pages
- C++11 Standard
  - 1338 Pages
- C++20 Standard
  - 1807 Pages (523 pages for the language and support libraries)



# libc++ pair

```
#ifndef _LIBCPP___UTILITY_PAIR_H
#define _LIBCPP___UTILITY_PAIR_H

#include <__config>
#include <__functional/unwrap_ref.h>
#include <__tuple>
#include <__utility/forward.h>
#include <__utility/move.h>
#include <__utility/piecewise_construct.h>
#include <cstdint>
#include <type_traits>

_LIBCPP_PUSH_MACROS
#include <__undef_macros>

_LIBCPP_BEGIN_NAMESPACE_STD

template <class _T1, class _T2>
struct _LIBCPP_TEMPLATE_VIS pair
{
    typedef _T1 first_type;
    typedef _T2 second_type;

    _T1 first;
    _T2 second;
};
```

```

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    pair(pair const&) = default;
    pair(pair&&) = default;
    template <bool _Val>
    using _EnableB _LIBCPP_NODEBUG_TYPE = typename enable_if<_Val, bool>::type;

    struct _CheckArgs {
        template <int&...>
        static constexpr bool __enable_explicit_default() {
            return is_default_constructible<_T1>::value
                && is_default_constructible<_T2>::value
                && !__enable_implicit_default<>();
        }
    };

    template <int&...>
    static constexpr bool __enable_implicit_default() {
        return __is_implicitly_default_constructible<_T1>::value
            && __is_implicitly_default_constructible<_T2>::value;
    }
};

```

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**“We’re getting an error that has something to do with  
rvalue references and `std::pair`.”**

# Beauty

```
C:/WinSdk/Include/10.0.18362.0/ucrt\time.h(36): error C2220: the following warning is treated as an error
```

```
C:/data/msvc/14.33.31424-Pre/include\utility(190): warning C4800: Implicit conversion from '_Ty' to bool. Possible information loss
```

```
    with  
    [  
        _Ty=int  
    ]
```

```
C:/data/msvc/14.33.31424-Pre/include\utility(190): note: consider using explicit cast or comparison to 0 to avoid this warning
```

```
C:/data/msvc/14.33.31424-Pre/include\utility(190): note: see declaration of '_Ty'
```

```
C:/data/msvc/14.33.31424-Pre/include\xmemory(673): note: see reference to function template instantiation 'std::pair<const int,bool>::pair<_Ty,_Ty,0>(_Other1 &&,_Other2 &&) noexcept' being compiled
```

```
    with  
    [  
        _Ty=int,  
        _Other1=int,  
        _Other2=int  
    ]
```

```
C:/data/msvc/14.33.31424-Pre/include\xmemory(680): note: see reference to function template instantiation 'std::pair<const int,bool>::pair<_Ty,_Ty,0>(_Other1 &&,_Other2 &&) noexcept'
```

```
being compiled
```

```
    with
```

```
_Ty=bool,  
_Pr=std::less<int>
```

```
]
```

<source>(9): note: see reference to function template instantiation

```
'std::pair<std::_Tree_iterator<std::_Tree_val<std::_Tree_simple_types<std::pair<const  
int,bool>>>>,bool>
```

```
std::_Tree<std::_Tmap_traits<_Kty,_Ty,_Pr,_Alloc,false>>::emplace<int,int>(int &&,int &&) '  
being compiled
```

```
with
```

```
[
```

```
_Kty=int,  
_Ty=bool,  
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```

```
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```

<source>(9): note: see reference to function template instantiation

```
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```
with
```

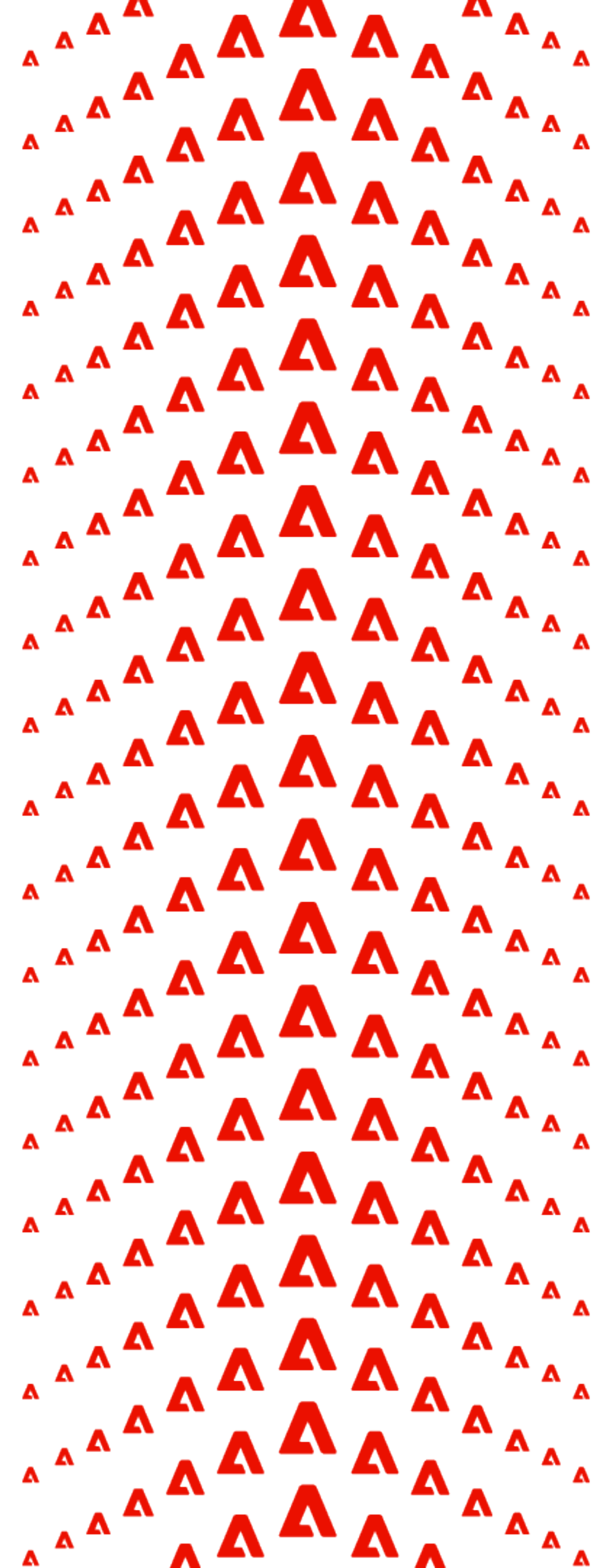
```
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```

```
_Kty=int,  
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```

```
]
```



# Beauty & Correctness



## *Beauty*

**The ease with which a language allows the expression of correct code.**

# Preconditions

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- A *Precondition* is an assertion that must be true before an operation

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`sort(first, last, compare)`



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  - For all  $p$ , let  $v$  equal the set of values  $*p$ ;
    - For all pairs  $(v_a, v_b)$ , *compare* is a predicate establishing a strict-weak-order relation
- The *domain of an operation* is the set of values satisfying all preconditions



# Preconditions

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- **When preconditions are not satisfied:**

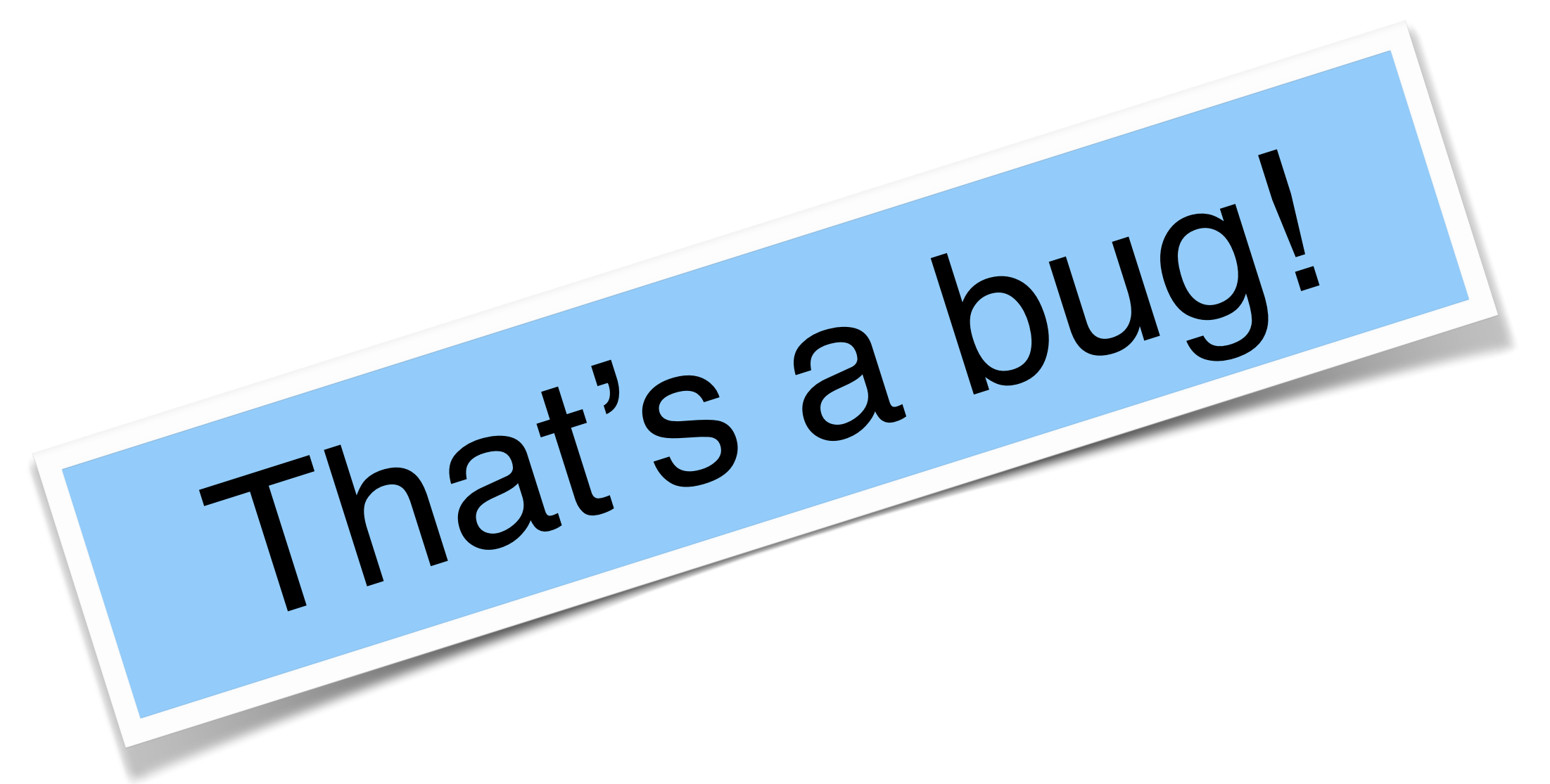
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  - An operation may lead to *undefined behavior*



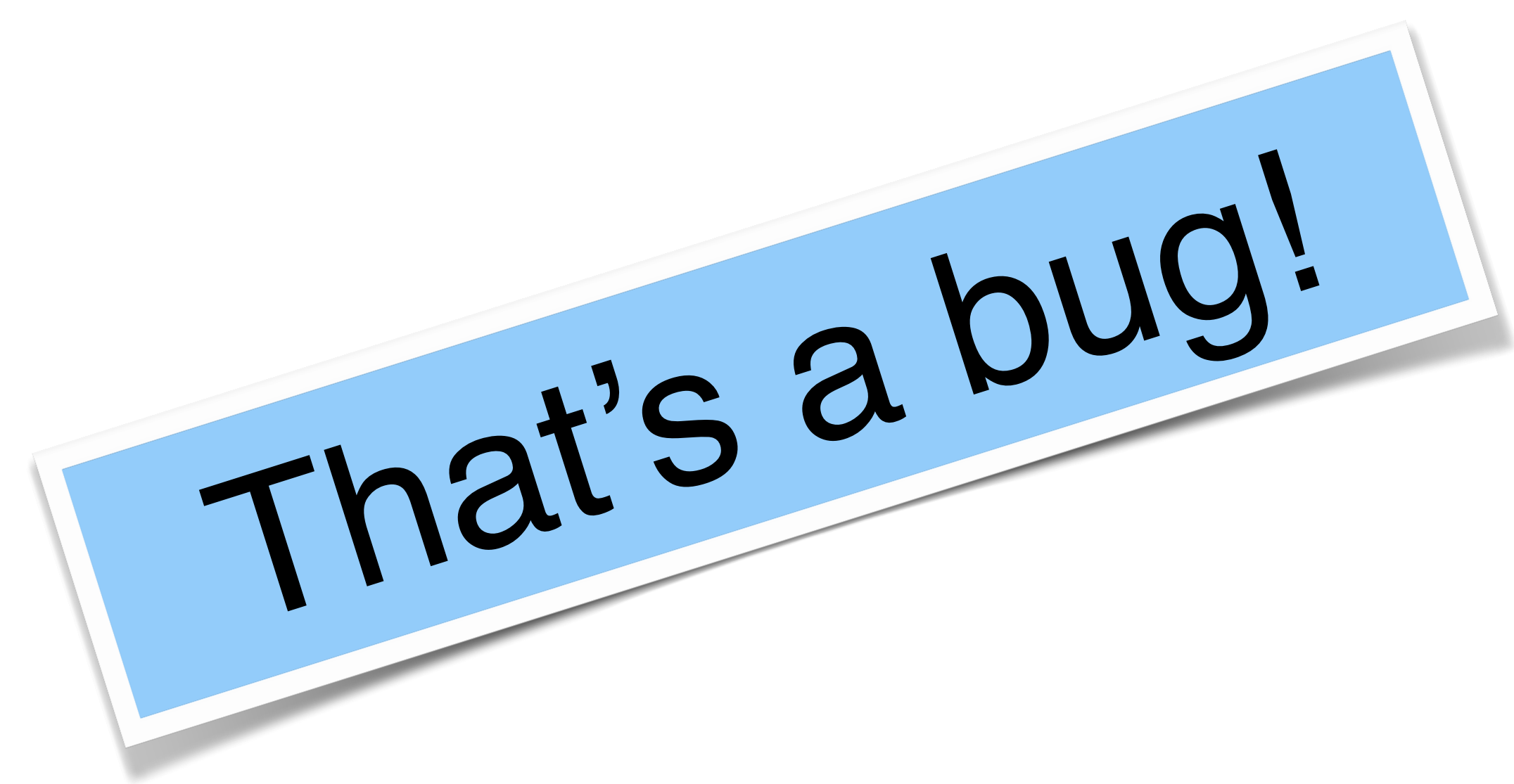
# Preconditions

- When preconditions are not satisfied:
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  - The result may be *unspecified* and may violate *class invariants*



# Preconditions

- **When preconditions are not satisfied:**
  - An operation may lead to *undefined behavior*
  - The result may be *unspecified* and may violate *class invariants*
  - It may *lead to program termination*





# Safety

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  - Directly or indirectly
  - Even if the operation preconditions are violated
- An *unsafe* operation may lead to undefined behavior if preconditions are violated
  - Either directly or during subsequent operations, safe or not
- We refer to an operation that terminates on a precondition violation or has no preconditions, as *strongly safe*

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- Errors are about correct code and recoverable situations
  
- Safety is a transitive property
- Correctness is not transitive
- Strong safety is not transitive

# Safety, Correctness, & Efficiency

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# Safety, Correctness, & Efficiency

- Safety bounds the behavior of incorrect code
  - Strong safety with tight preconditions can assist with correctness by catching mistakes at runtime
  - Safety can also mask errors by providing consistent if incorrect results
  - Safety is fundamentally at odds with efficiency

# Safety, Correctness, & Efficiency

# Safety, Correctness, & Efficiency

- Integer overflow in C++ is undefined behavior



# Safety, Correctness, & Efficiency

- Integer overflow in C++ is undefined behavior
- Defining overflow as modulo-2 arithmetic is safe but hides unintended overflow
  - And also comes at some cost to efficiency
- Defining overflow as trapping would catch mistakes
  - But would come at an additional cost on most processors, including x64 and ARM

# Limits of Safety

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- Within a safe, Turing-complete language you can build an unsafe C machine

# Limits of Safety

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safety  $\cong$  sandboxing

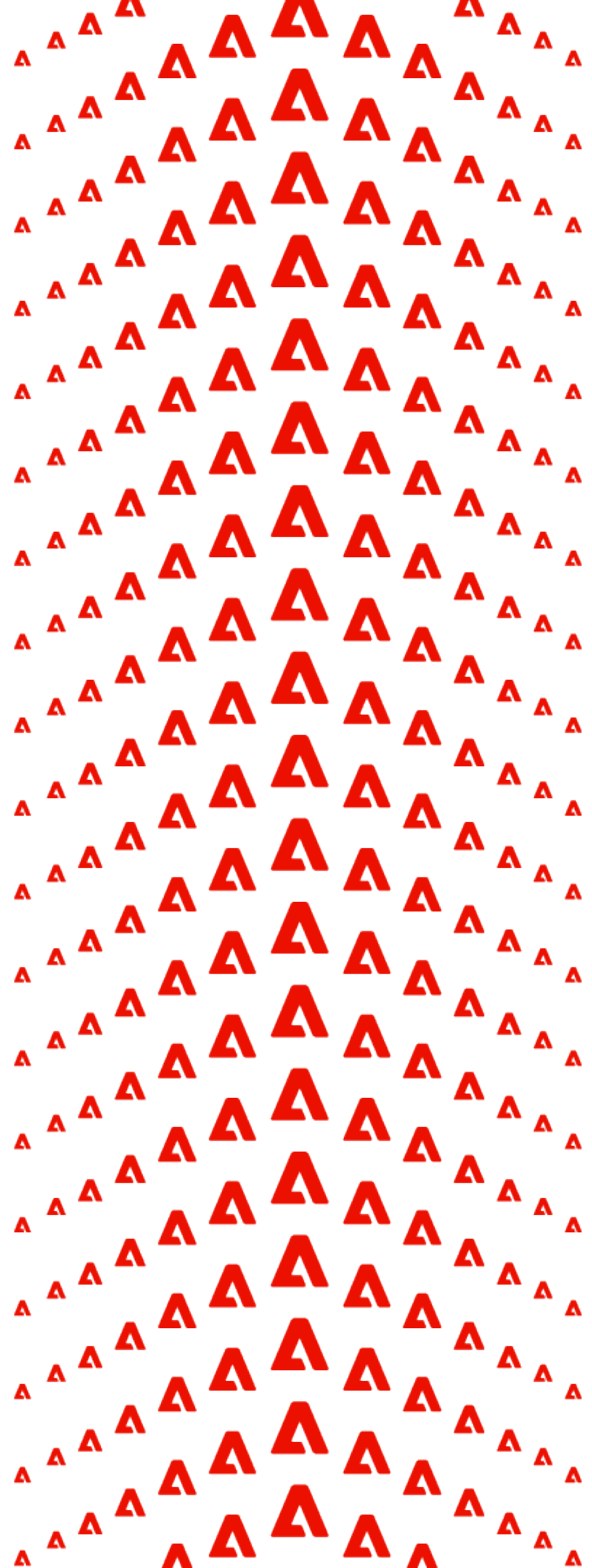
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- See `asm.js`

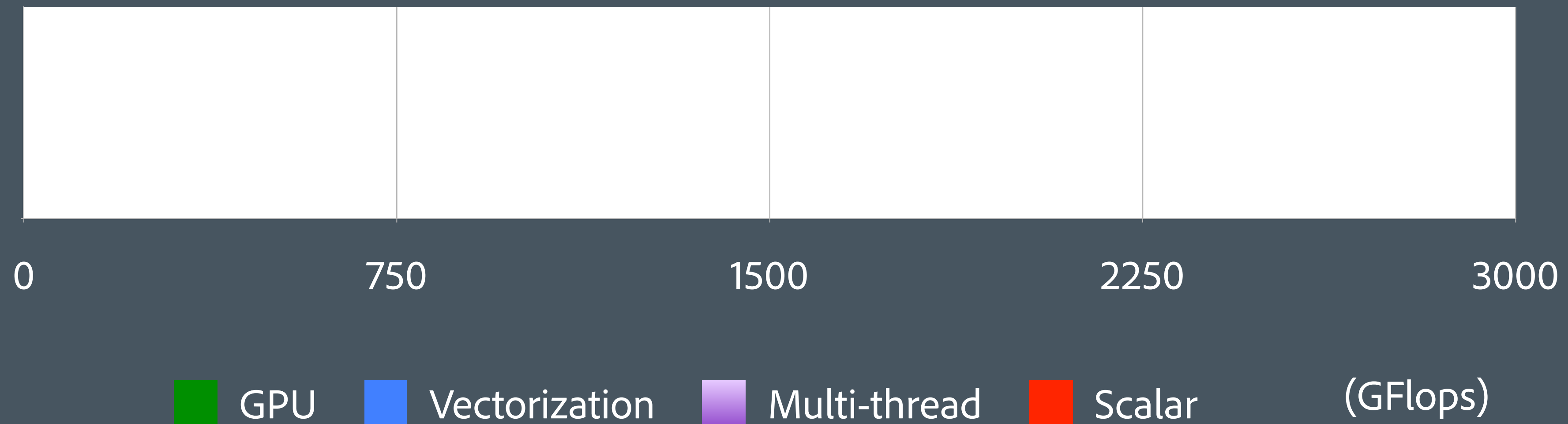
**Truth**



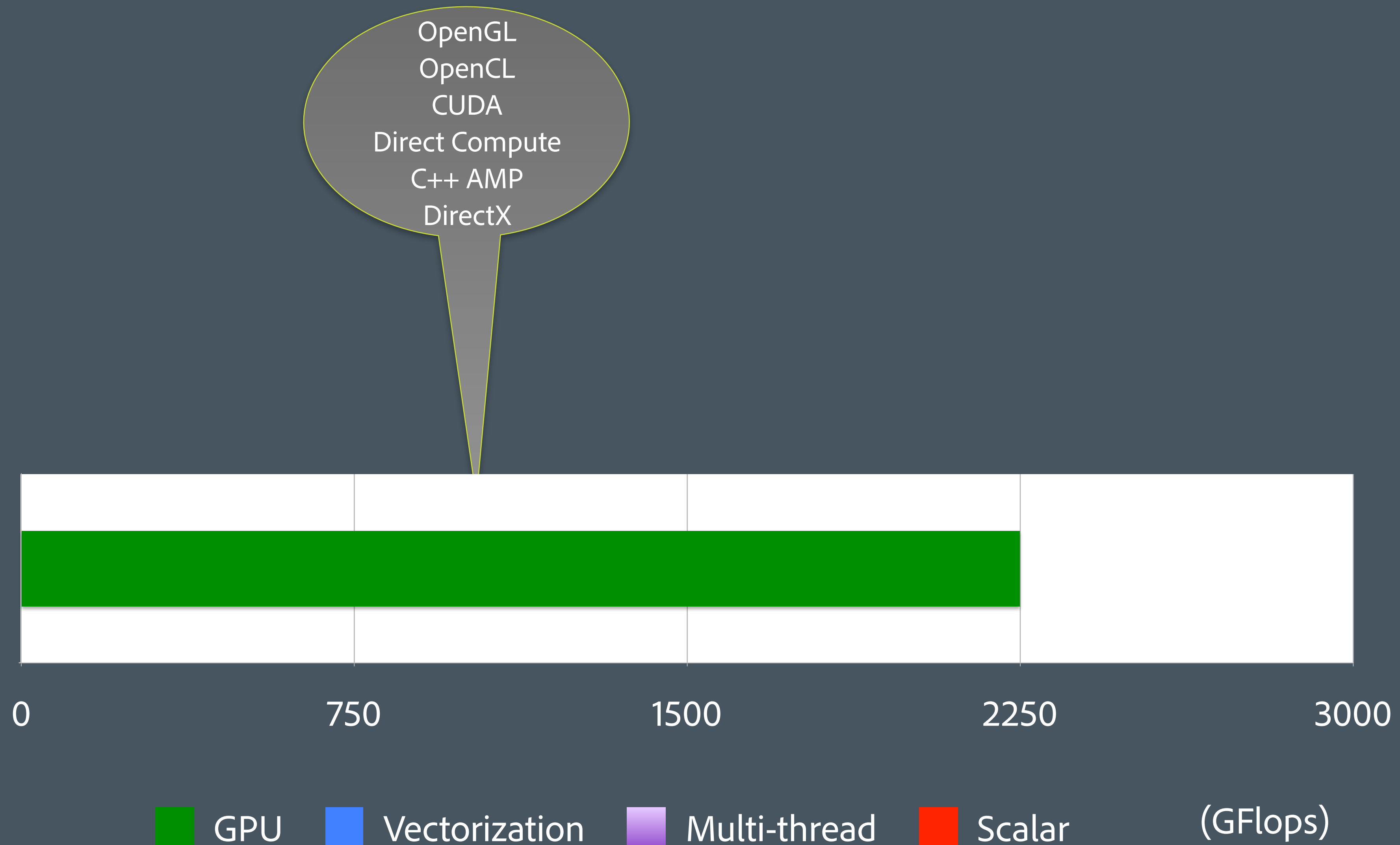
# Desktop Compute Power (8-core 3.5GHz Sandy Bridge + AMD Radeon 6950)



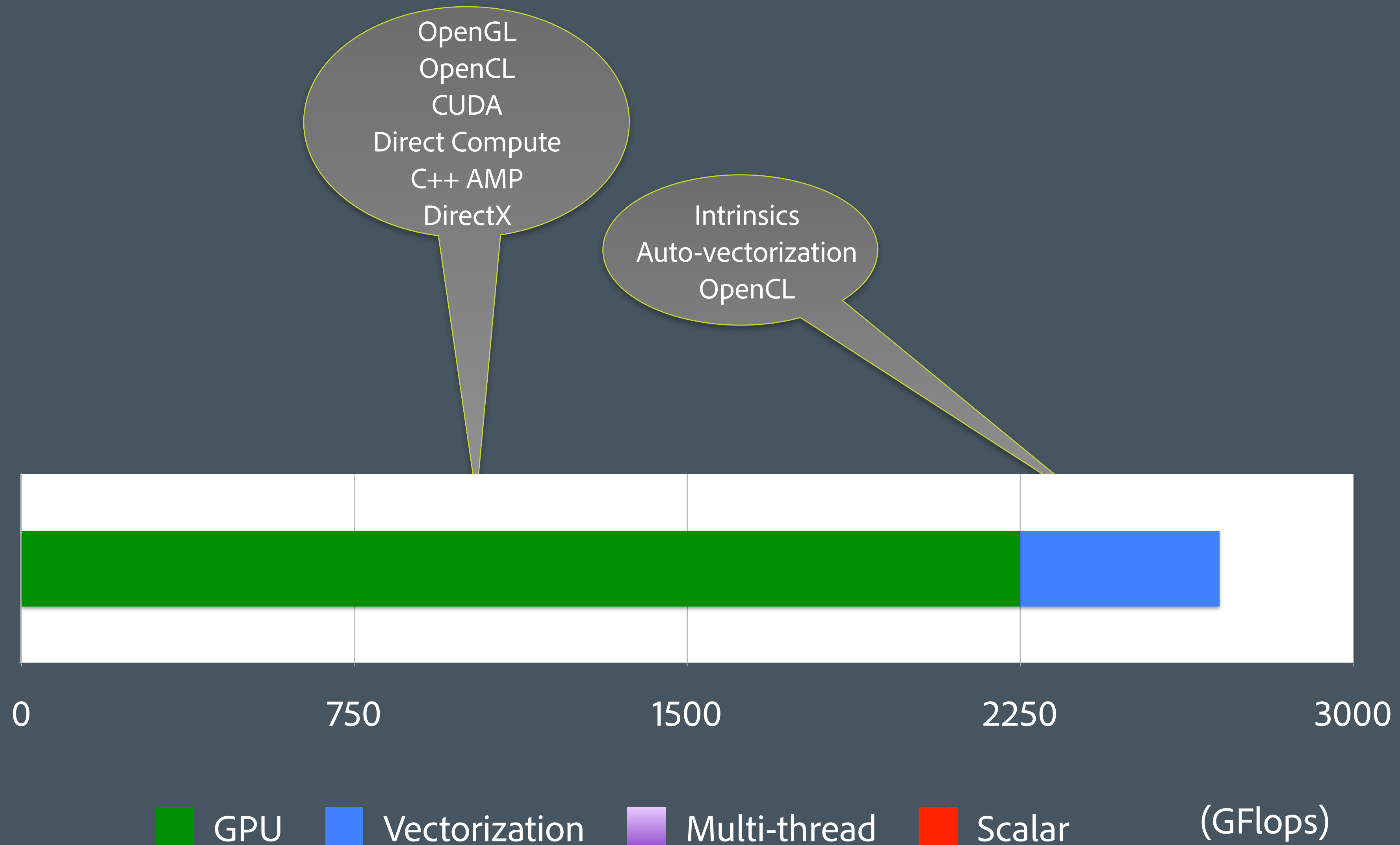
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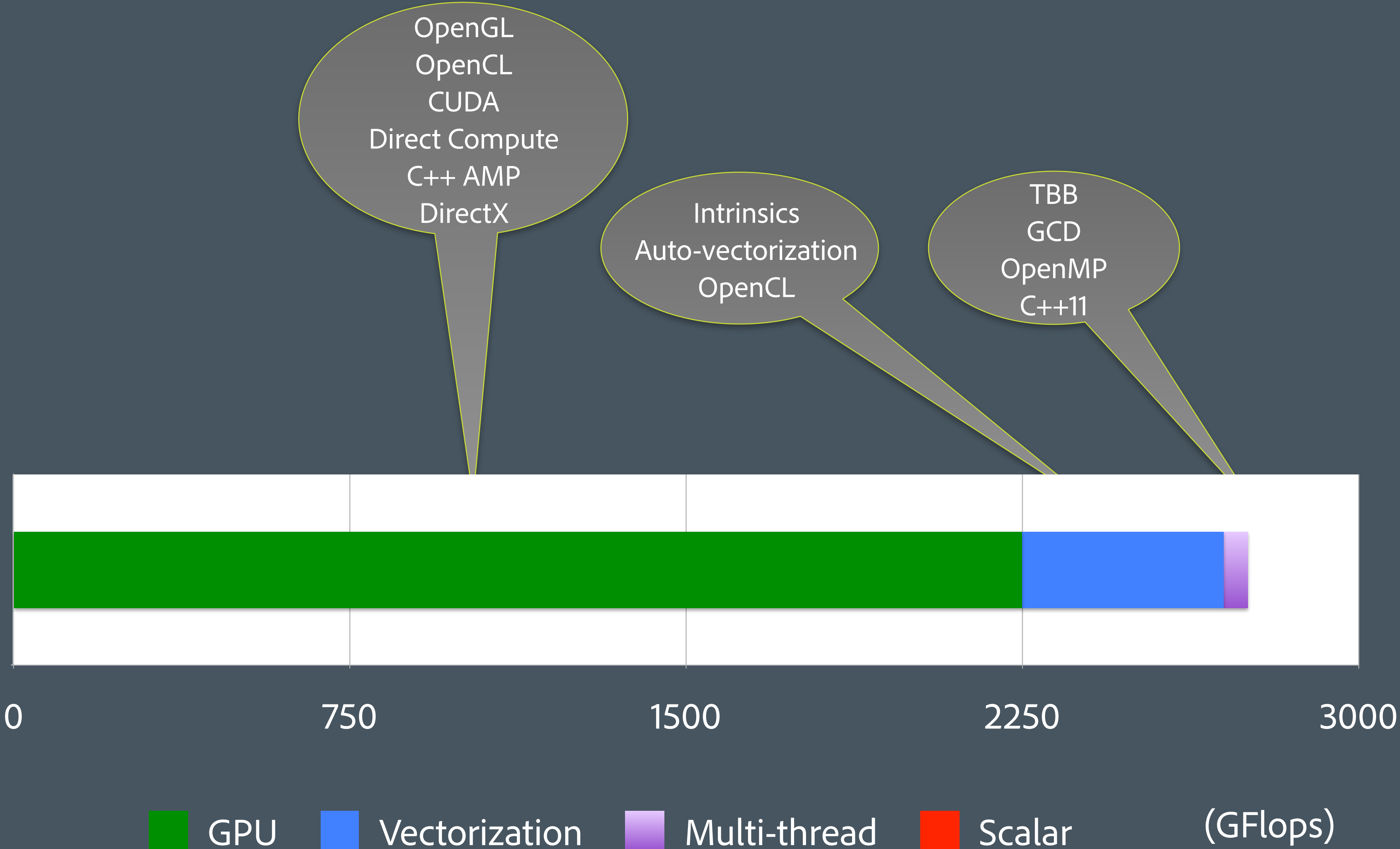
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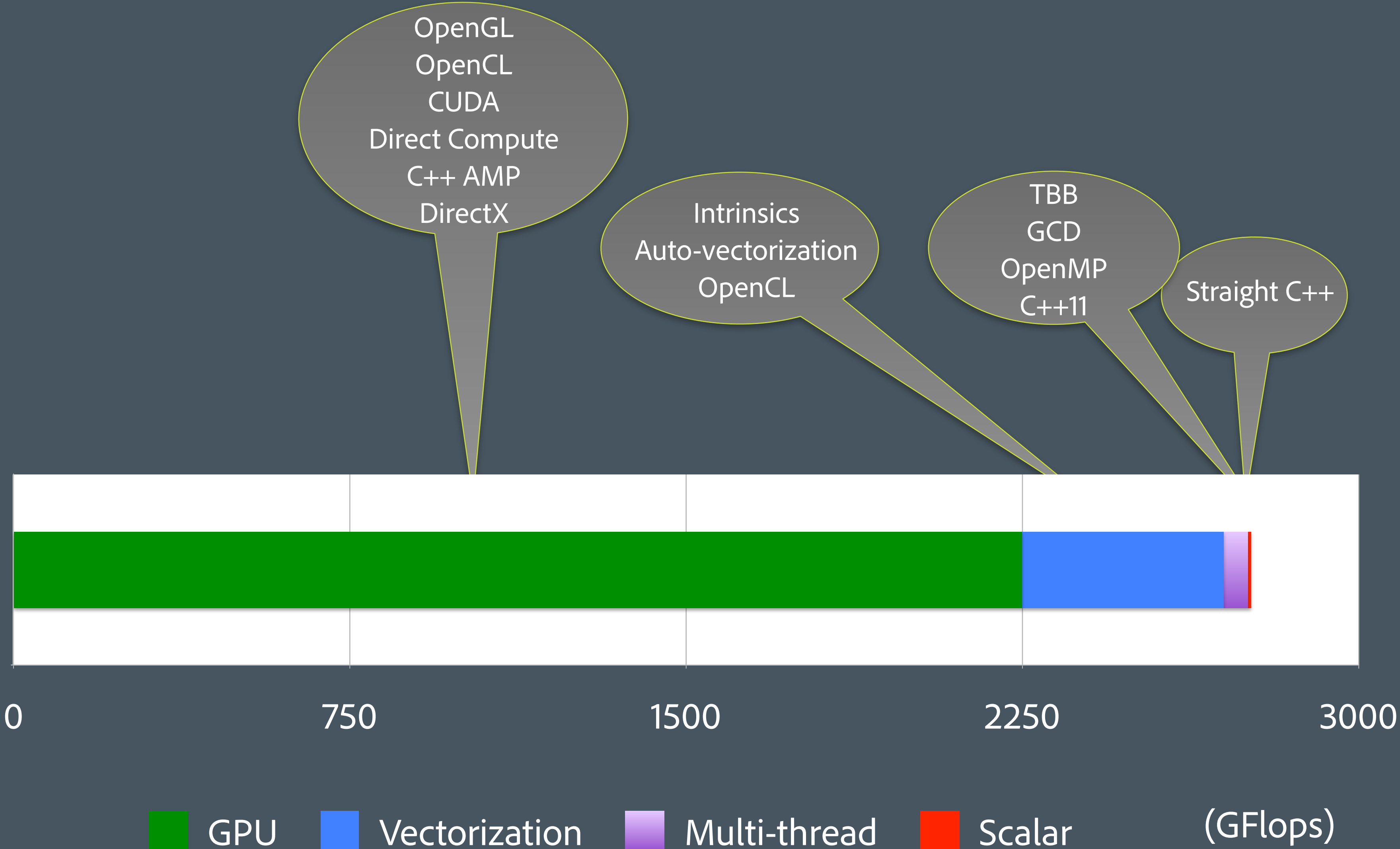
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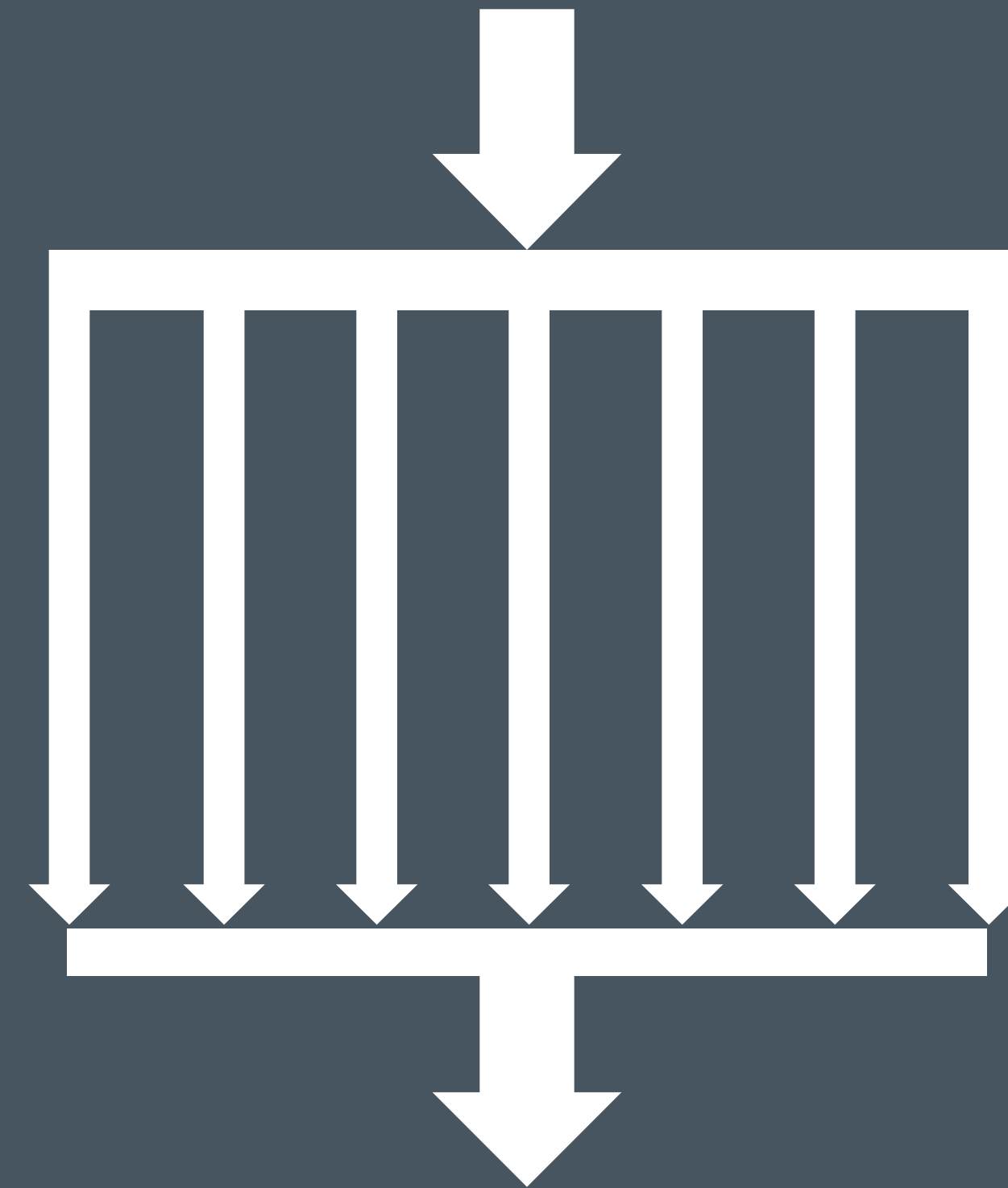
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# Two kinds of parallel

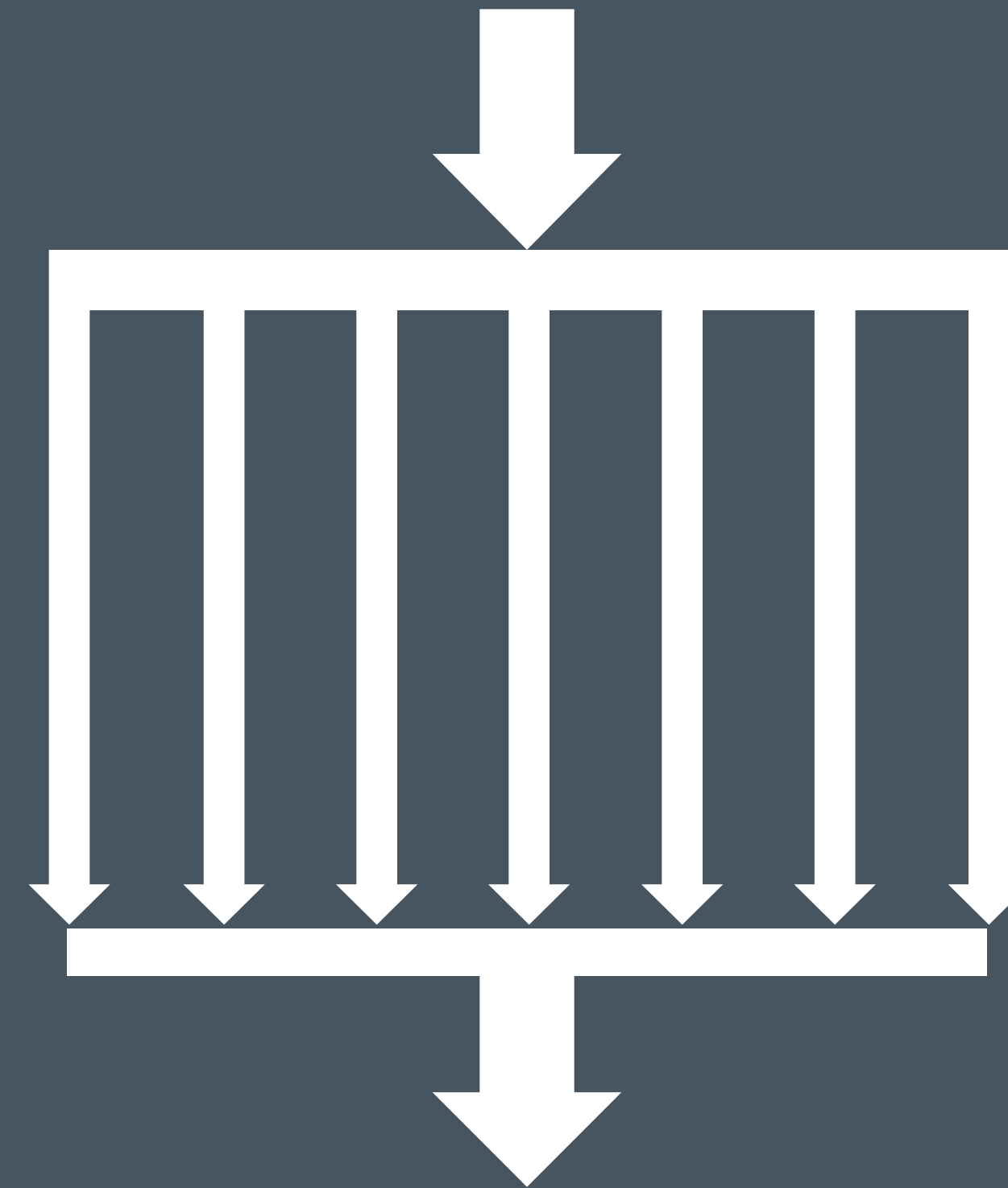


# Two kinds of parallel

Functional



Data Parallel



# Ad-hoc Threading



# Ad-hoc Threading

- The speaker notes for the previous slide contained this note:

# Ad-hoc Threading

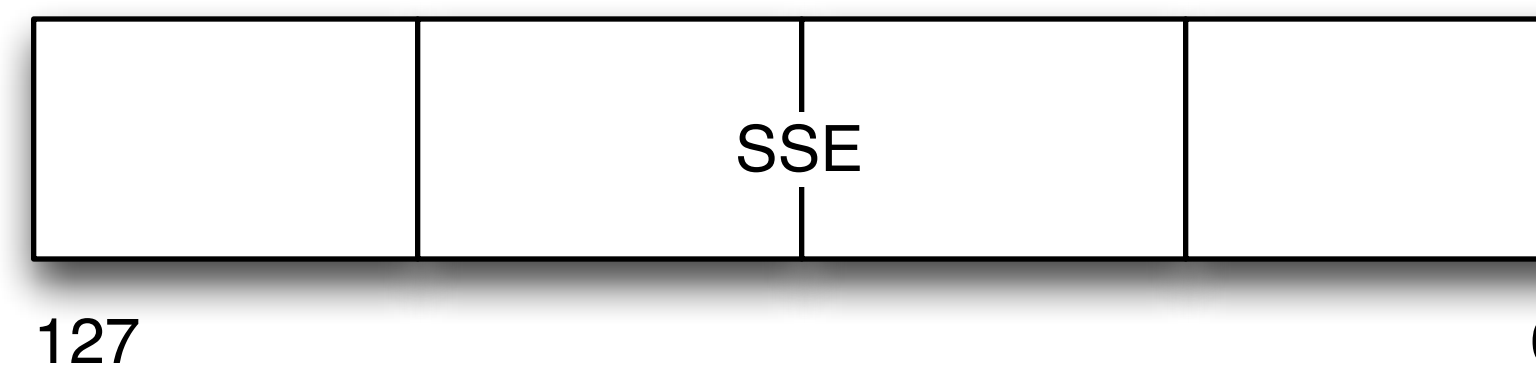
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# Ad-hoc Threading

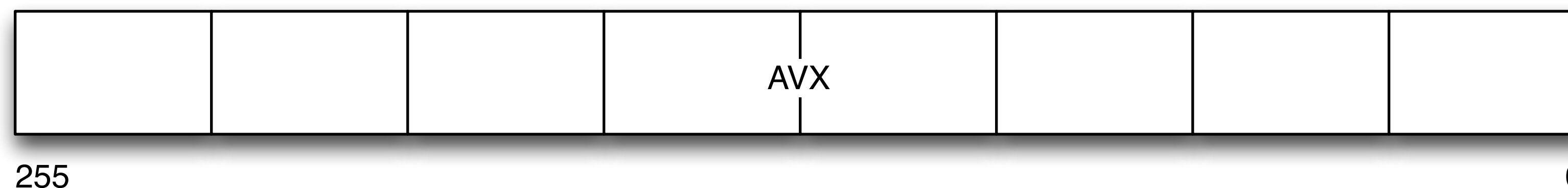
- The speaker notes for the previous slide contained this note:
  - “Ad hoc threading – over 100 threads in Photoshop CS5, most waiting for their feature or library to be called.”
- For the current Photoshop, that number is closer to 2000
  - I dislike `std::async`, `std::thread`, and `std::jthread`



- Intrinsic: great speed potential, but...

```
__m128i vDst = _mm_cvttps_epi32(_mm_mul_ps(_mm_cvtepi32_ps(vSum0), vInvArea));
```

- Moving target: MMX, SSE, SSE2, SSE3, SSE 4.1, SSE 4.2, AVX, AVX2, AVX3



- Solutions:

- Auto-vectorization

```
#pragma SIMD
```

- CEAN

```
Dest[:] += src[start:length] + 2;
```

# SIMD

- I believe a large class of SIMD problems can be expressed with generic algorithms:

```
simd::transform(r1, r2, out, [&](auto a, auto b) {  
    out((a * alpha) + (b * (1.0 - alpha)));  
});
```

# SIMD

- And I want that to vectorize even when multiplication is defined as:

```
normalized8 operator*(normalized8 a, normalized8 b) {  
    // (a * b + 127) / 255;  
  
    auto tmp = (uint8_t)a * (uint8_t)b + 128;  
    return normalized8{(tmp + (tmp >> 8)) >> 8};  
}
```

# Why Not Put Everything on the GPU?





# Why Not Put Everything on the GPU?



Data Parallel

300

:

1

# Why Not Put Everything on the GPU?



Data Parallel

300

:

1

Sequential

1

:

10

## Truth

- Typical object-oriented paradigms of using shared references to objects break down in a massively parallel environment
- Sharing implies either single-threaded
  - Or synchronization
- Ten years after this observation, many developers still don't understand this tweet:



**Sean Parent**

@SeanParent



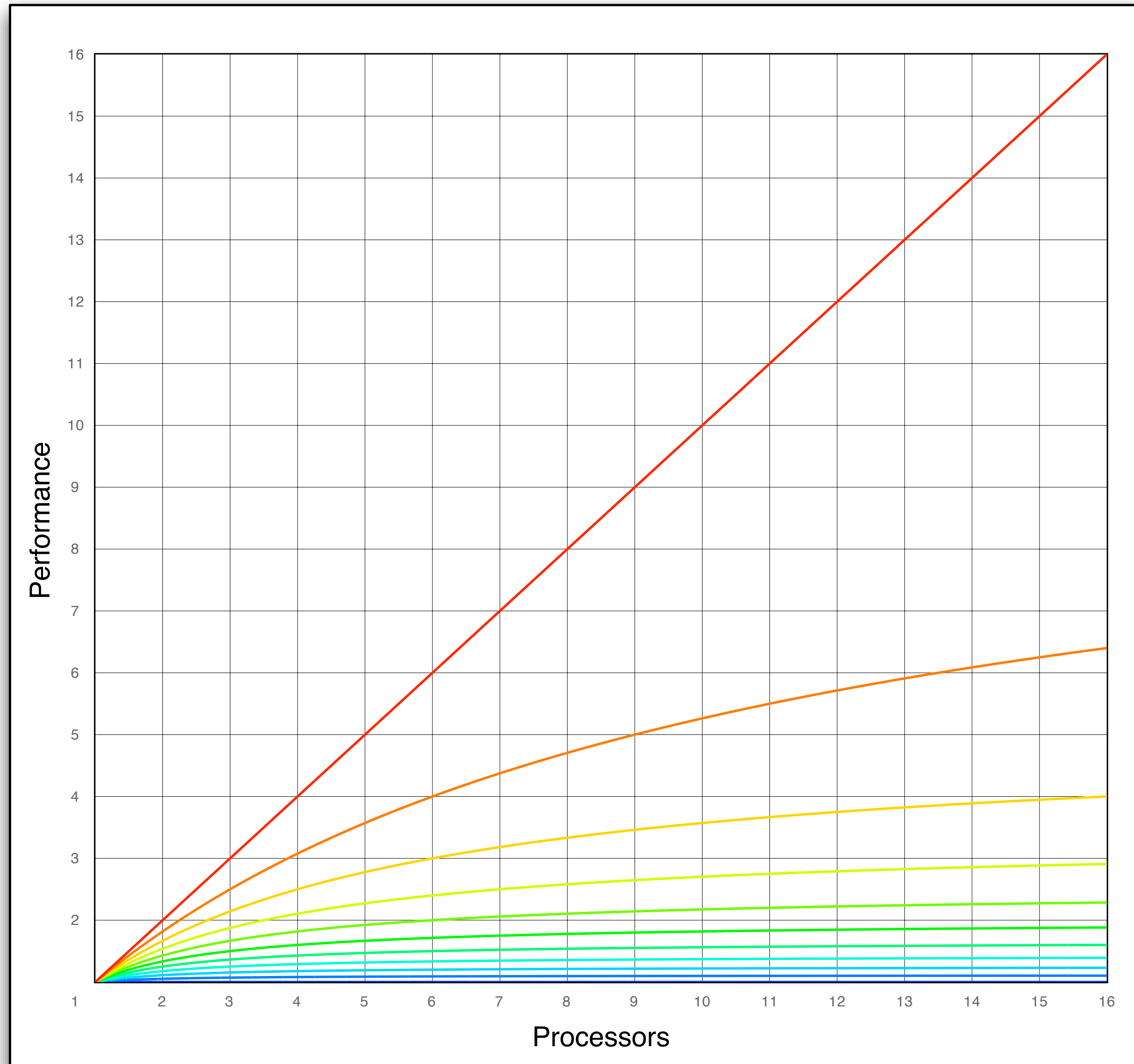
I think I'm going to start putting this after the declaration of all my types.

```
template <> class std::shared_ptr<my_type>; // Please stop.
```

2:59 PM · Oct 27, 2020 · Twitter Web App



# Amdahl's Law



# Truth

- To utilize the hardware we need to move towards functional, declarative, reactive, and value semantic programming
- No raw loops

- Without addressing vectorization, GPGPU, and scalable parallelism, standard C++ is just a scripting system to get to the other 99% of the machine through other languages and libraries

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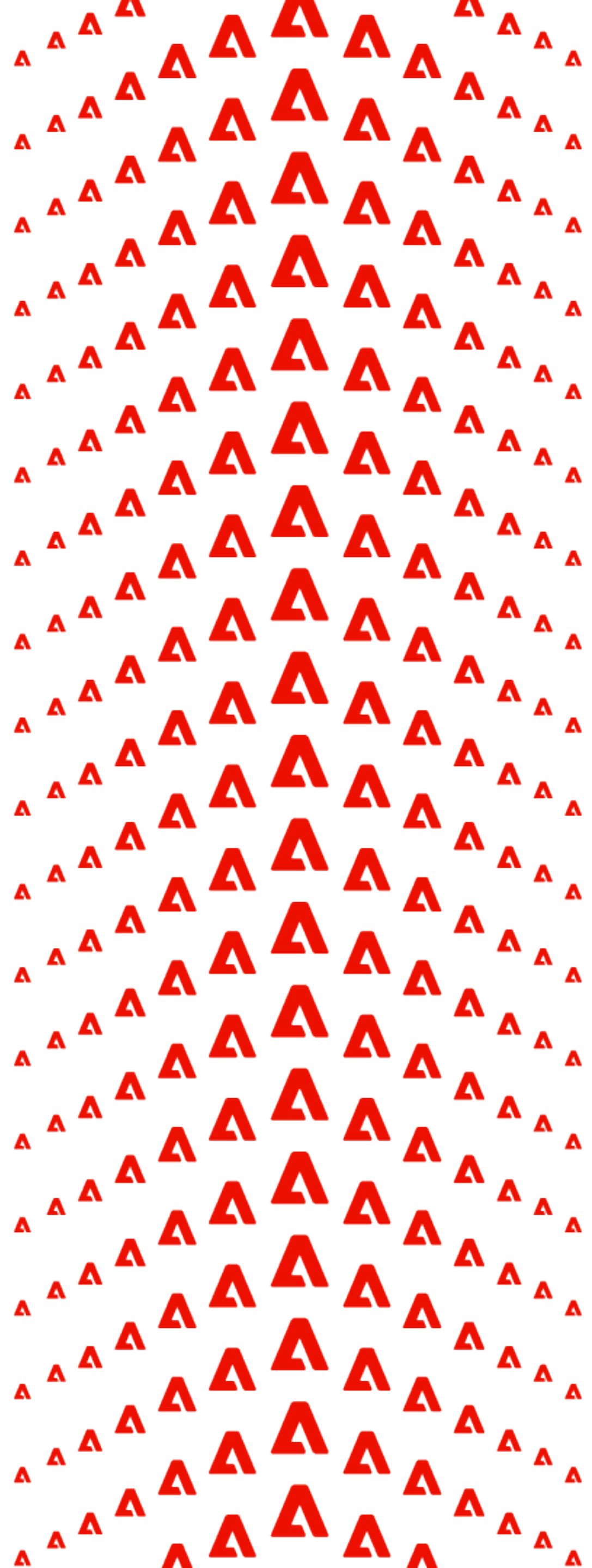
Do we need such a  
complex scripting system?



## *Truth*

**The confidence a language provides that  
code is correct and efficient.**

**Goodness**



# Content Ubiquity

- Ubiquitous access to:
  - calendar
  - contacts
  - notes & tasks
  - e-mail (corporate and personal)
  - A full web experience
  - Music
    - iTunes Music Match
    - Spotify
    - Pandora
  - Movies
    - Netflix
    - Vudu
- Photos
  - Flickr
  - Facebook
  - Adobe Revel
- Documents
  - Google Docs
  - Microsoft Office
- Everything...

*Content ubiquity* is access to all  
your information, on all your  
devices, all of the time

# Demo

# Bringing Adobe's Creative Cloud to the web: Starting with Photoshop

# The Problem

- Ubiquity has gone mainstream
  - A typical US household now has 3 TVs, 2 PCs, and 1 Smartphone
    - 1 in 3 households has an internet connected TV
  - A typical US worker has access to a PC at work or is provided an e-mail solution for communication
- The deluge of digital information has become a challenge to manage
  - How do I get this contract to my phone?
  - How do I get this video from my phone to my PC?
  - Which computer has the latest version of this photo?

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Content ubiquity has  
become the expectation



# The Challenge

- Content Ubiquity isn't a feature you can bolt-on
  - Dropbox, and similar technologies that require management and synchronization aren't the solution
- Achieving a seamless experience requires rethinking...
  - data model to support incremental changes
  - transactional models to support dynamic mobile environment
  - editor model to support partial editing (proxies, pyramid)
  - UI model to support touch, small devices, 10 foot interfaces

# Content Ubiquity Opens the Door to Sharing and Collaboration

- If you can make changes available to other devices immediately then you can make changes available to other apps immediately (works with sandboxing technology)
- If you can make documents available to all your devices then you can make documents available to others - supporting both collaboration and sharing

# Developer Pain

- To provide a solution requires you write for multiple platforms
- And many vendors are focusing on proprietary technology to get to 99% of the machine
- C++ itself becomes a fragmented scripting system
  - Objective-C++, Managed C++

## Developer Pain

- Vendor lock-in on commodity technologies only serves to slow development
  - including incorporating vendor specific technology that provides user benefit

# Now What?

- C++Next
  - Simplicity
  - Standardize access to modern hardware

# Act Three - *Now What?*



# Val Language

<https://val-lang.github.io/>



## About the artist

### MUE Studio

MUE Studio in New York City, a collaboration of Minjiin Kang and Mijoo Kim, creates visual experiences through 3D image design and photography. Drawing inspiration from the architecture and culture they see around them every day, the duo strive to blur the boundary between fantasy and reality in their work. For this piece, they used Adobe Photoshop and Cinema 4D to build a dreamlike space that connects emotionally with viewers and offers them an escape.

Made with

 Adobe Photoshop







Bē

Artwork by MUE Studio