C++ Allocators for the Working Programmer

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C++ Allocators for the Working Programmer

John Lakos

Joshua Berne

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This is John’s dedication to Josh for being so great and writing this book so well.
JL

This is Josh’s dedication to his wife, child, and mother-in-law for being all supportive and wonderful. And to steak. Steak is great.
JMB

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Foreword

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Acknowledgements

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About the Authors

John Lakos, author of Large-Scale C++ Software Design [Pearson, 1996] and Large-Scale C++ — Volume I: Process and Architecture [Pearson, 2019], serves at Bloomberg in New York City as a senior architect and mentor for C++ software development worldwide. He is also an active voting member of the C++ Standards Committee's Evolution Working Group. From 1997 to 2001, Dr. Lakos directed the design and development of infrastructure libraries for proprietary analytic financial applications at Bear Stearns. From 1983 to 1997, Dr. Lakos was employed at Mentor Graphics, where he developed large frameworks and advanced ICCAD applications for which he holds multiple software patents. His academic credentials include a Ph.D. in Computer Science (1997) and an Sc.D. in Electrical Engineering (1989) from Columbia University. Dr. Lakos received his undergraduate degrees from MIT in Mathematics (1982) and Computer Science (1981).

Joshua Berne serves at Bloomberg LP as a senior software engineer on Bloomberg's core library team. After the difficult choice to pursue a career in software engineering over research mathematics, he has been an active programmer in the financial industry, writing day trading applications in C++ for E*TRADE Capital Markets and, after that, architecting large distributed trading systems in Java for Instinet and IDC. Since joining Bloomberg in 2017, he has been an active participant in the C++ Standards Committee, seeking to bring the advancements made within Bloomberg to the C++ Standard and thus to the rest of the world. His first WG21 paper was [1]

Chapter 1

Foundations

1.1 Motivation

- Why local allocation can help
- Limits of global allocation
- Reference Emery's paper?

1.1.1 What is an Allocator

- an allocator allocates and deallocates memory
- what is a "general purpose" allocator
  - same contract and requirements as new/delete malloc/free
  - thread-safe - allocate concurrently, deallocate from any thread
  - objects of any size
  - overhead constant in terms of currently allocated memory
- types of "special purpose" allocators
  - Unsynchronized
  - Monotonic
- Global vs. Local allocators
  - global allocators can be specialized
  - local allocators can be general purpose

1.1.2 The History of C++ Allocators

- describe C++03 allocators
- [2] - Towards a better allocator model
- [3], [4],
- Scoped allocators: [5], [6],
- c++17, c++20 changes to PMR

1.1.3 What we'll teach you about allocators

- Summary of what each chapter will teach

1.1.4 Making money with allocators

- Summary of how architecture can facilitate leveraging allocators

---

1.2 Technical Basics

1.2.1 C++ Allocators

- Go over the mess of c++03 style allocator types

1.2.2 The std::pmr Interface

- Show std::pmr::polymorphic_allocator
- Show simplification to ALLOCATOR types
- Show the memory_resource interface, how to do an allocation

Chapter 2

Application Developers

2.1 What is an Allocator-Aware Type?

2.1.1 Defining a PMR Allocator-Aware Type

2.1.2 std::pmr Collections

2.2 Using Allocator-Aware Types

2.2.1 How to use a Custom Memory Resource

2.2.2 How to Choose an Allocator

2.2.3 Testing Code that Allocates

2.3 Case Study 1: Unique Value Counting

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Chapter 4

Writing Allocators

4.1 Implementation

4.1.1 Learning from Global Alocators

4.1.2 Thread-Unsafe Allocators

4.1.3 Reuse Free Allocators

4.1.4 Wrapping Other Allocators for Utility

4.2 Benchmarking Allocators

4.3 Case Study 4: A Buffered Sequential Allocator

Chapter 5

Making Money

5.1 Optimizing exisitng software

5.1.1 Identifying short-lived objects

- escape analysis
- recursive functions
- Automated tooling to help discover?

5.1.2 Replacing many allocations with few

- identify

5.2 Designing for allocator usage

5.2.1 Shaping tasks for allocators

- Differentiating between long and short lived data.
- Message processing in local allocators, updating persistent state in global allocator
- Structuruing persistent data for advantageous cache usage

5.2.2 Keeping allocators with subsystems

- Moving allocators with their data - queues of smart pointers,

Chapter 6

Advanced

6.1 Modern Hardware

6.2 Effective Benchmarking

Here we would be discussing the approach we have to benchmarking.

```
struct S {
  void foo();
};

void S::foo()
{
}
```

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[6] Pablo Halpern, "The scoped allocator model (rev 1)," Tech. Rep. N2523, WG21 - The C++ Standards Committee, 2008.

Appendix A

Other Libraries

A.1 BDE

A.2 Thrust

Appendix B

Future Developments

B.1 More PMR Types

B.2 Automating Allocator Suppoer