Applied Hierarchical Reuse

Capitalizing on Bloomberg's Foundation Libraries

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Abstract

Designing one library is hard; designing an open-ended collection of interoperable libraries is harder. Partitioning functionality across multiple libraries presents its own unique set of challenges: Functionality must be easy to discover, redundancy must be eliminated, and interface and contract relationships across components and libraries should be easy to explore without advanced IDE capabilities. Further, dependencies among libraries must be carefully managed – the libraries must function as a coherent whole, defining and using a curated suite of *vocabulary types*, but clients should pay in compile time, link time, and executable size only for the functionality they need.

Creating a unified suite of interoperable libraries also has many challenges in common with creating individual ones. The software should be easy to understand, easy to use, highly performant, portable, and reliable. Moreover, all of these libraries should adhere to a uniform physical structure, be devoid of gratuitous variation in rendering, and use consistent terminology throughout. By achieving such a high level of consistency, performance, and reliability across all of the libraries at once, the local consistency within each individual library becomes truly exceptional. Additionally, even single-library projects that leverage such principles will derive substantial benefit.

There are many software methodologies appropriate for small- and medium-sized projects, but most simply do not scale to larger development efforts. In this talk we will explore problems associated with very large scale development, and the cohesive techniques we have found to address those problems culminating in a proven component-based methodology, refined through practical experience at Bloomberg. The real-world application of this methodology – including *three levels of aggregation*, *acyclic dependencies*, *nominal cohesion*, *fine-grained factoring*, *class categories*, *narrow contracts*, and *thorough component-level testing* – will be demonstrated using the recently released open-source distribution of Bloomberg's foundation libraries.

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- Requires an ability to isolate and modularize logical functionality within discrete, fine-grained physical components.
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- Demands a host of additional considerations in order to maximize wide-spread ***hierarchical reuse***.

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- Understand ***specific problems*** associated with very large-scale development.
- Present ***cohesive techniques*** we have found to address these problems.
- Demonstrate ***our methodology*** using Bloomberg's foundation libraries.

Outline

0. Goals

   What we are trying to do, for whom, and how.

1. Process & Architecture

   Organizing Software as Components, Packages, & Package Groups.

2. Design & Implementation

   Using Class Categories, Value Semantics, & Vocabulary Types.

3. Verification & Testing

   Component-Level Test Drivers, Peer Review, & Defensive Checks.

4. Bloomberg Development Environment (BDE)

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What are the goals?

- Solve interesting problems.
- Employ new language features early.
- Strive for header-only implementations (i.e., no `.cpp` files).
- Write code that stress-tests compilers.
- Ensure that no C++ language construct goes unused.

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- Experts capable of reverse engineering advanced C++ implementations.
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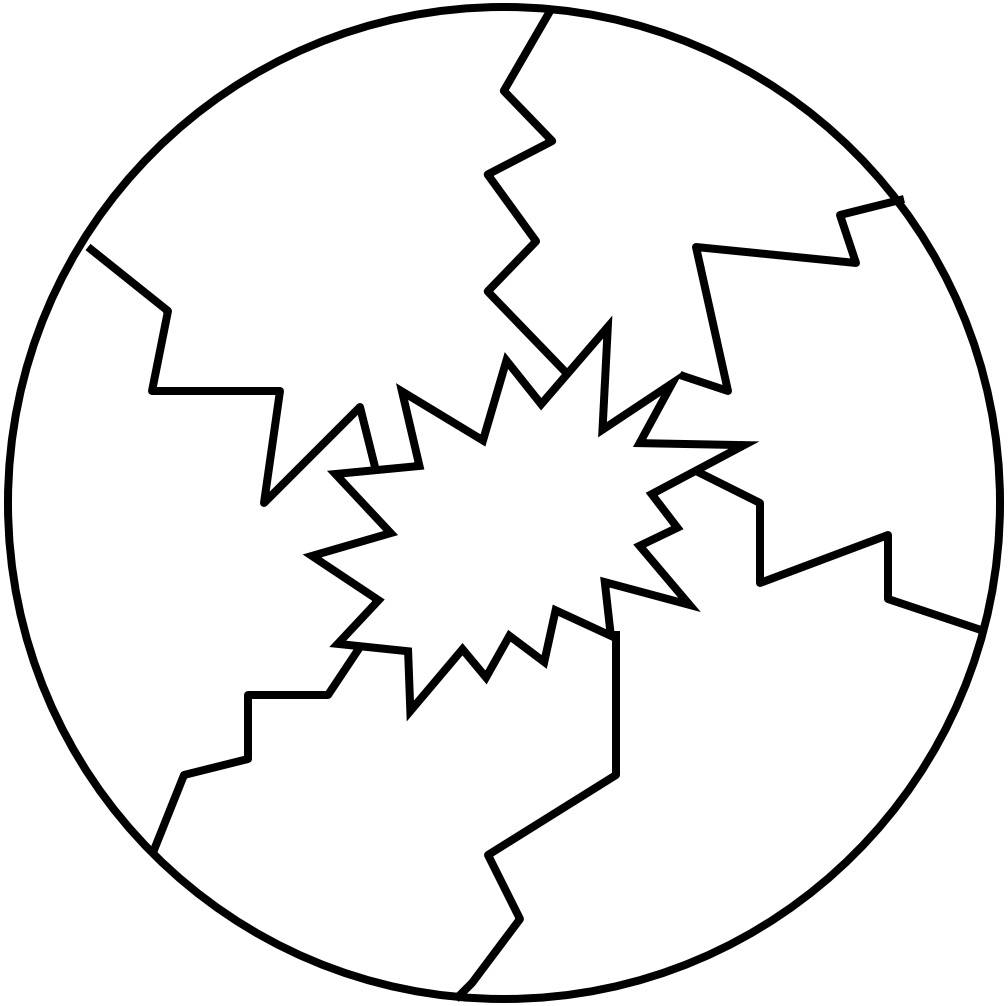
- **Achieve *wide-spread, fine-grained, hierarchical* reuse.**

Achieving Reuse



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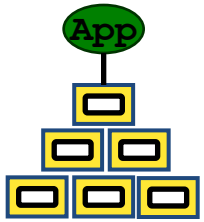

Brittle

Within just one version of a single App

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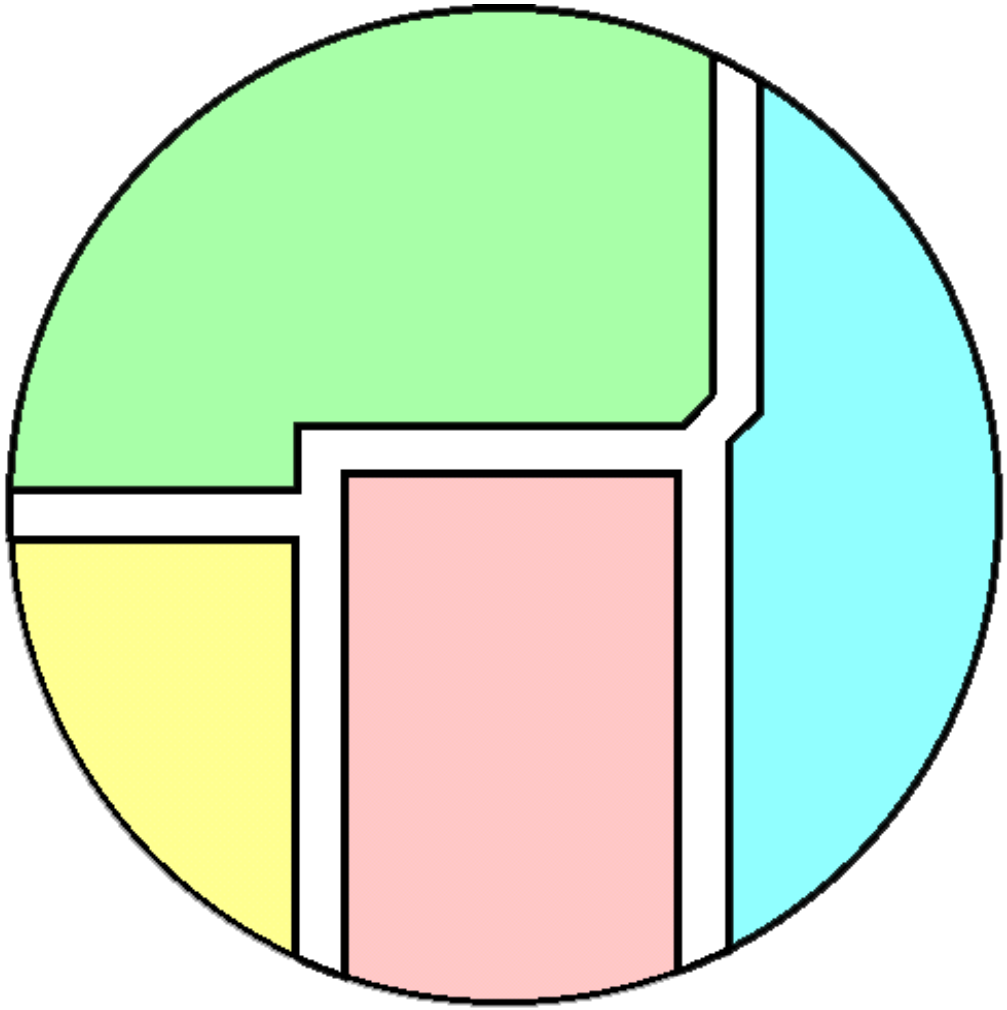

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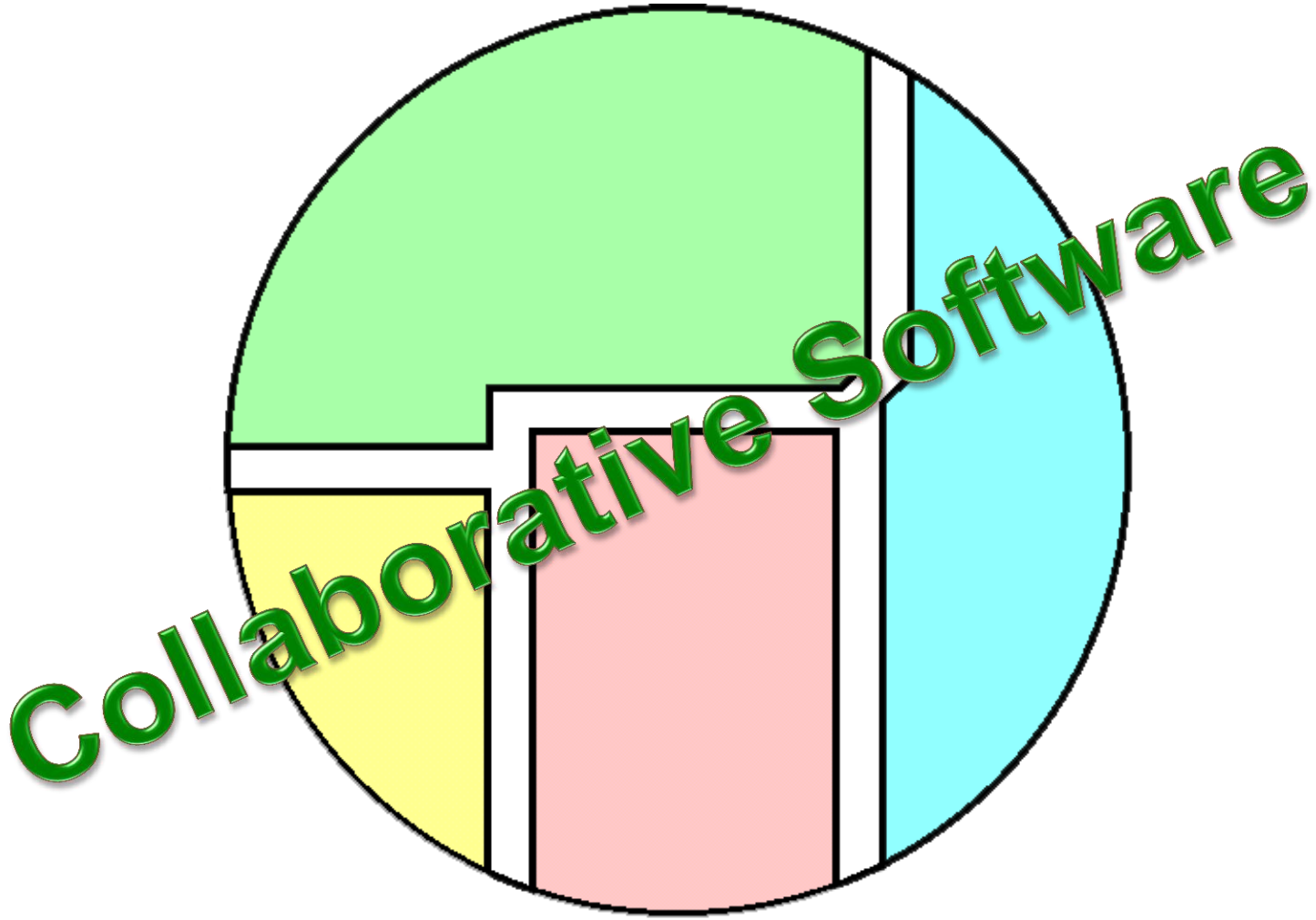

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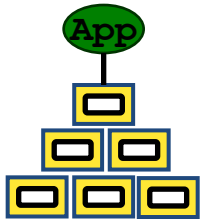

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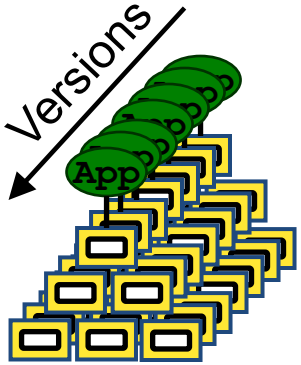

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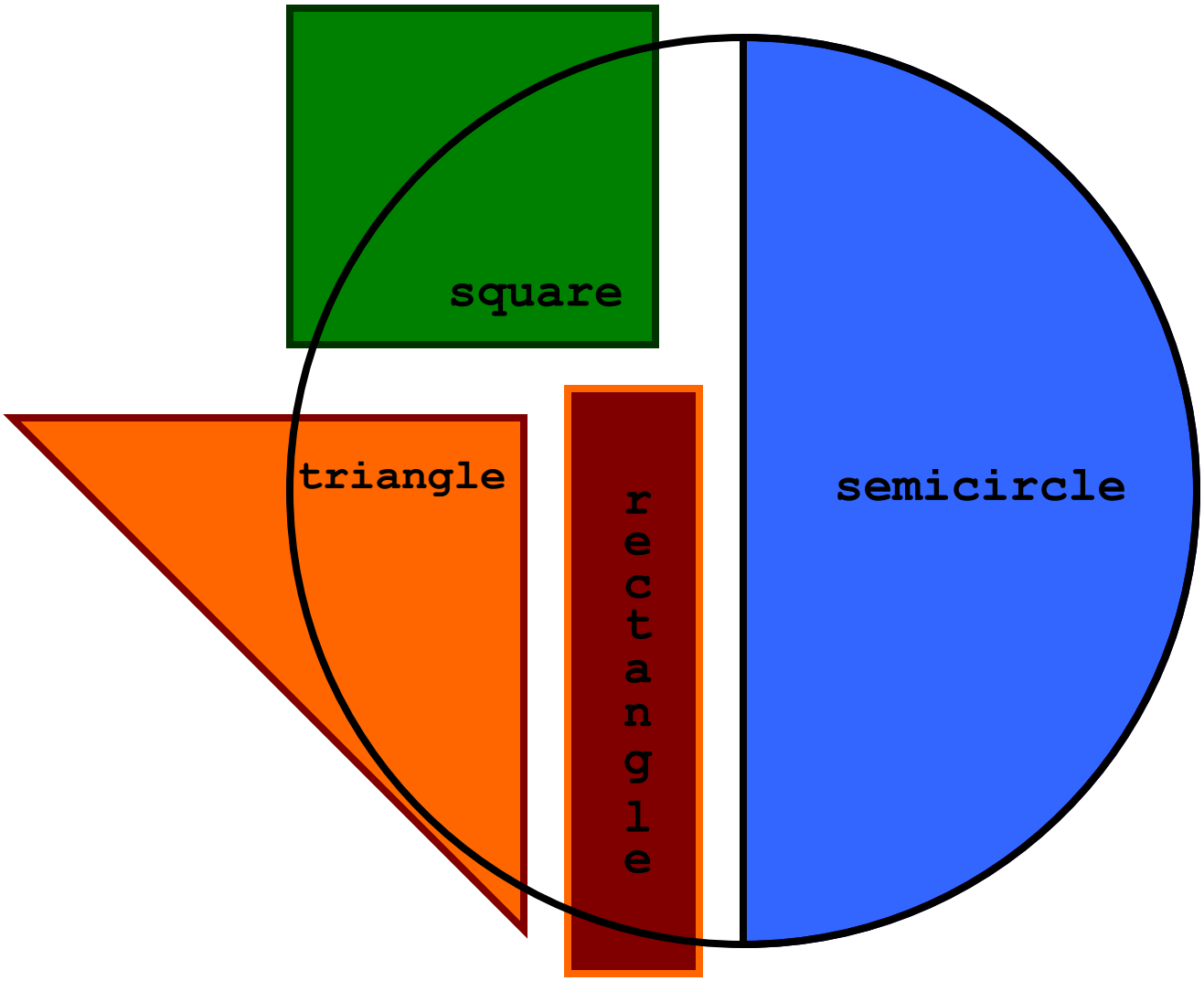

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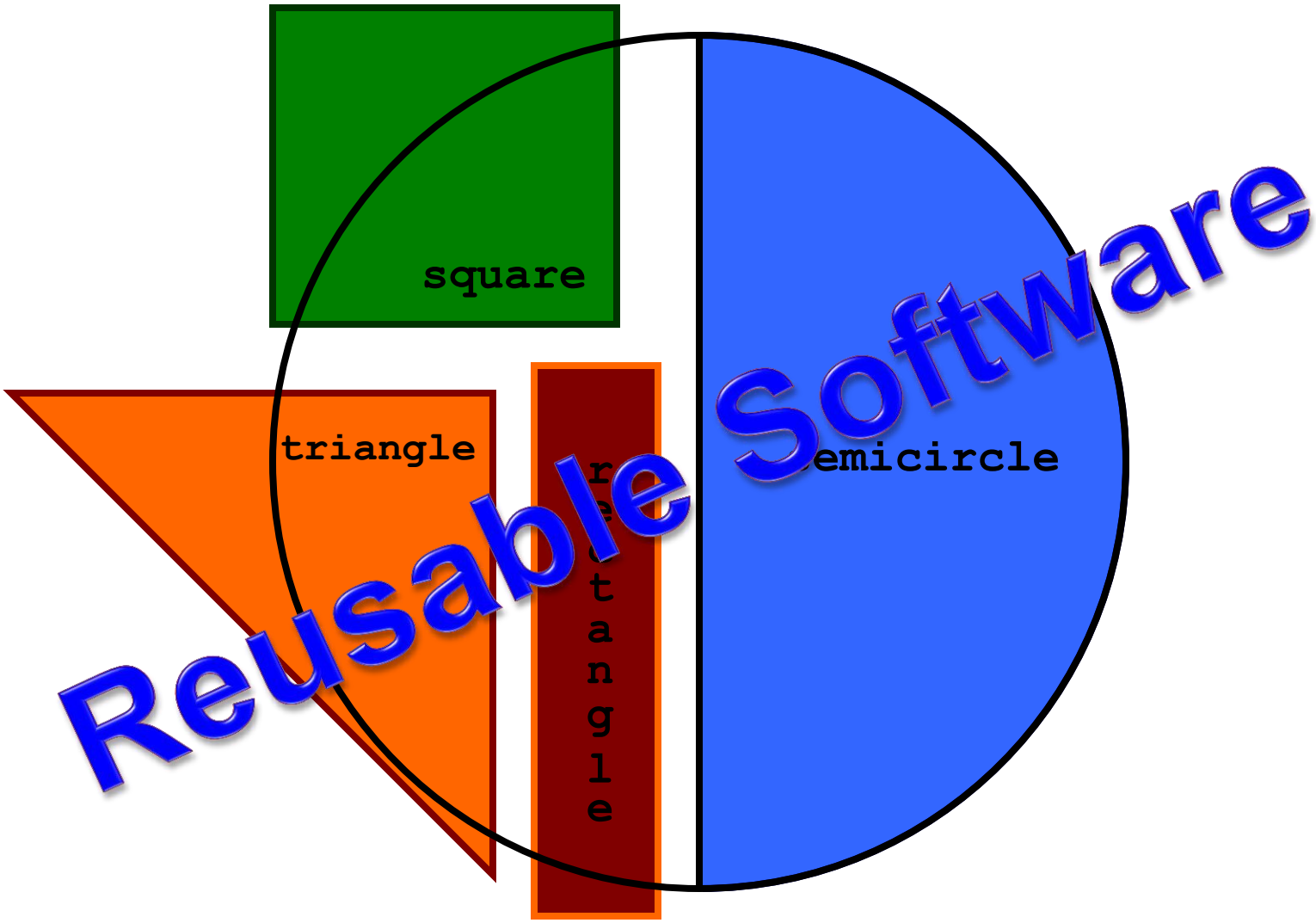

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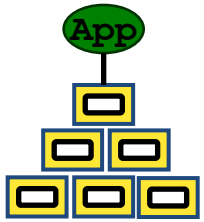

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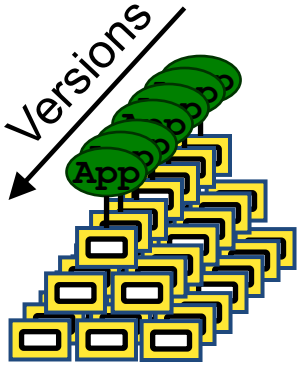

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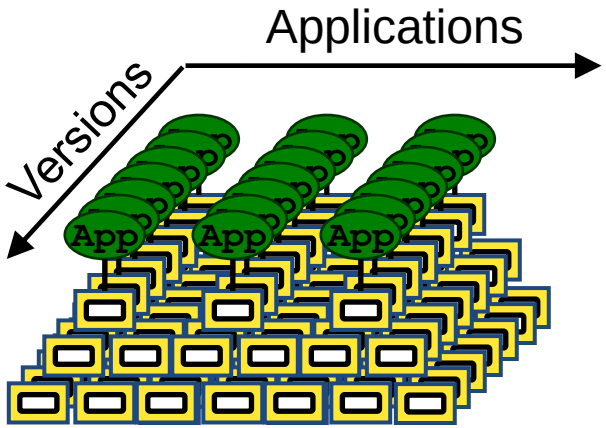


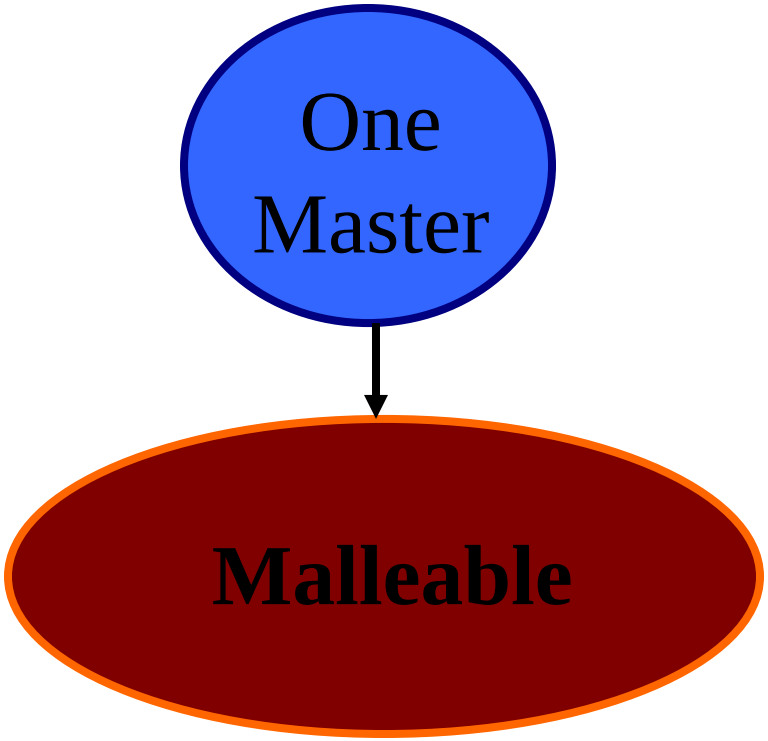
Reusable

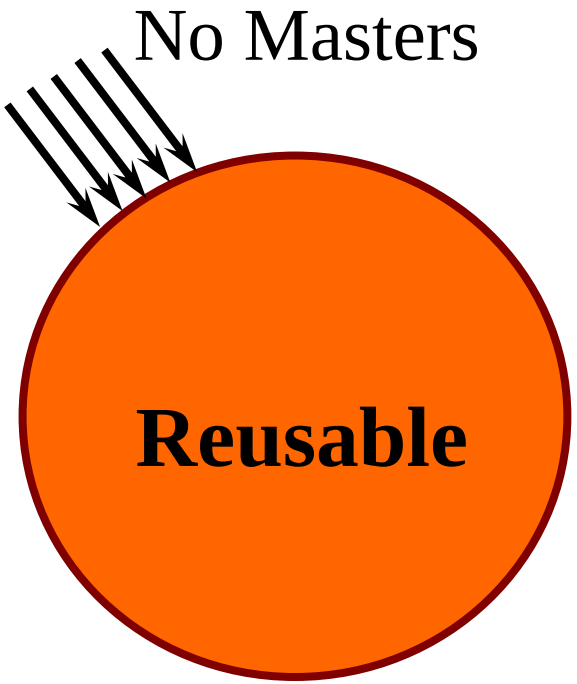
Across several versions of many distinct applications and products

Achieving Reuse

Good applications are *malleable*…

…but reusable software is ***stable***!





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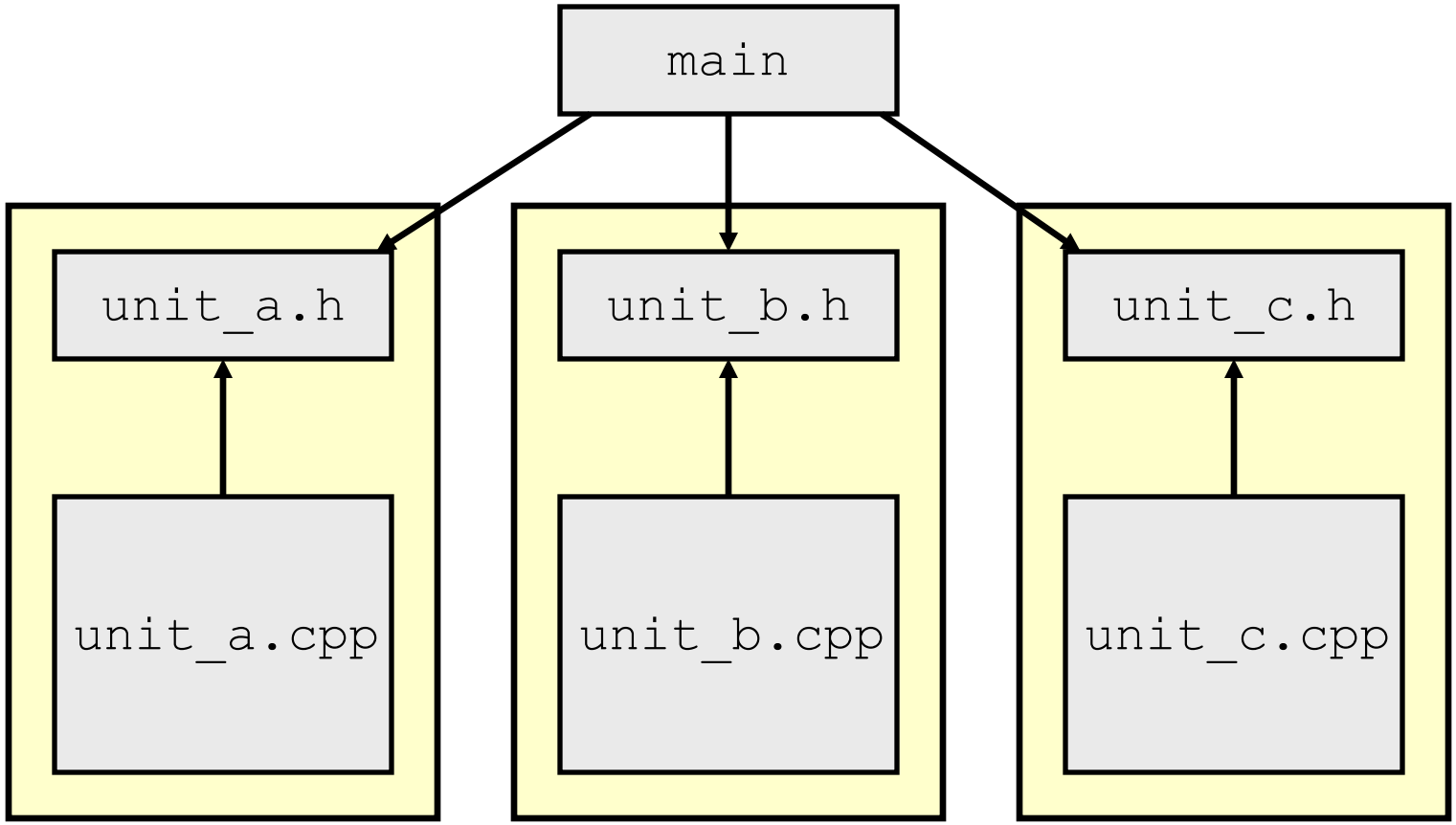
Coarse-Grained Physical Modularity



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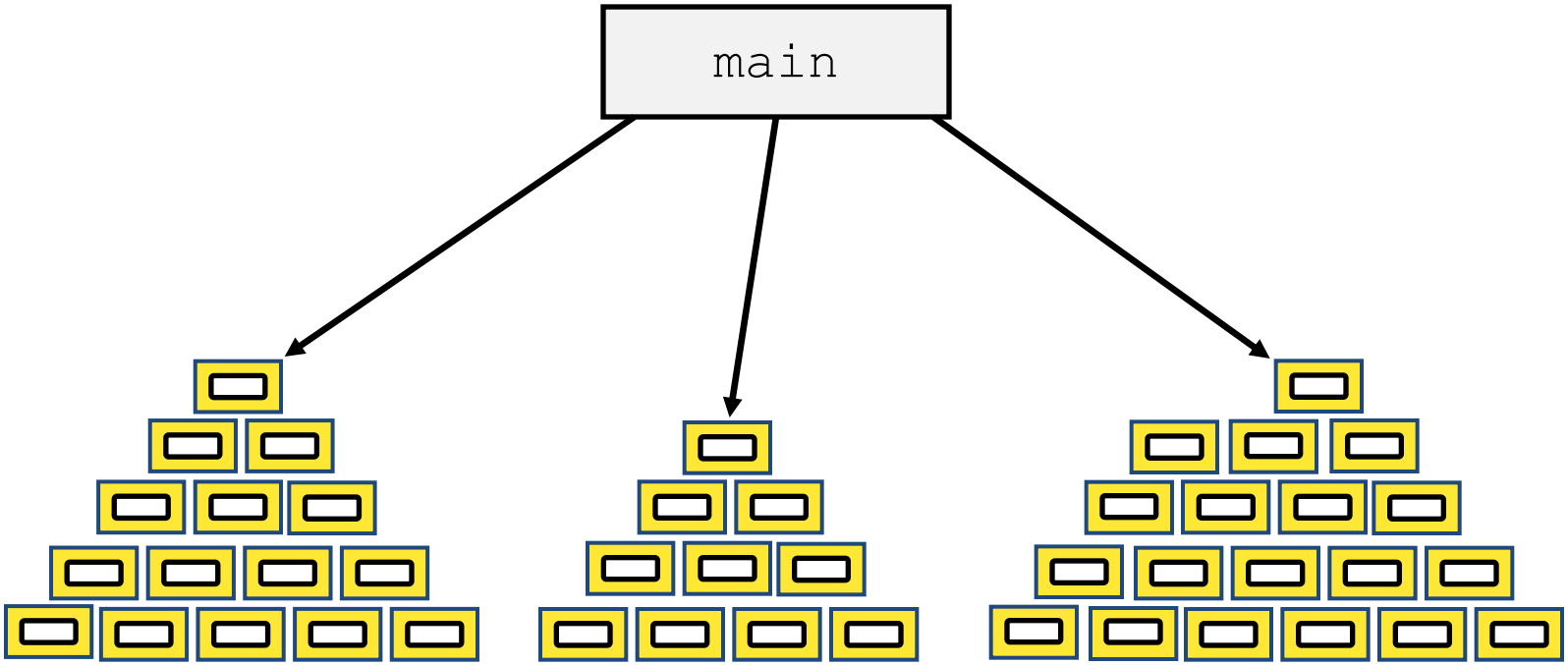

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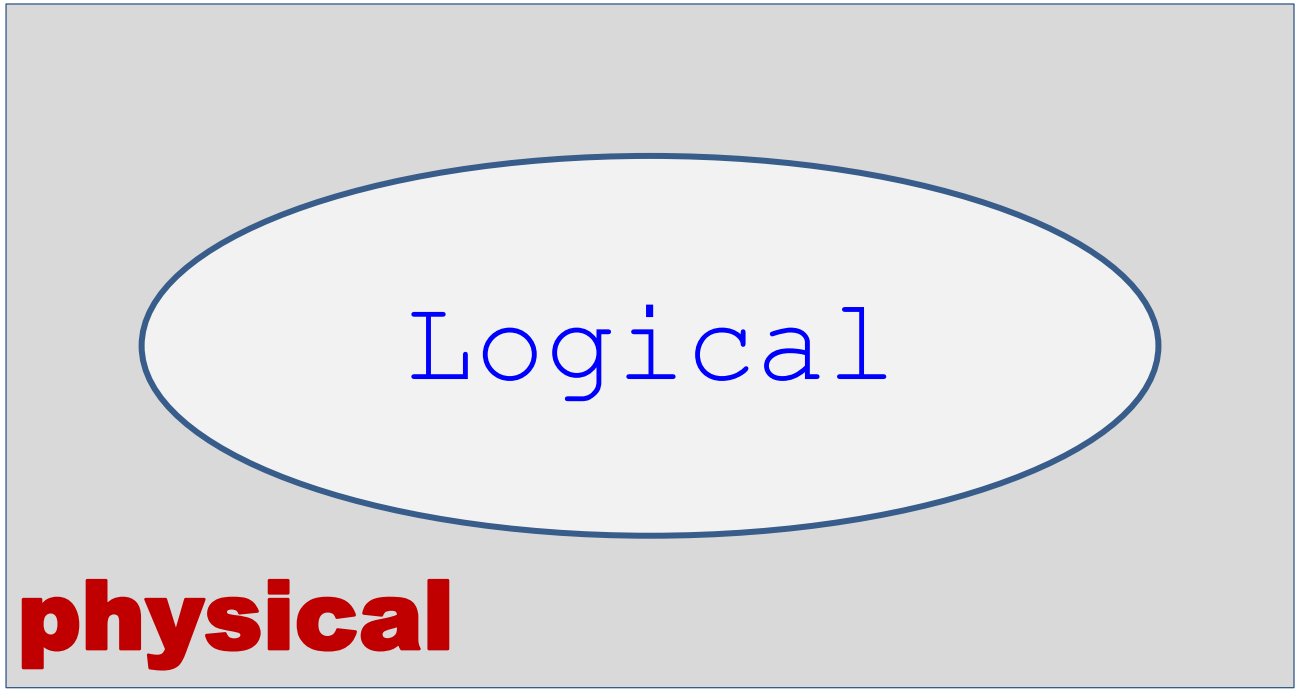

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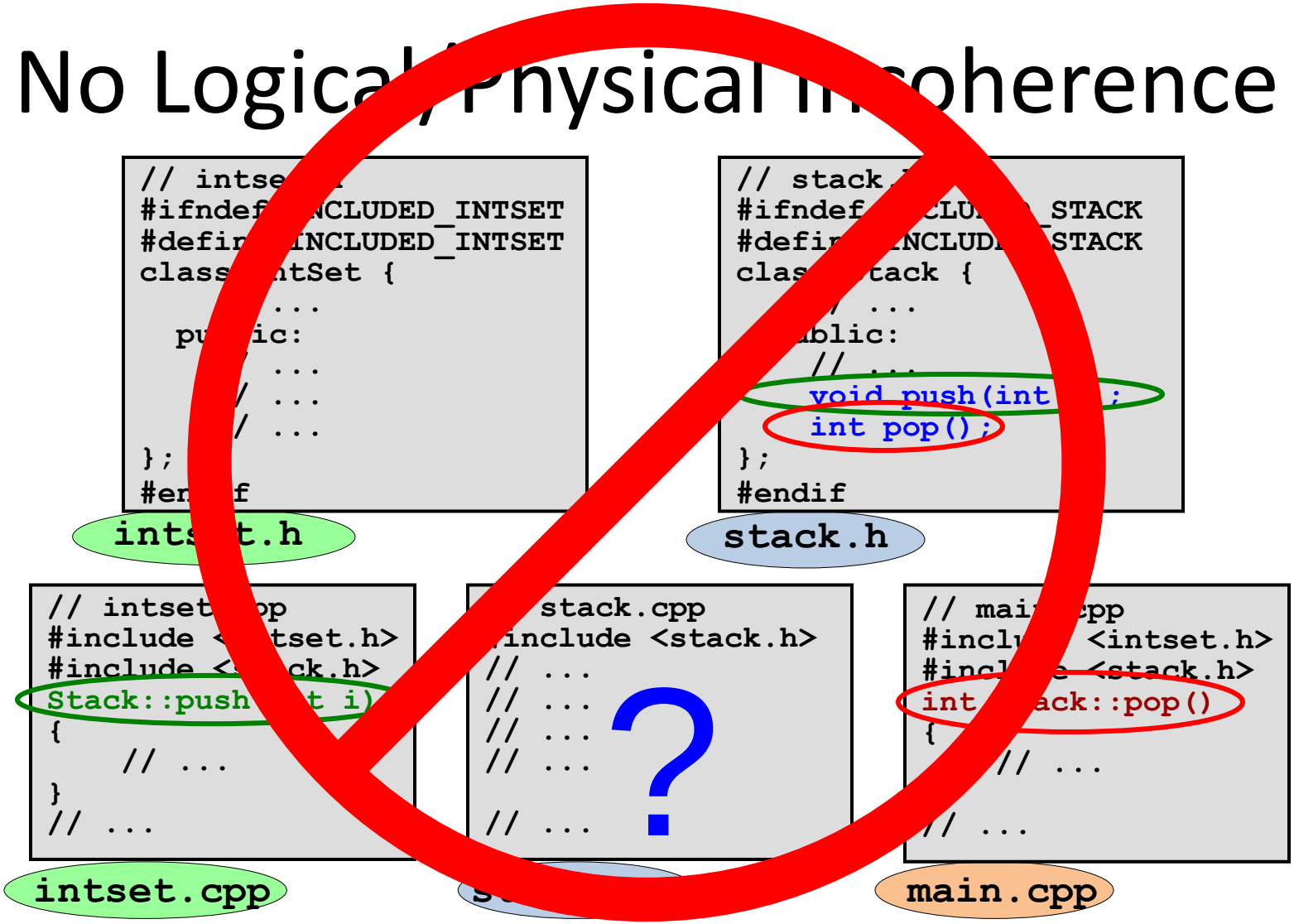

Achieving Fine-Grained Reuse

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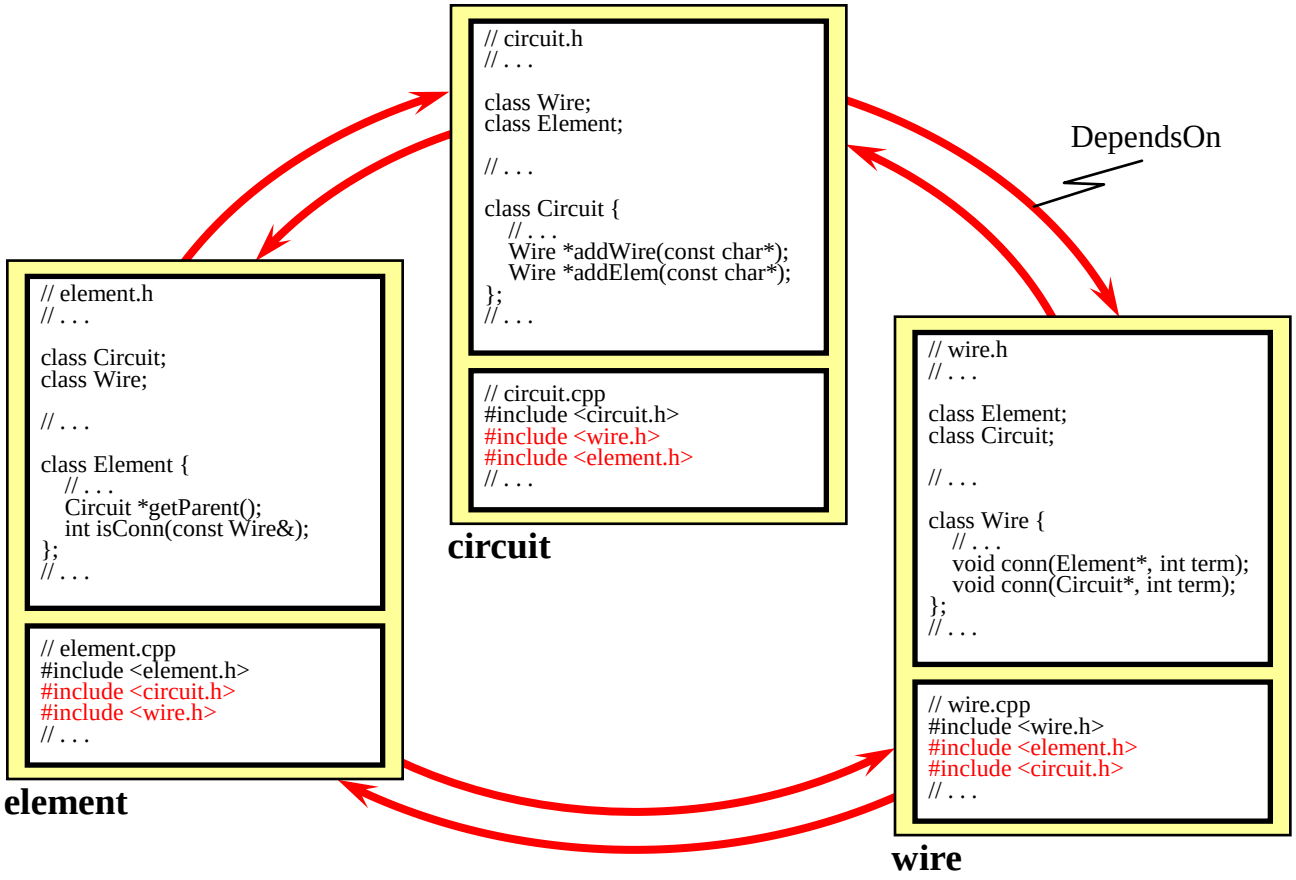

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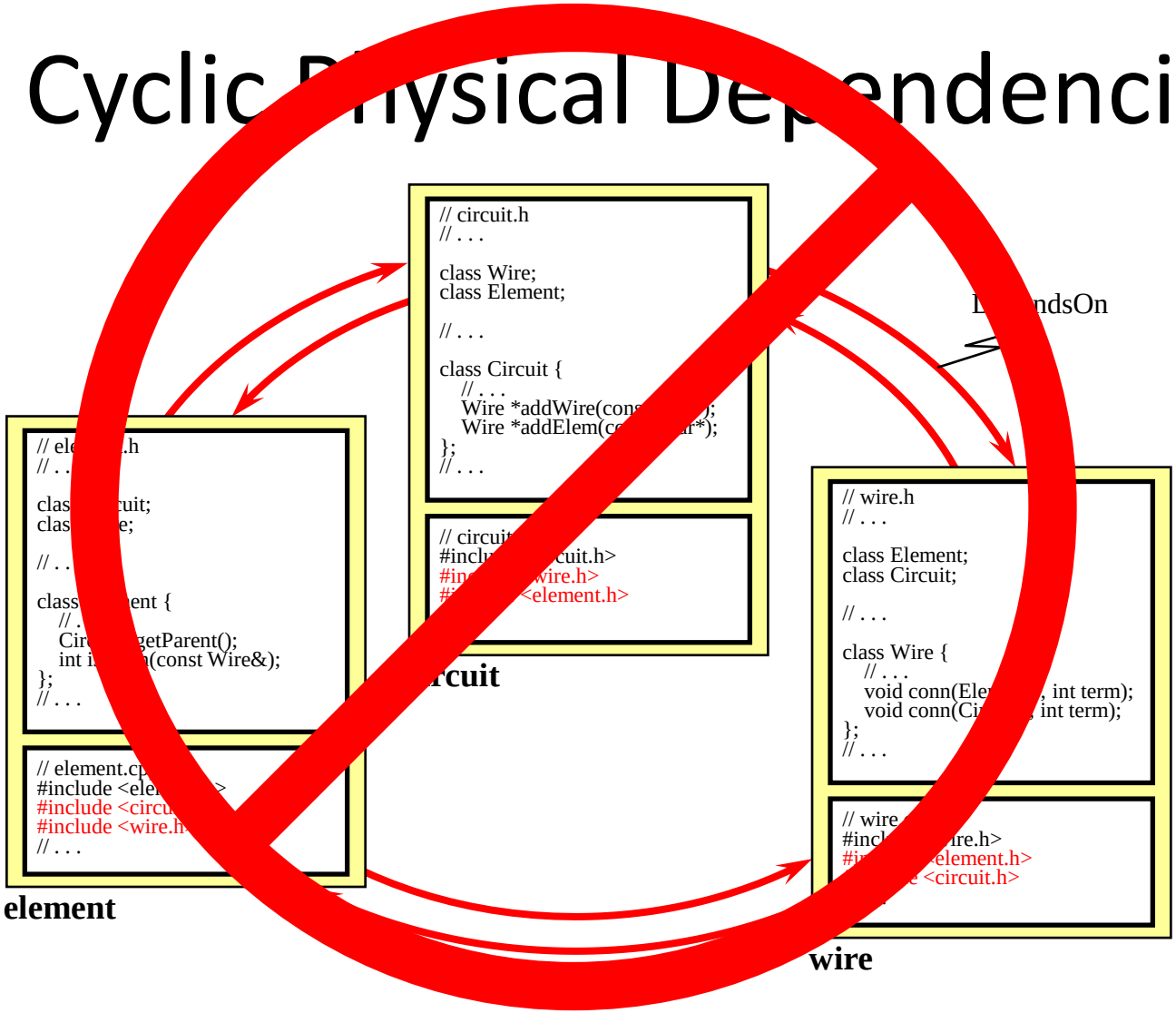
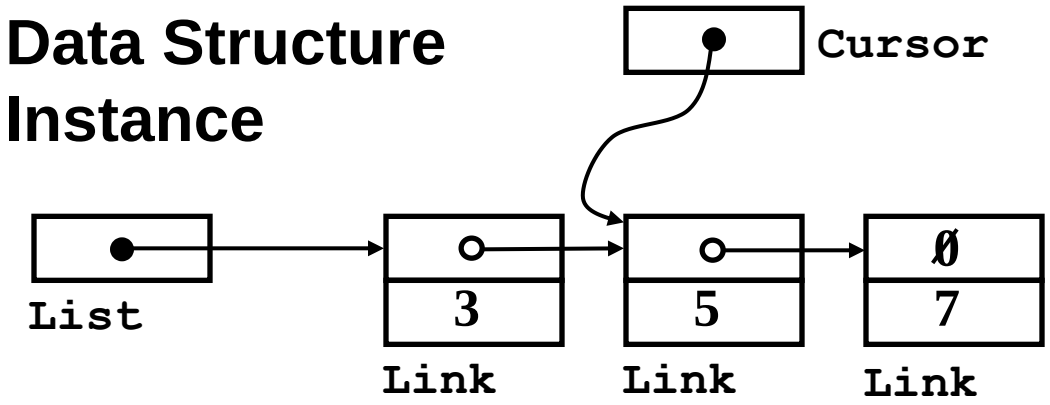
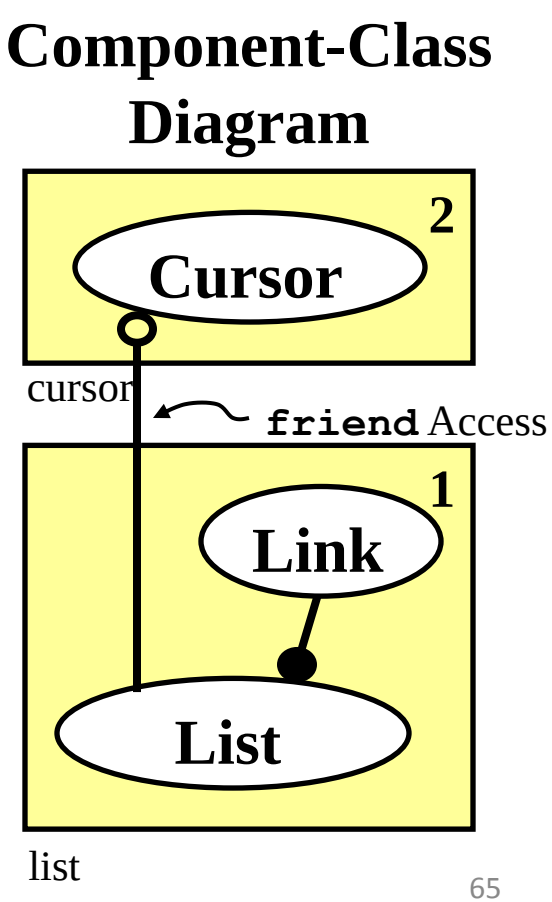


Achieving Fine-Grained Reuse

No Private "Back Door" Access





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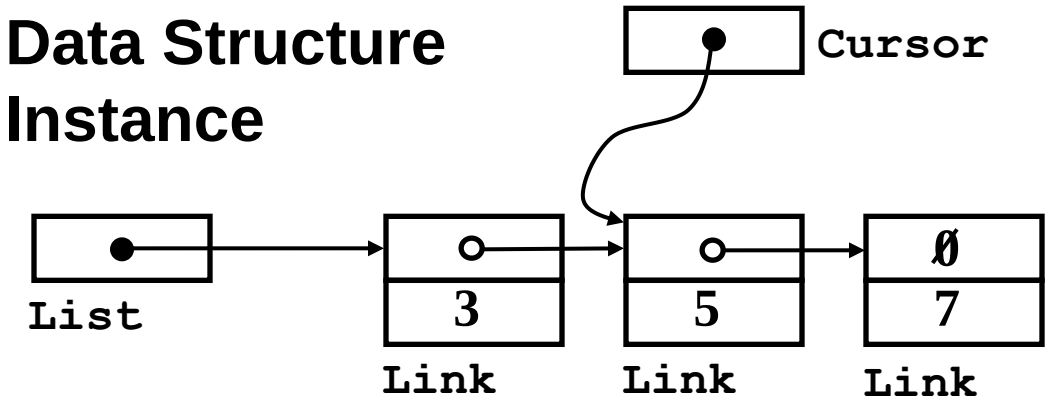

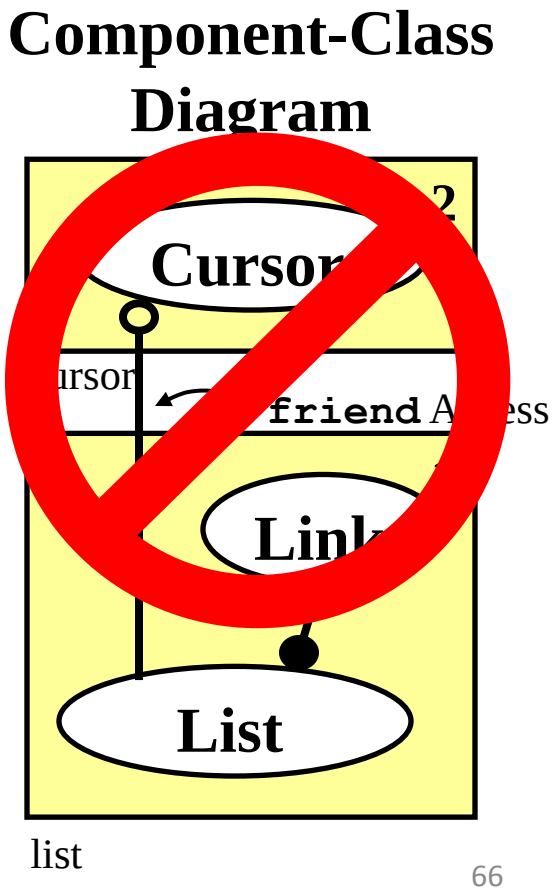

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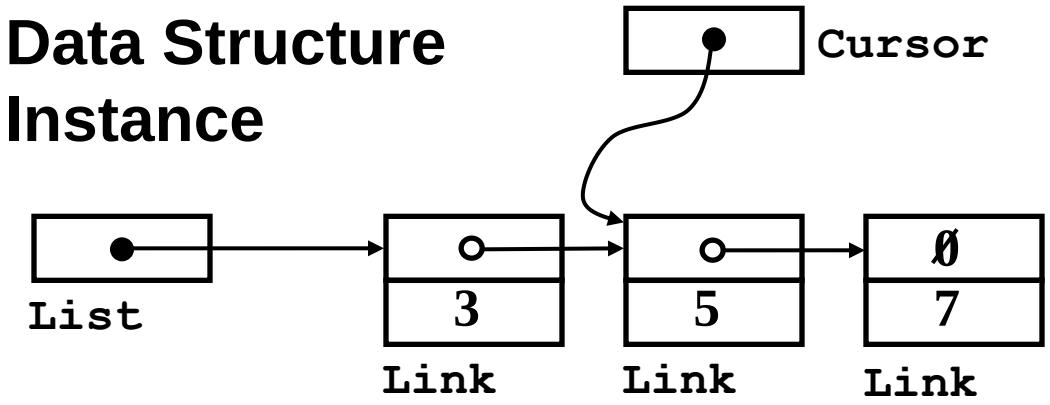

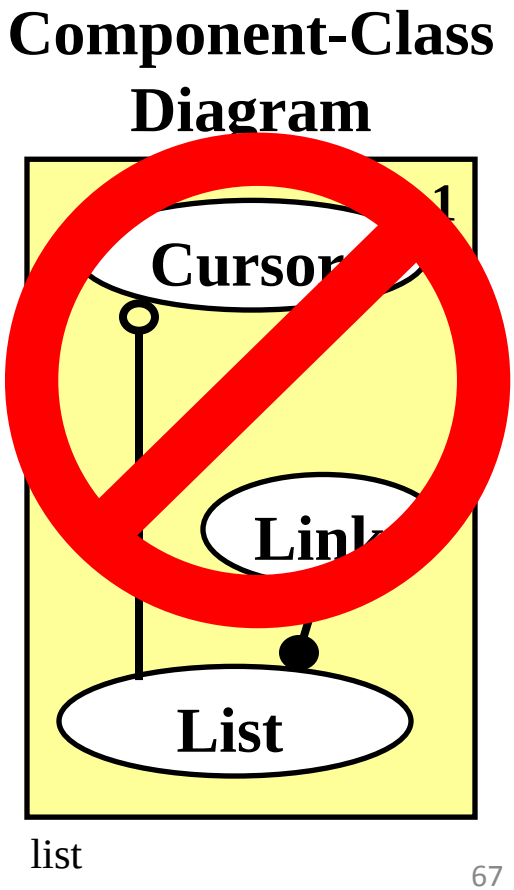

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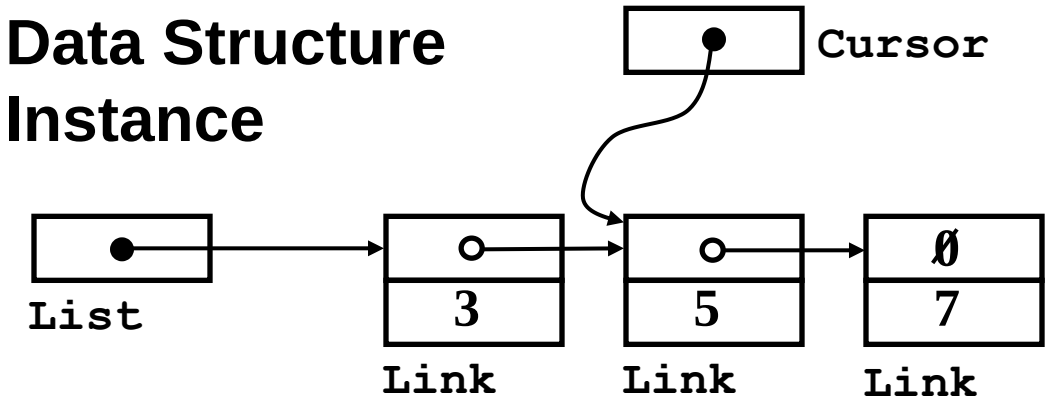

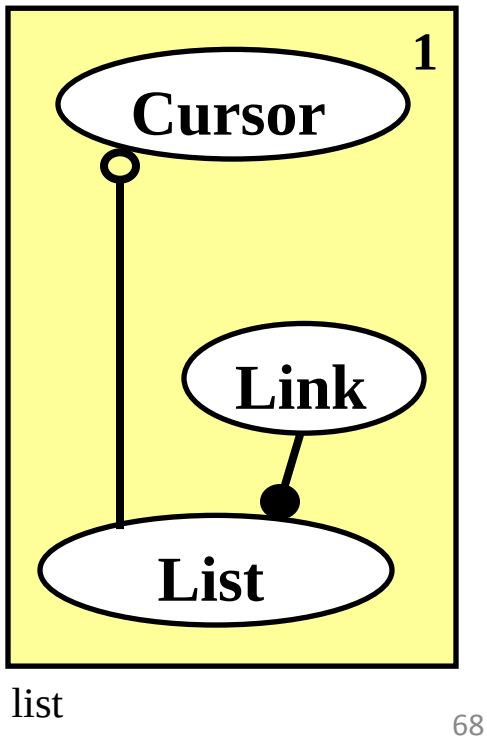

Achieving Hierarchical Reuse

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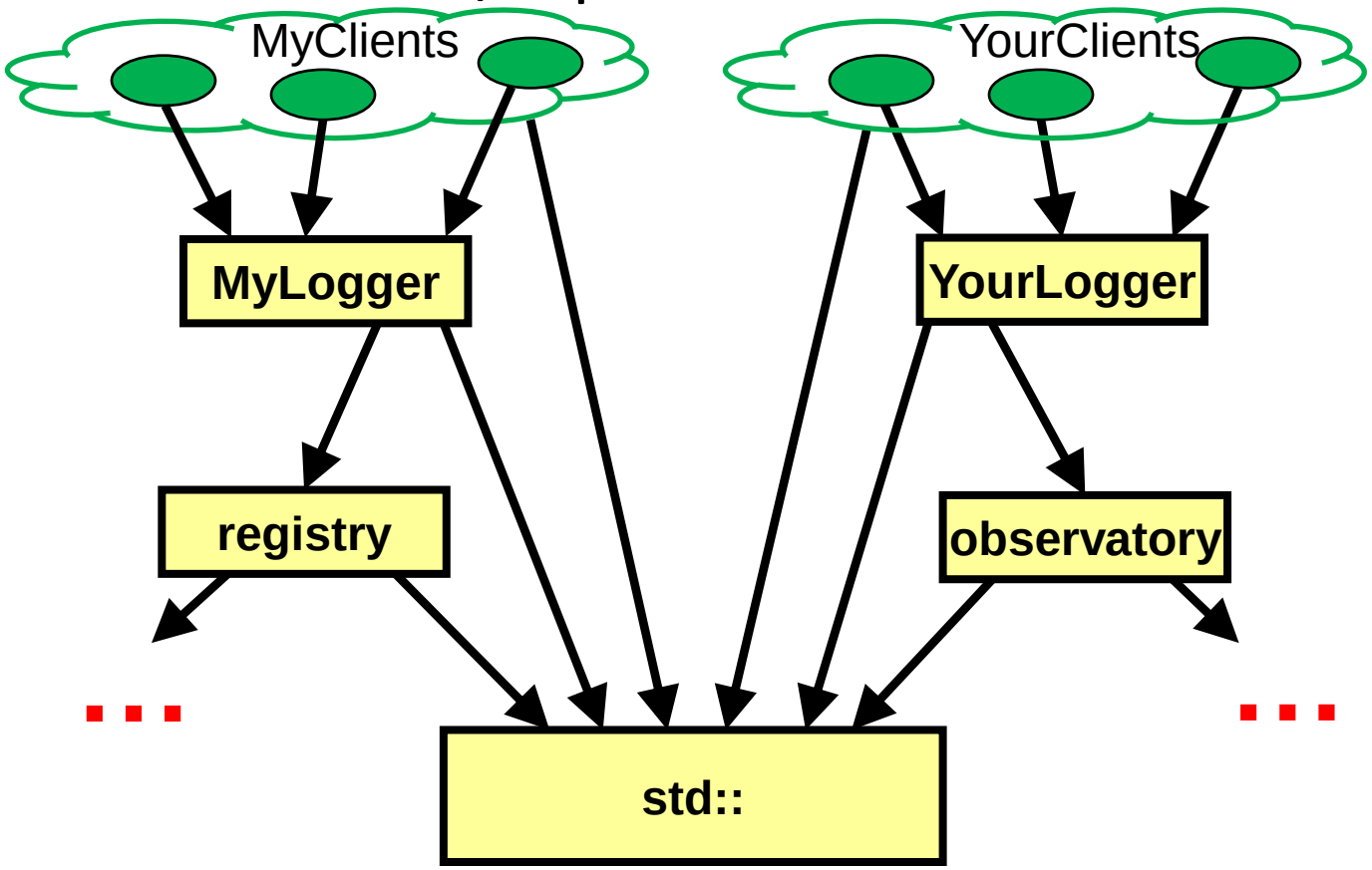
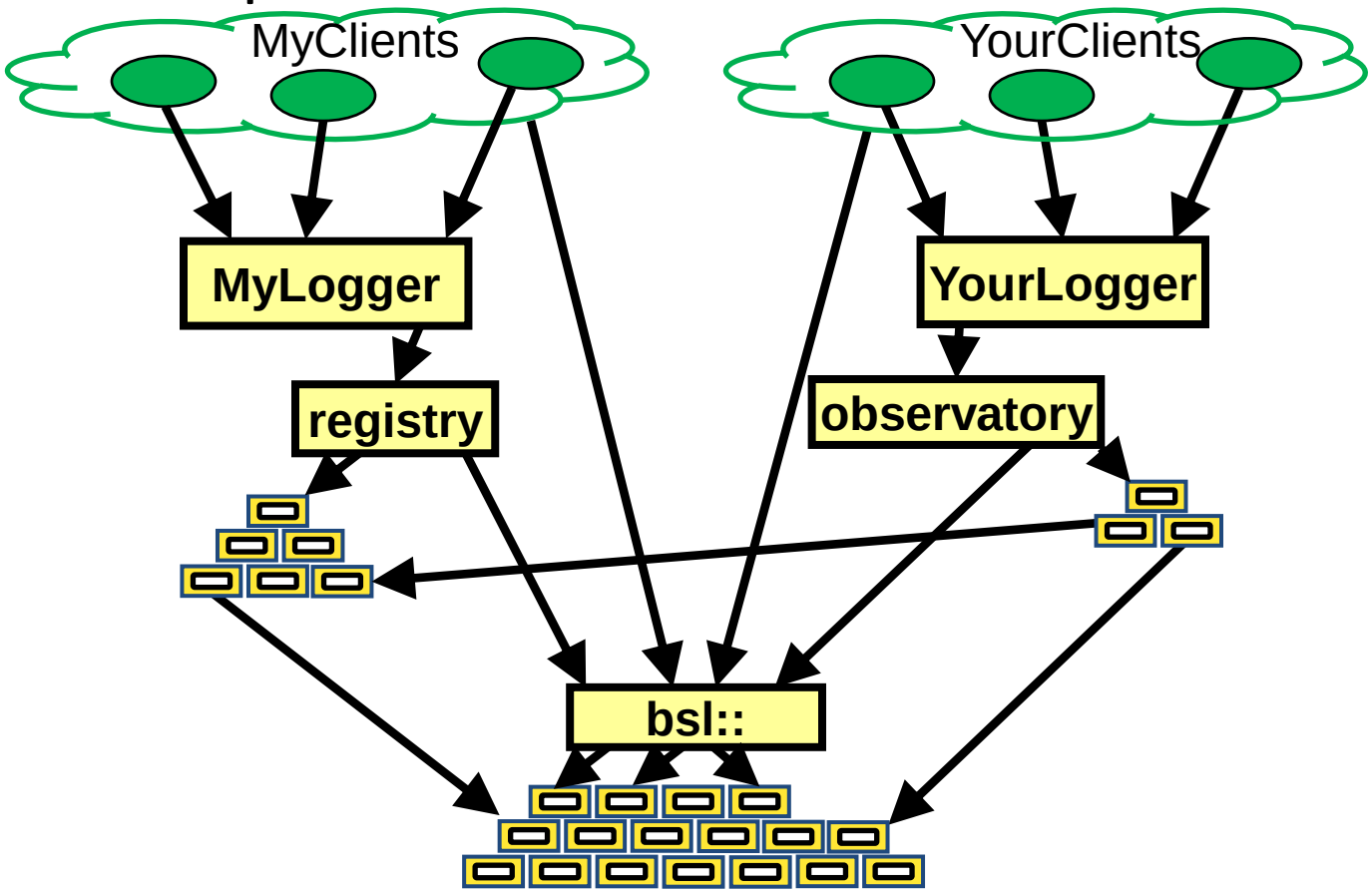


Achieving Hierarchical Reuse

Hierarchical Reuse: Even the (stable) intermediate pieces are exposed for reuse.



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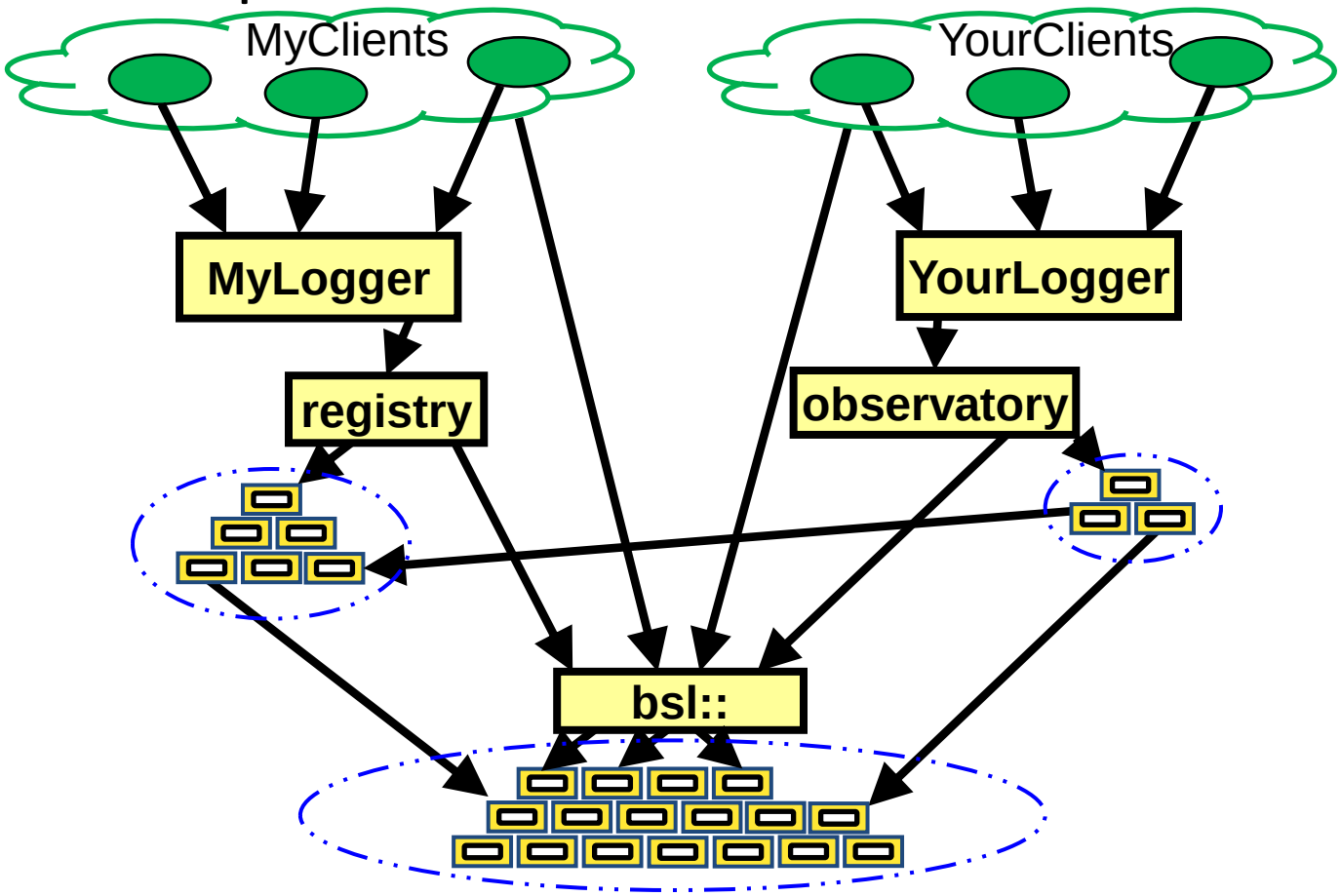


Achieving Hierarchical Reuse

Application Software:

Library Software:

Solutions

Sub-Solutions

Sub-Sub-Solutions

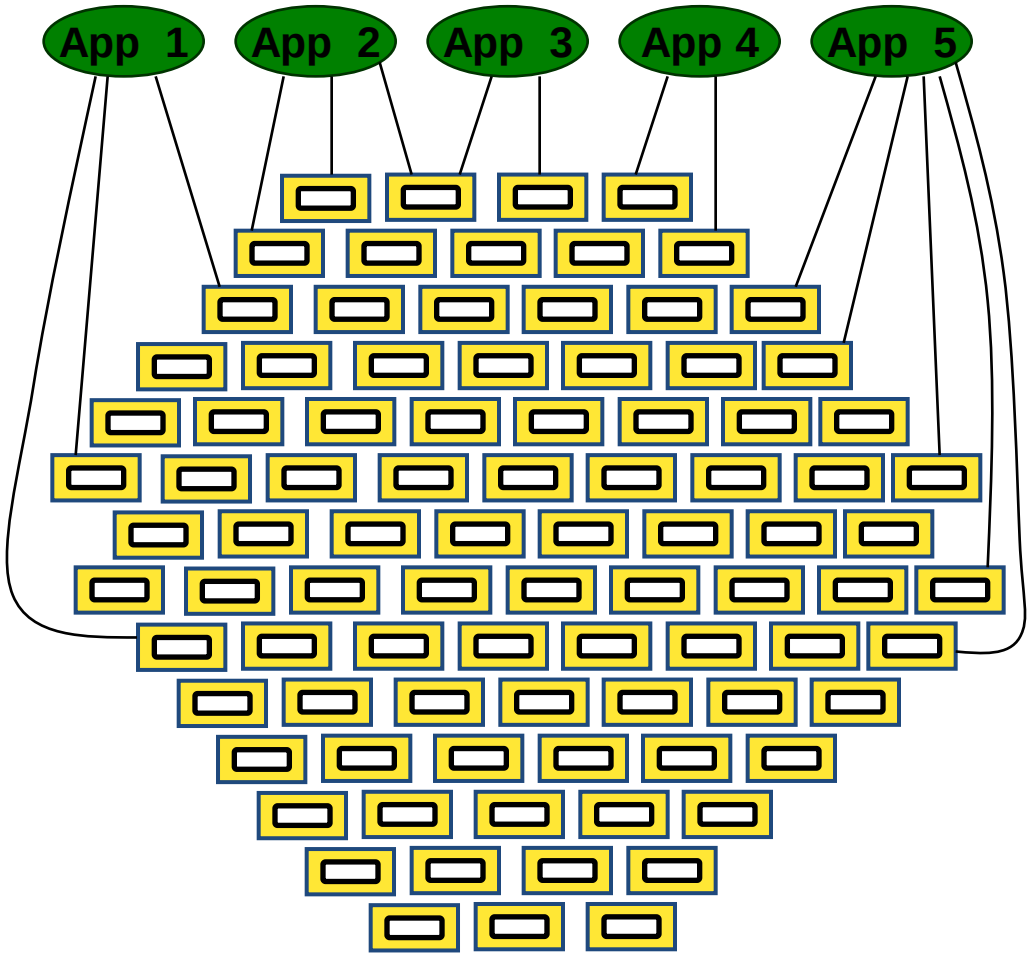
Vocabulary-Type Utilities

Vocabulary Types

Implementation Utilities

Low-Level Interfaces

Platform Adapters



Achieving Wide-Spread Reuse

As library developers, we must

Achieving Wide-Spread Reuse

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- Draw complexity inward; push simplicity outward.

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As library developers, we must:

- Draw complexity inward; push simplicity outward.
- Provide correct, complete, yet concise function contract documentation.
- Avoid gratuitous variation in rendering.
- Achieve reliability *at least* as good as our compilers.

Achieving Wide-Spread Reuse

To the maximum extent practicable…

…every software component we write must be:

1. Easy to Understand
2. Easy to Use
3. High Performance
4. Portable
5. Reliable

Achieving Wide-Spread Reuse

1. Easy to Understand

- Canonical rendering.
- Clear and complete reference documentation.
- Relevant usage examples.

Achieving Wide-Spread Reuse

1. Easy to Understand
2. Easy to Use

- Effective usage model.
- Intuitive interface.
- Appropriate level of safety.
- Minimal physical dependencies.

Achieving Wide-Spread Reuse

1. Easy to Understand
2. Easy to Use
3. High Performance

- Execution (i.e., wall and CPU) run time.
- Process (i.e., in-core memory) size.
- Compile time (or the degree of compile-time coupling).
- Link time (or the extent of link-time dependency).
- Executable (i.e., on-disk) code size.

Achieving Wide-Spread Reuse

1. Easy to Understand
2. Easy to Use
3. High Performance
4. Portable

- Builds on all supported platforms.
- Runs on all supported platforms.
- Produces the same results on all supported platforms.
- Achieves "reasonable" performance on all supported platforms.

Achieving Wide-Spread Reuse

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- No core dumps.

0. Goals

Achieving Wide-Spread Reuse

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2. Easy to Use
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- No bugs!

Achieving Wide-Spread Reuse

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4. Portable
5. Reliable

- No core dumps.
- No memory leaks.
- No incorrect results.
- No bugs!
- No, we're not kidding.

Achieving Wide-Spread Reuse

Wait a minute…

Just how good does software need to be?

Achieving Wide-Spread Reuse

Writing an ***application*** is somewhat analogous to building a house:

Achieving Wide-Spread Reuse

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Achieving Wide-Spread Reuse

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- It must be safe under normal conditions.

0. Goals

Achieving Wide-Spread Reuse

Achieving Wide-Spread Reuse

Writing an ***application*** is somewhat analogous to building a house:

- It must adequately perform its function.
- It must be safe under normal conditions.
- Beyond that, there are costs and benefits that have to be weighed.

0. Goals

Achieving Wide-Spread Reuse

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Achieving Wide-Spread Reuse

Achieving Wide-Spread Reuse

Writing a ***Reusable library*** is different.

Achieving Wide-Spread Reuse

Writing a ***Reusable library*** is different.

The goal of reusable software is to be *reused* wherever "appropriate" and human beings – not computers – will make that determination.

– Lakos1x

Achieving Wide-Spread Reuse

``We conjecture that the barriers to reuse are not on the producer's side, but on the consumer's side. If a software engineer, a potential consumer of standardized components, perceives it to be more expensive to find a component that meets his needs, and so verify, than to write one anew, a new, duplicative component will be written. Notice that we said *perceives* above. It does not matter what the true cost of reconstruction is.''

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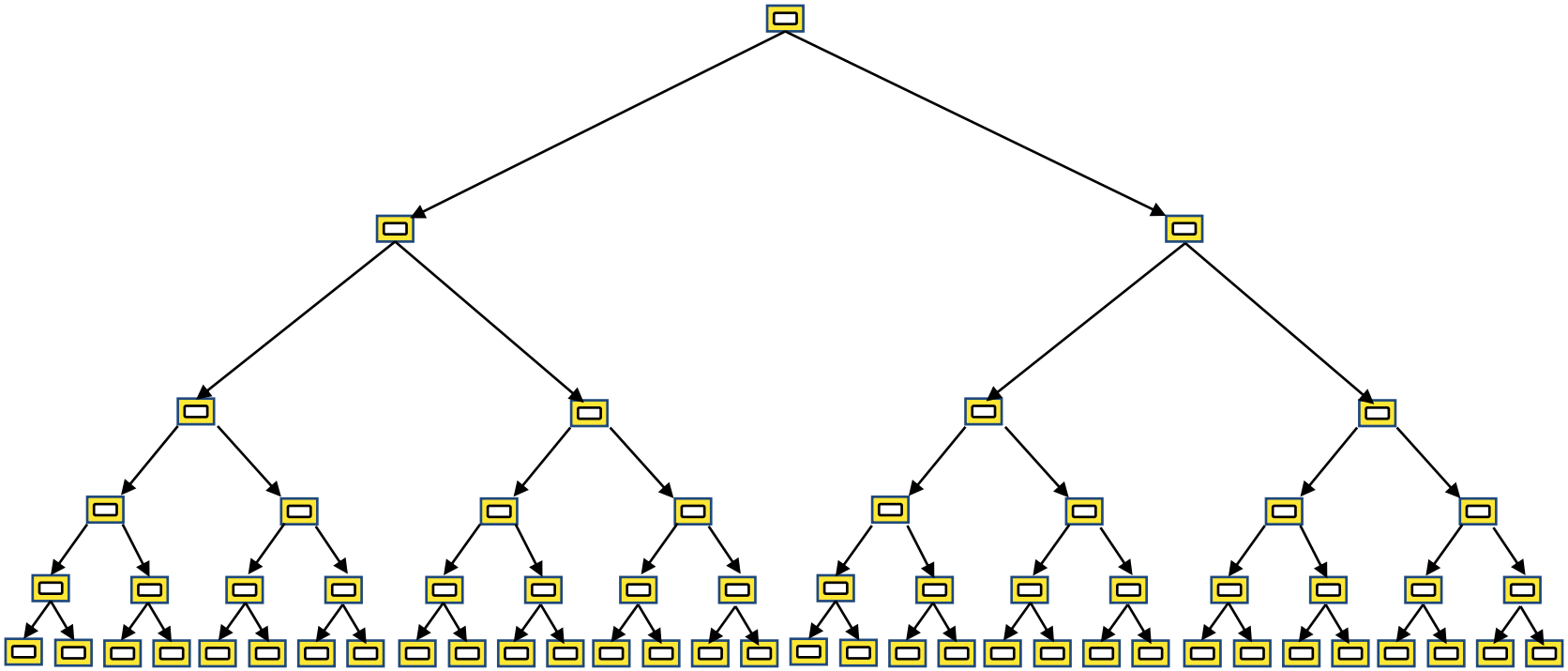
Achieving Wide-Spread Reuse

Reusable library software:

- Must be perceived as ***far*** better than what a prospective client (or anyone else) could do in any practical time frame.
- Unlike a house (or an App), can be consumed by many different (kinds of) clients.
- The more clients, the greater the utility (and vice versa).

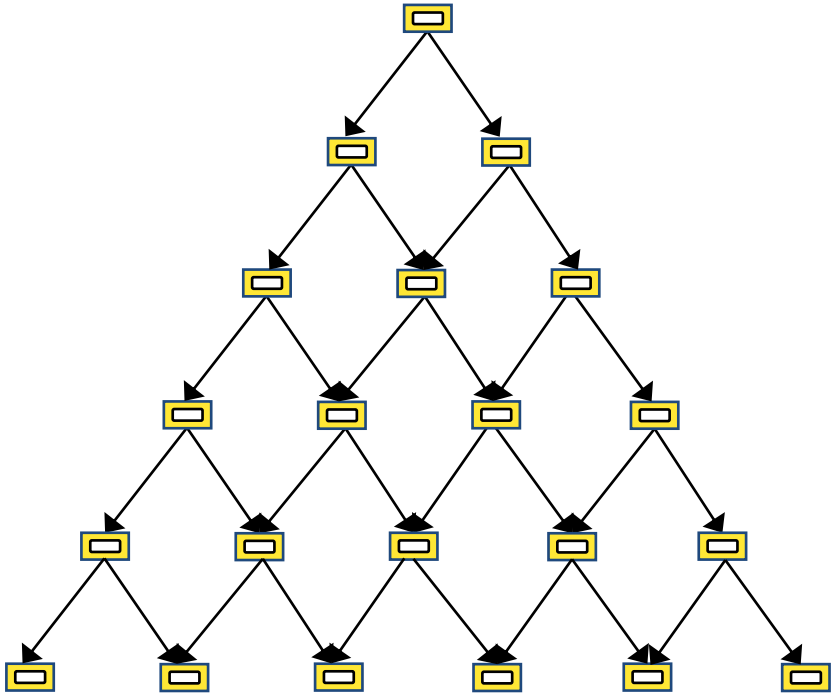
Achieving Wide-Spread Reuse



No Re-convergence

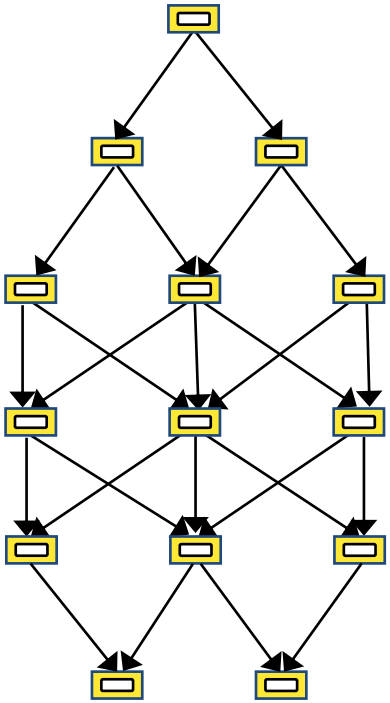
0. Goals

Achieving Wide-Spread Reuse



Significant Re-convergence

Achieving Wide-Spread Reuse



Maximal Re-convergence

Achieving Wide-Spread Reuse

So how good does our ***reusable library software*** need to be?

Achieving Wide-Spread Reuse

Achieving Wide-Spread Reuse

Nothing Succeeds Like Excess!

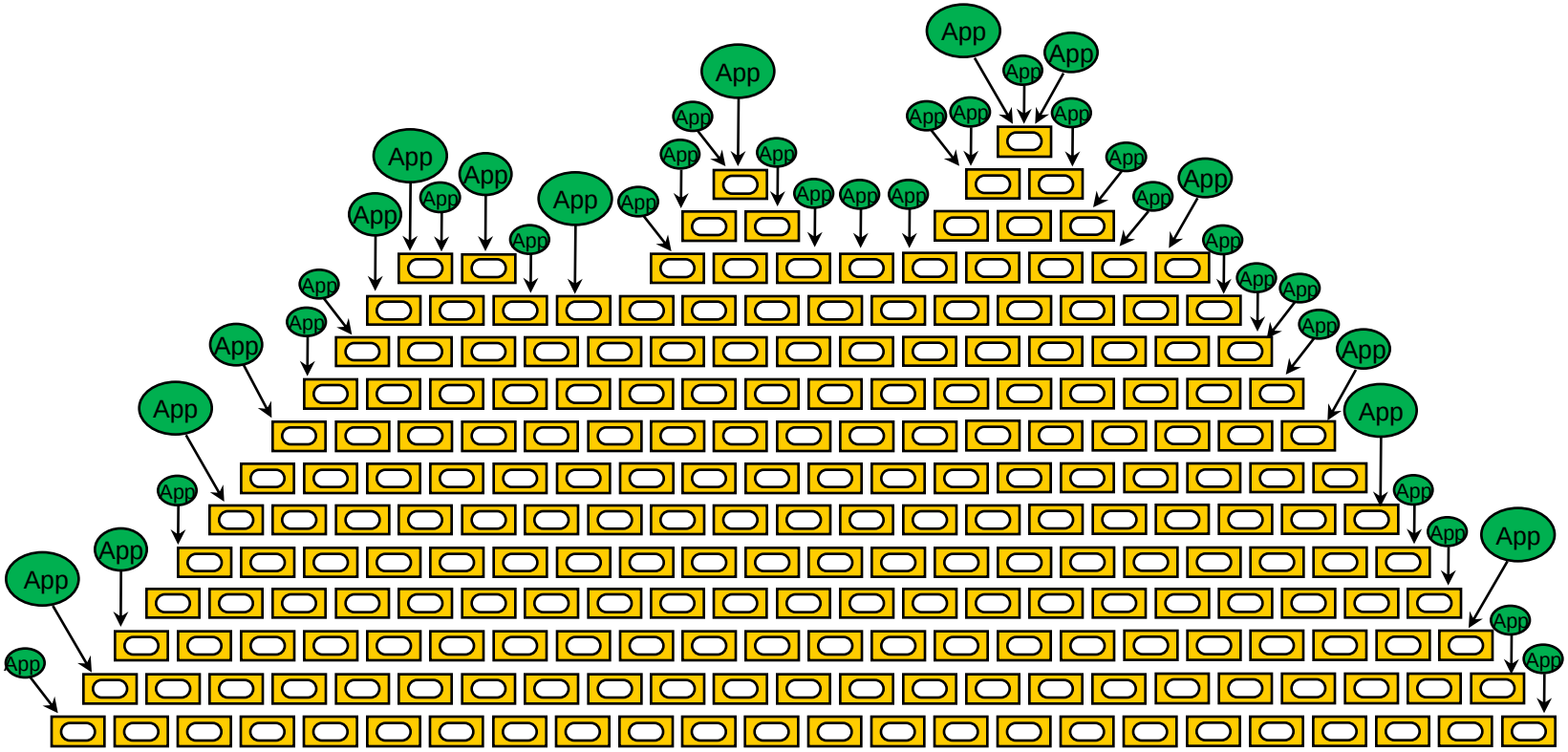
Achieving Wide-Spread Reuse

Nothing Succeeds Like Excess!

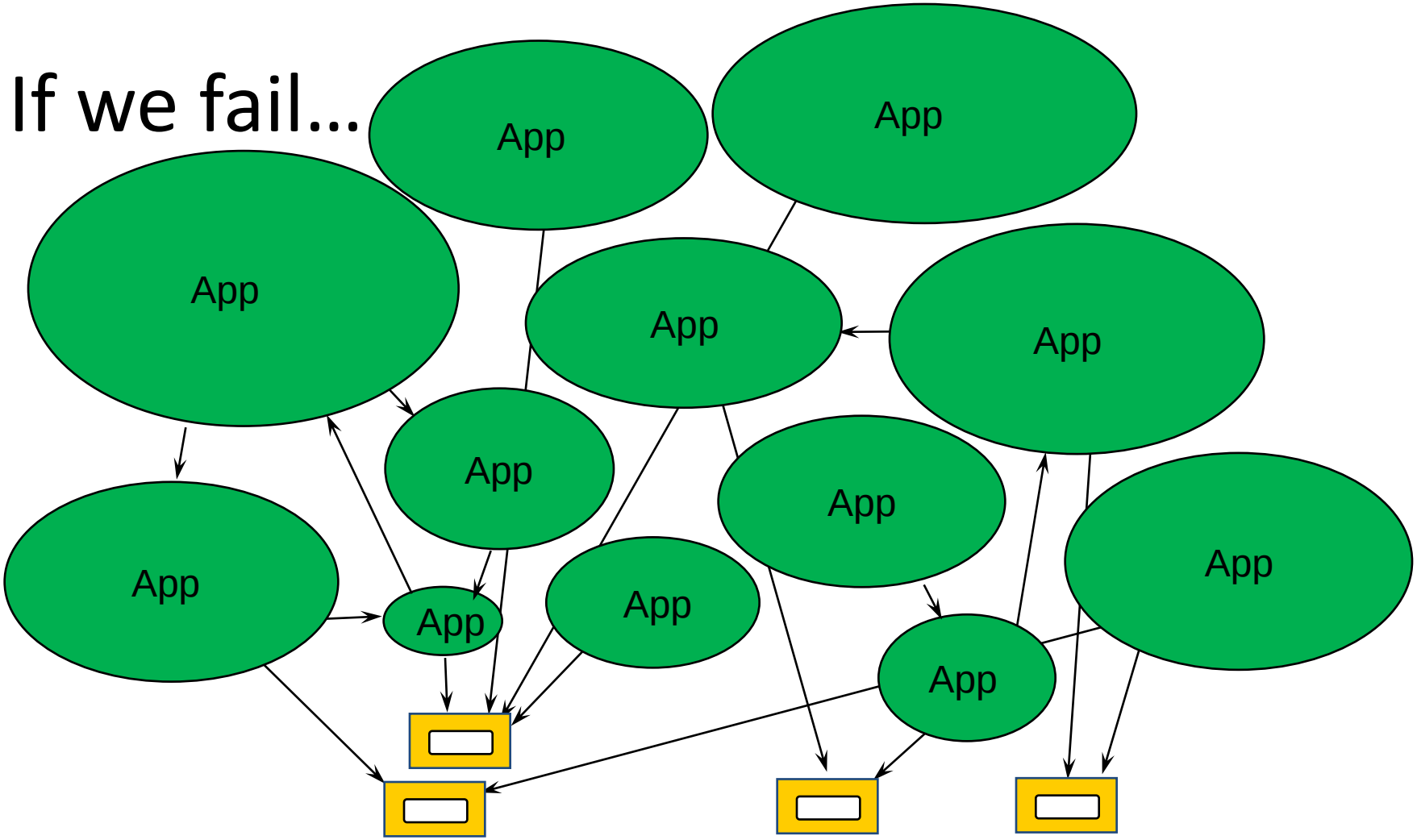
(If it's worth doing, it's worth overdoing.)

Achieving Wide-Spread Reuse

If we succeed…

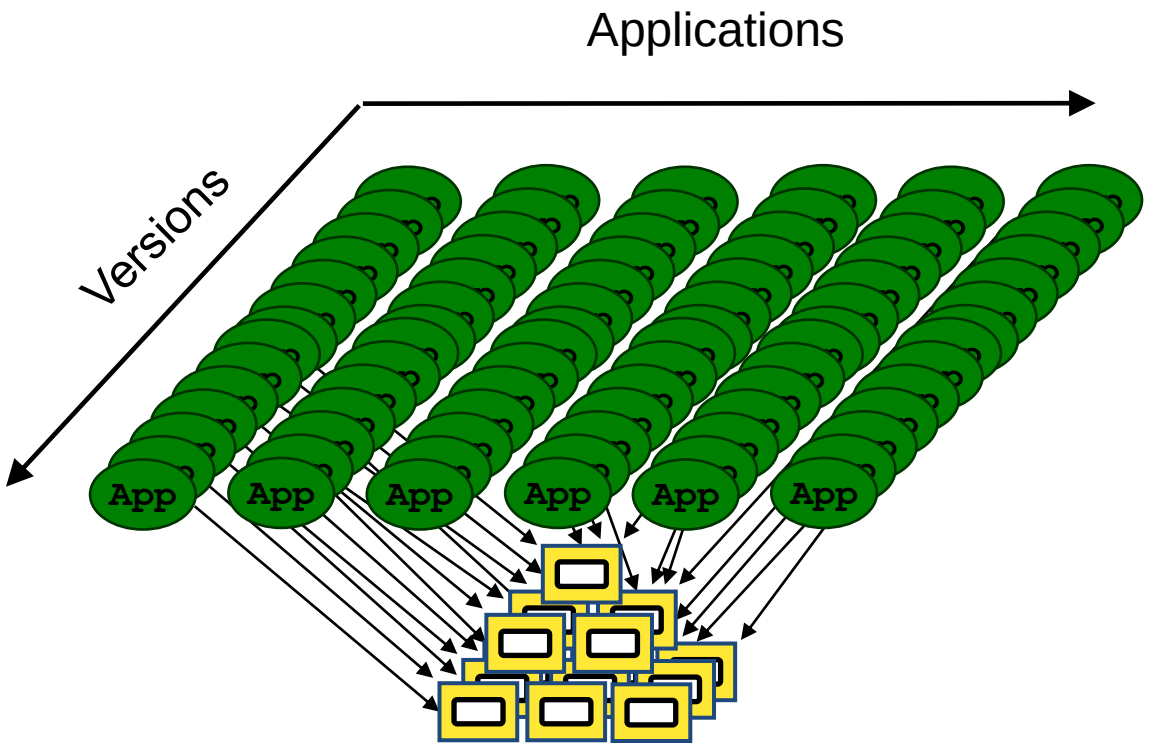


Achieving Wide-Spread Reuse



Achieving Wide-Spread Reuse

Fortunately, we can amortize the *perceived* cost over many **products X versions**:



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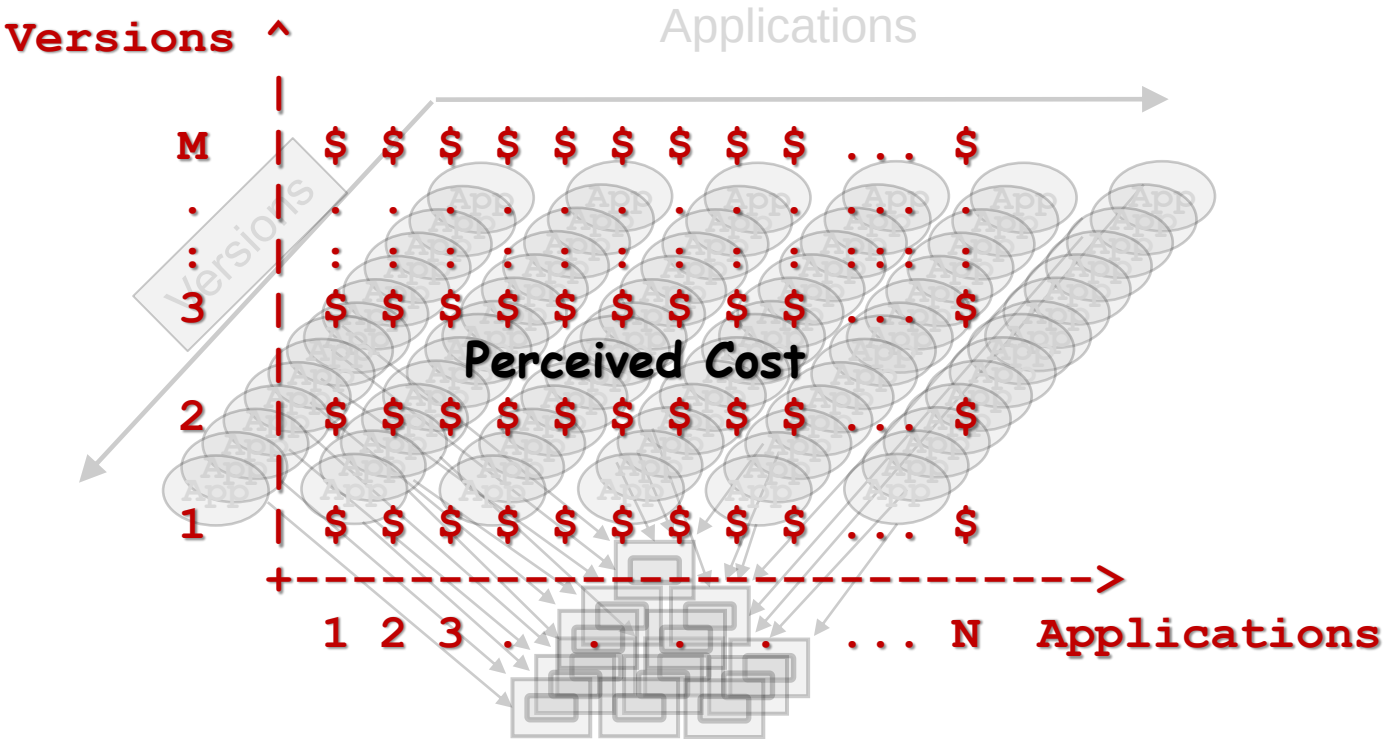

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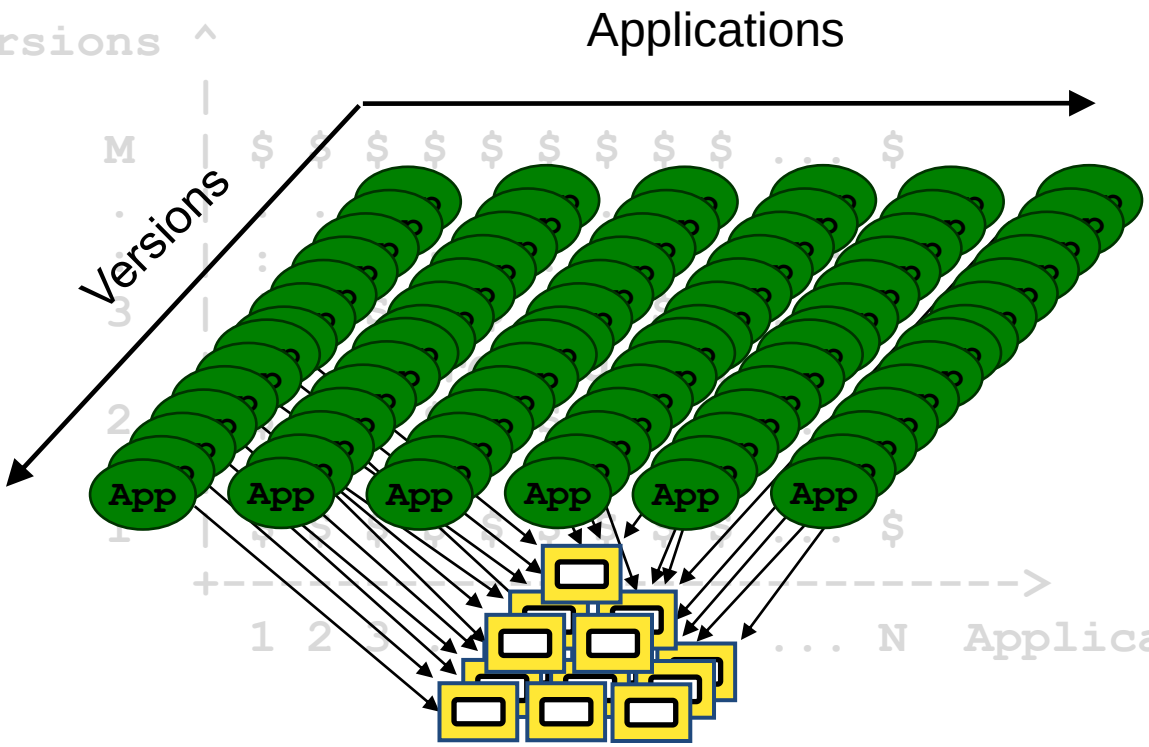
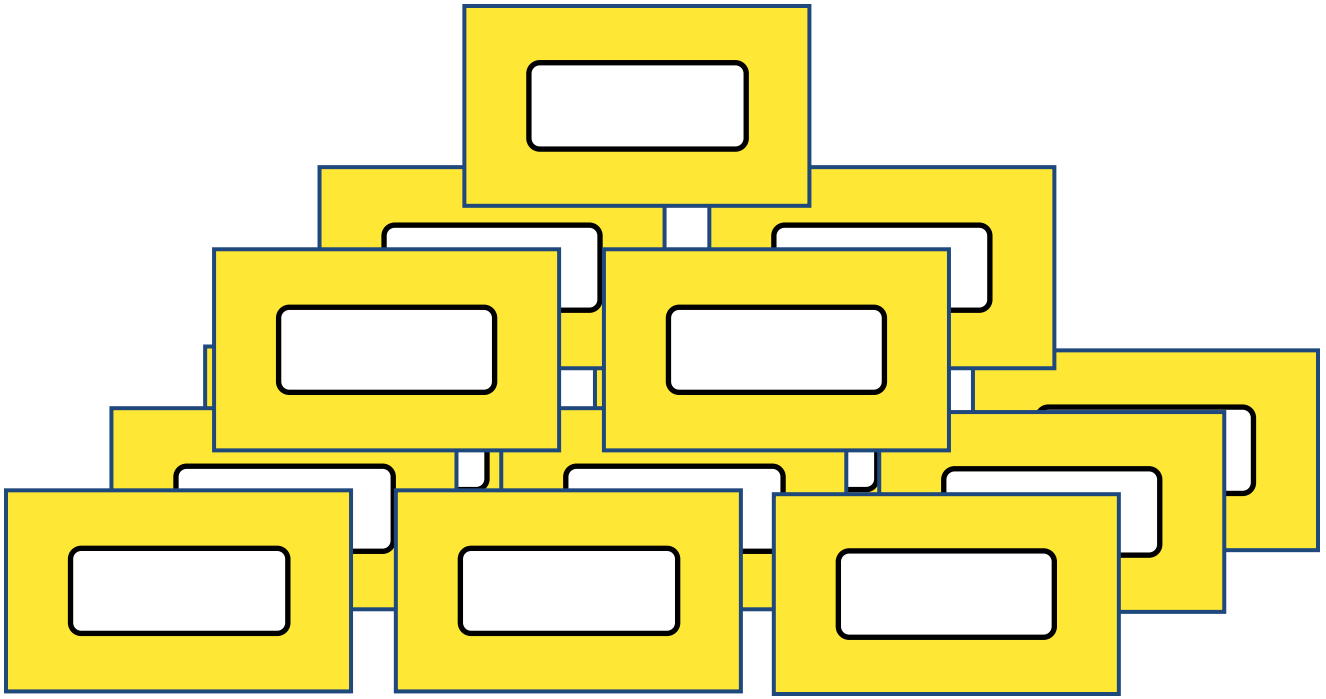


Achieving Wide-Spread Reuse

Hierarchically Reusable Software



Achieving Wide-Spread Reuse

Hierarchically Reusable Software

a.k.a.:

Outline

0. Goals

   What we are trying to do, for whom, and how.

1. Process & Architecture

   Organizing Software as Components, Packages, & Package Groups.

2. Design & Implementation

   Using Class Categories, Value Semantics, & Vocabulary Types.

3. Verification & Testing

   Component-Level Test Drivers, Peer Review, & Defensive Checks.

4. Bloomberg Development Environment

   Rendered as Fine-Grained *Hierarchically* *Reusable* Components.

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Introduction

All of the software we write is governed by a common overarching set of ***Organizing Principles***.

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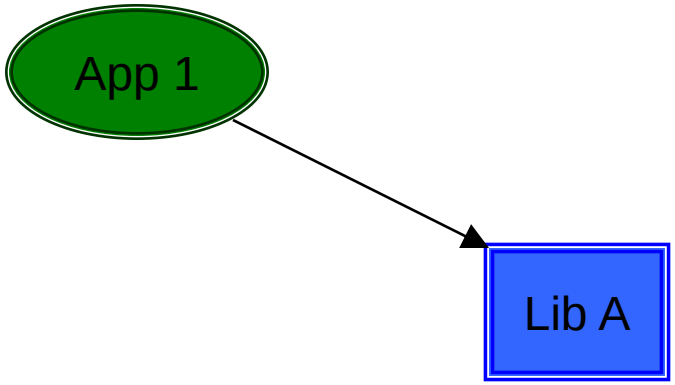
Organizing Principles.

Among the most central of which is achieving

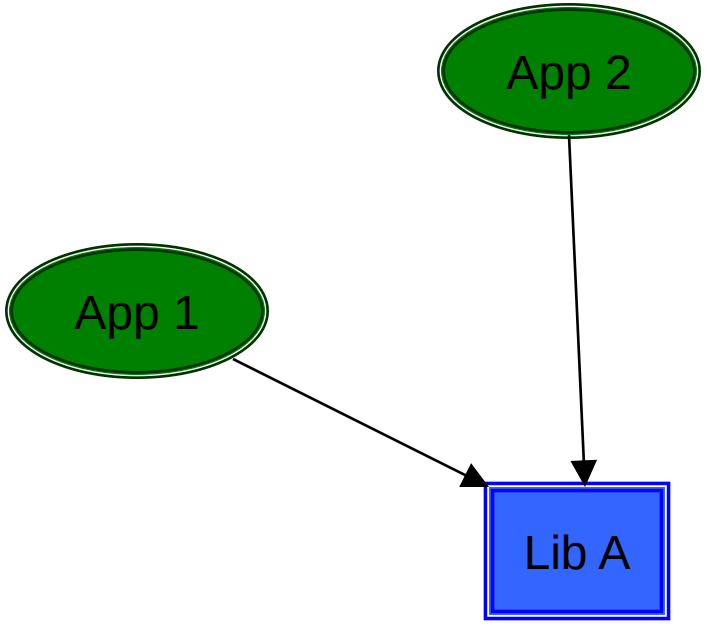
Sound Physical Design.

Creating a Big Ball of Mud



Creating a Big Ball of Mud

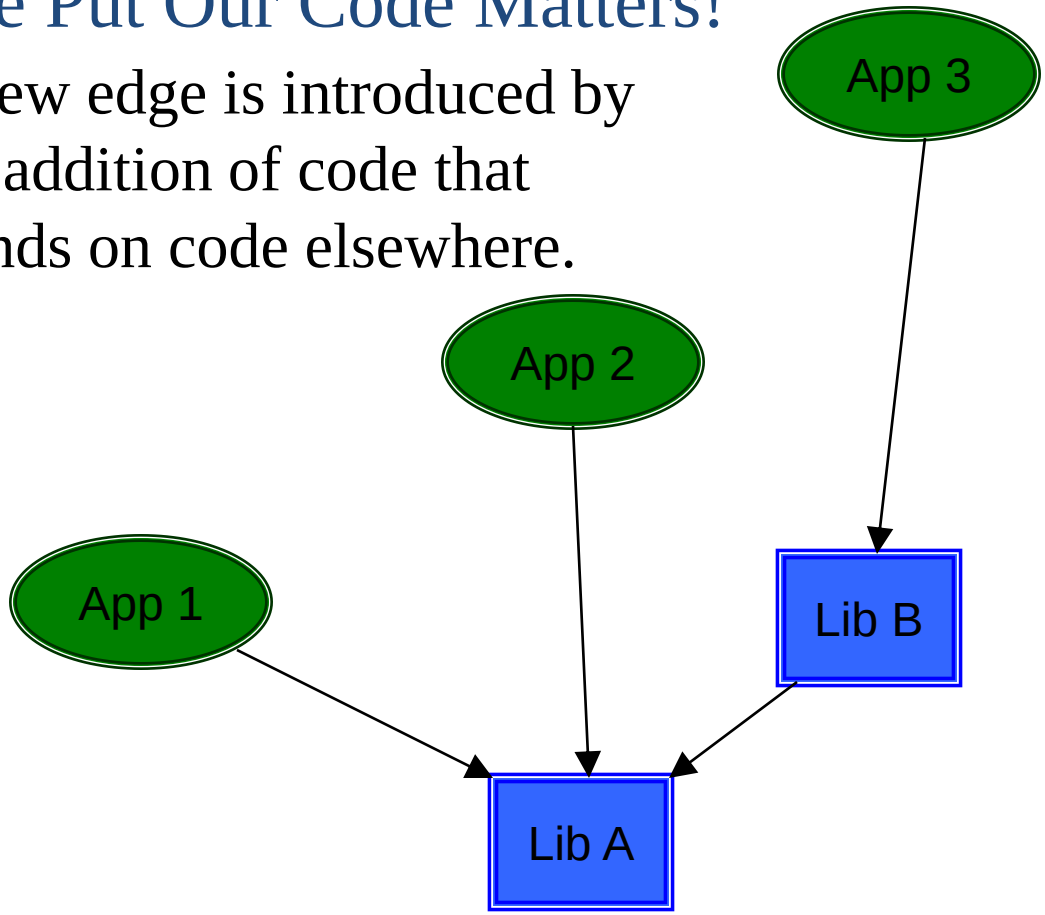
Where We Put Our Code Matters!



Creating a Big Ball of Mud

Where We Put Our Code Matters!

Each new edge is introduced by the addition of code that depends on code elsewhere.



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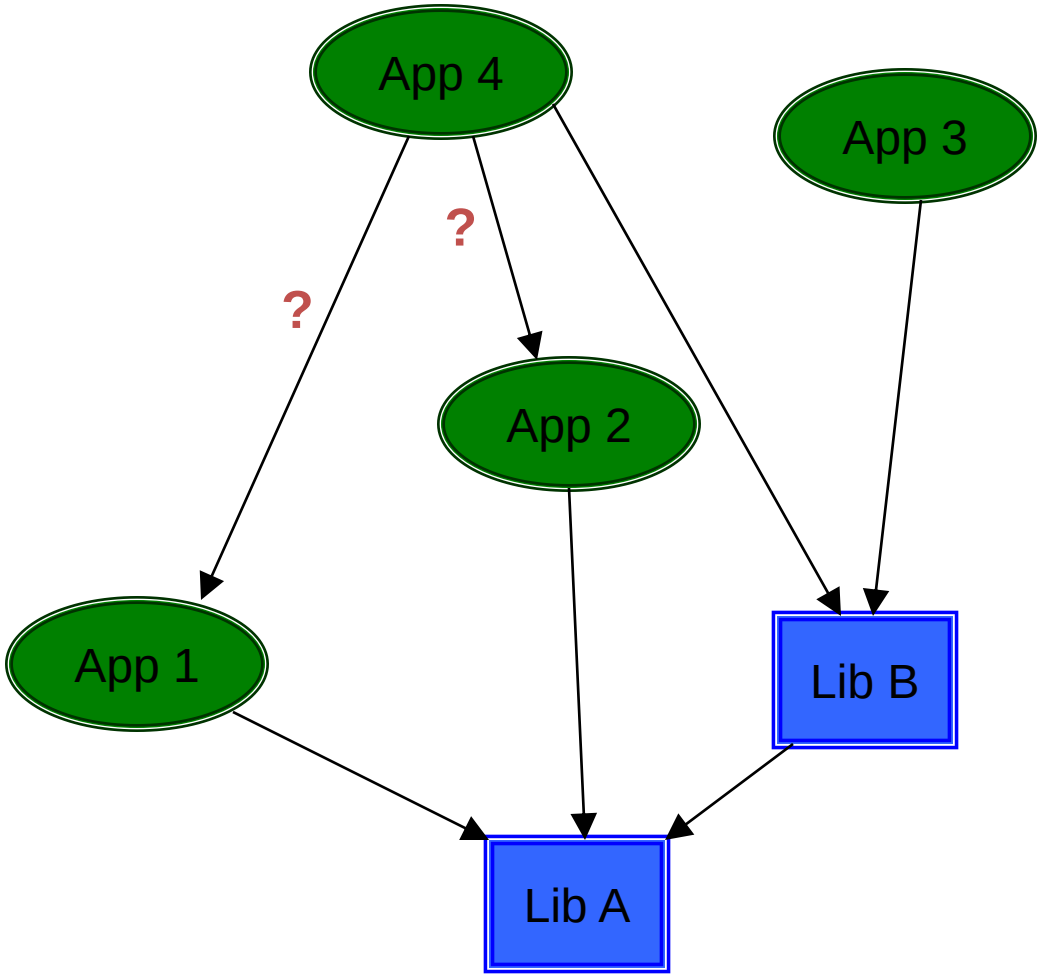

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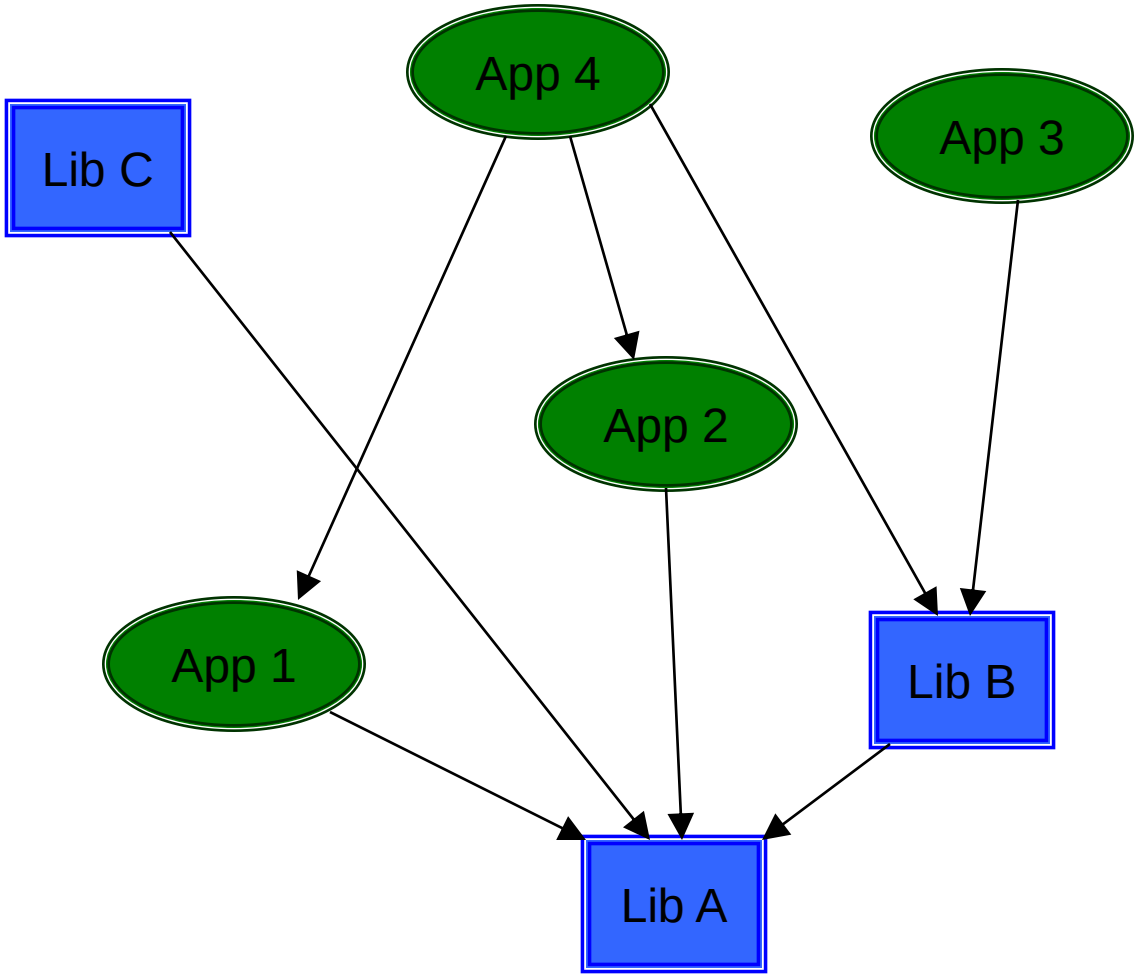

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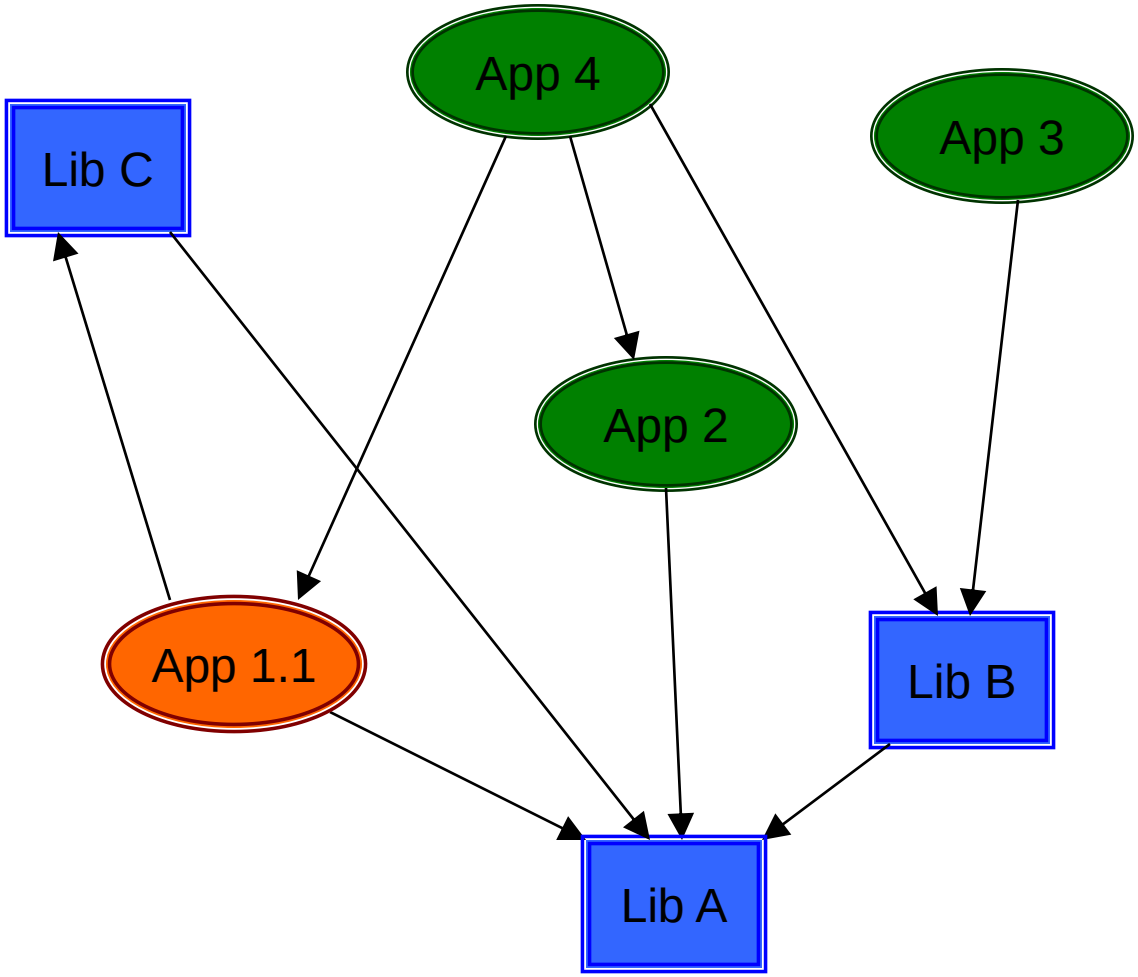

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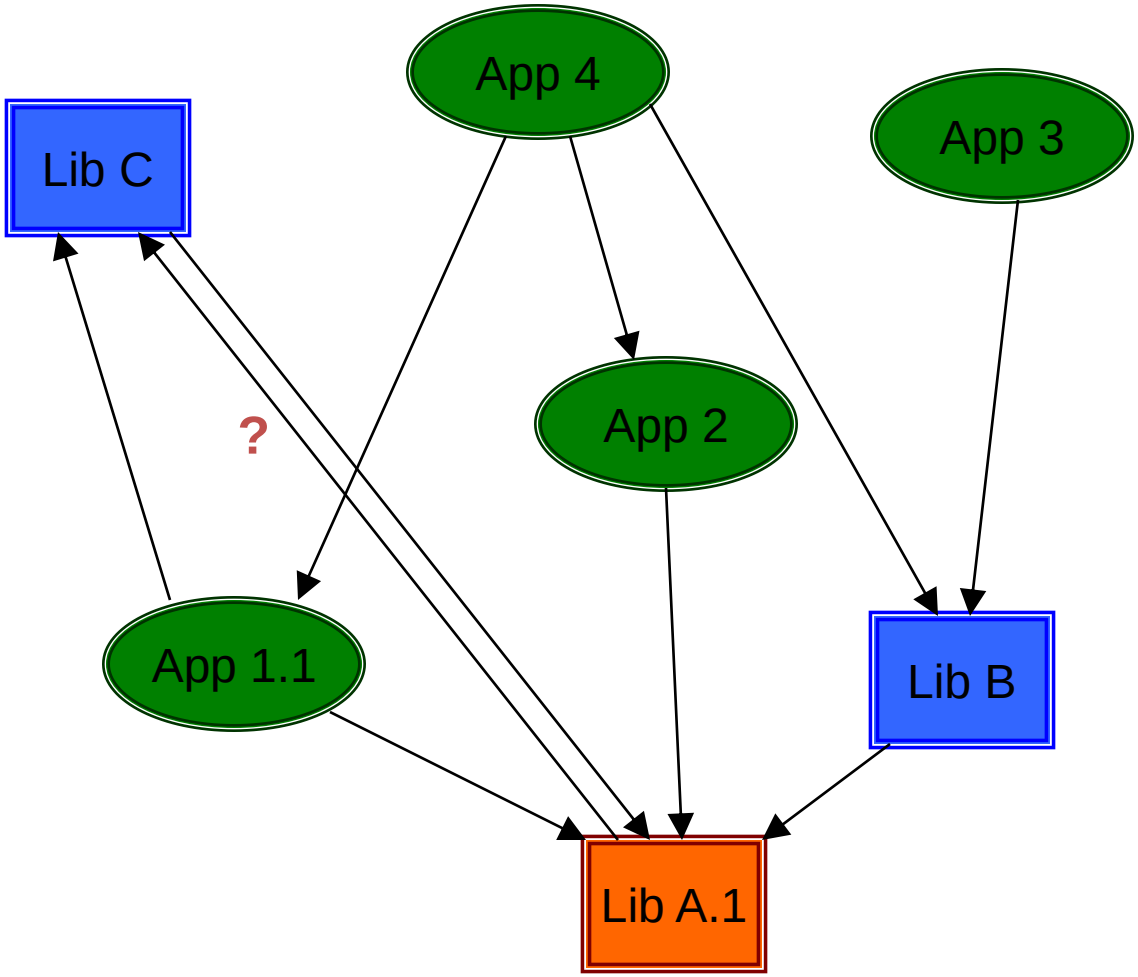

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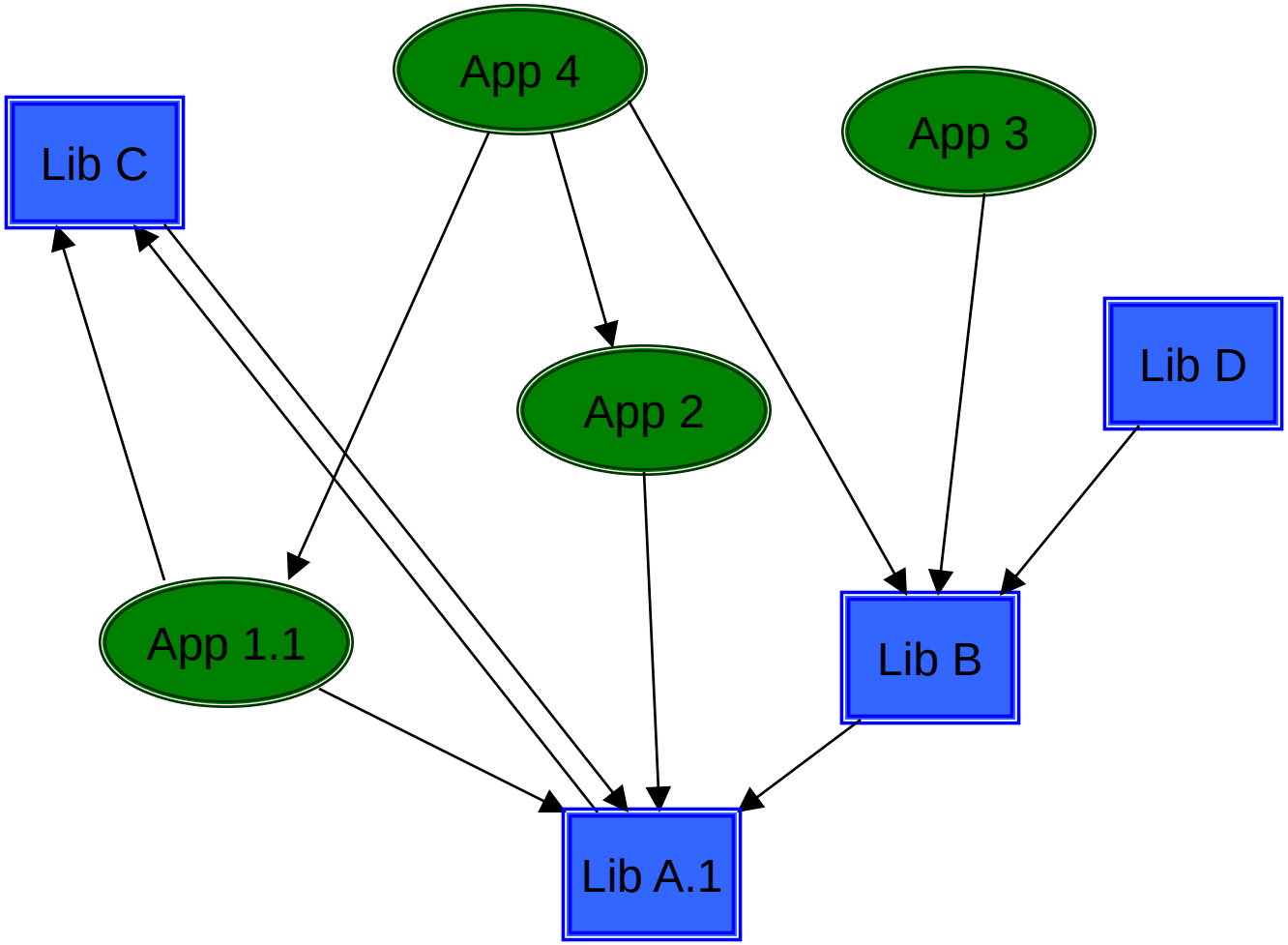

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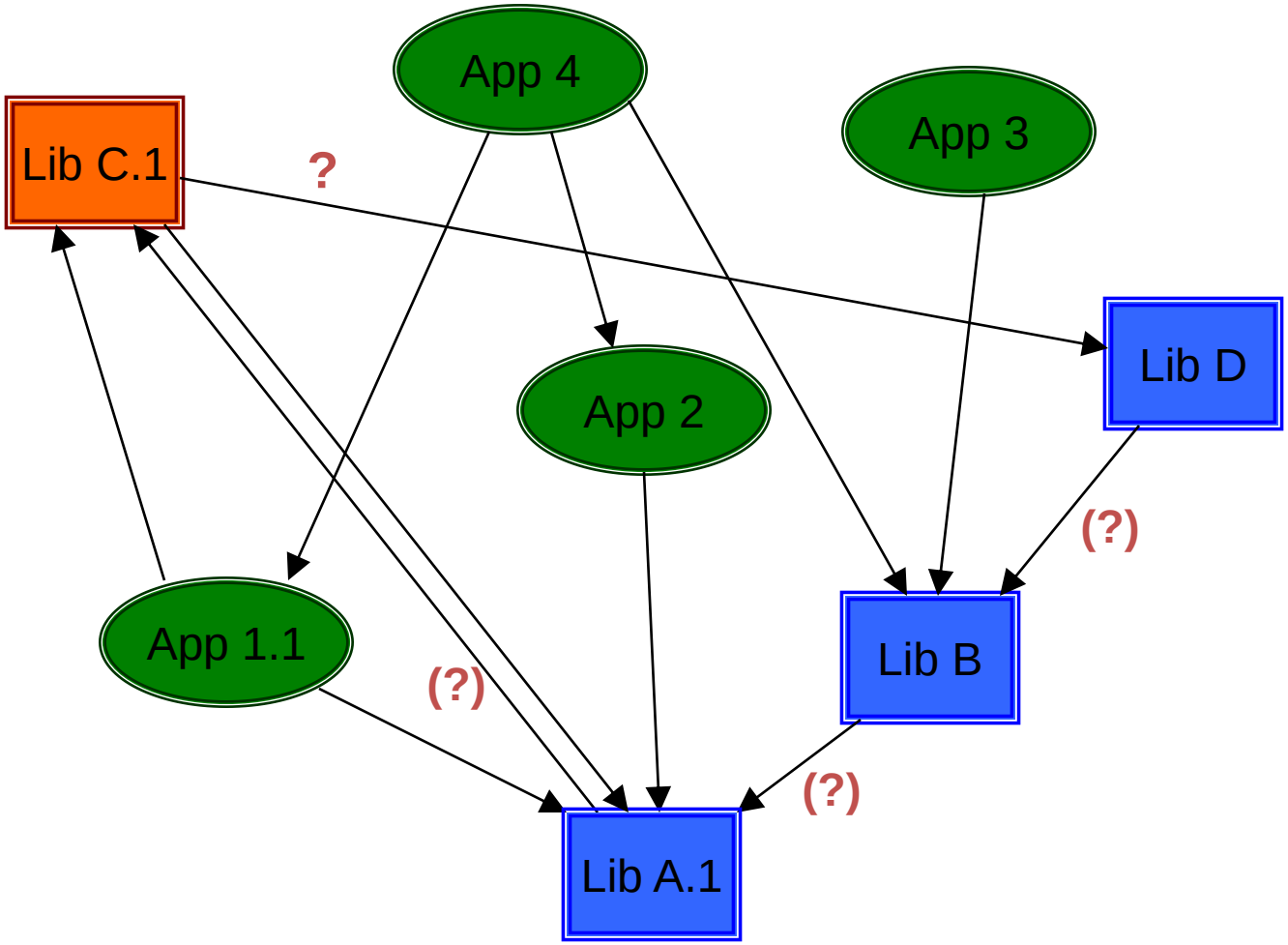

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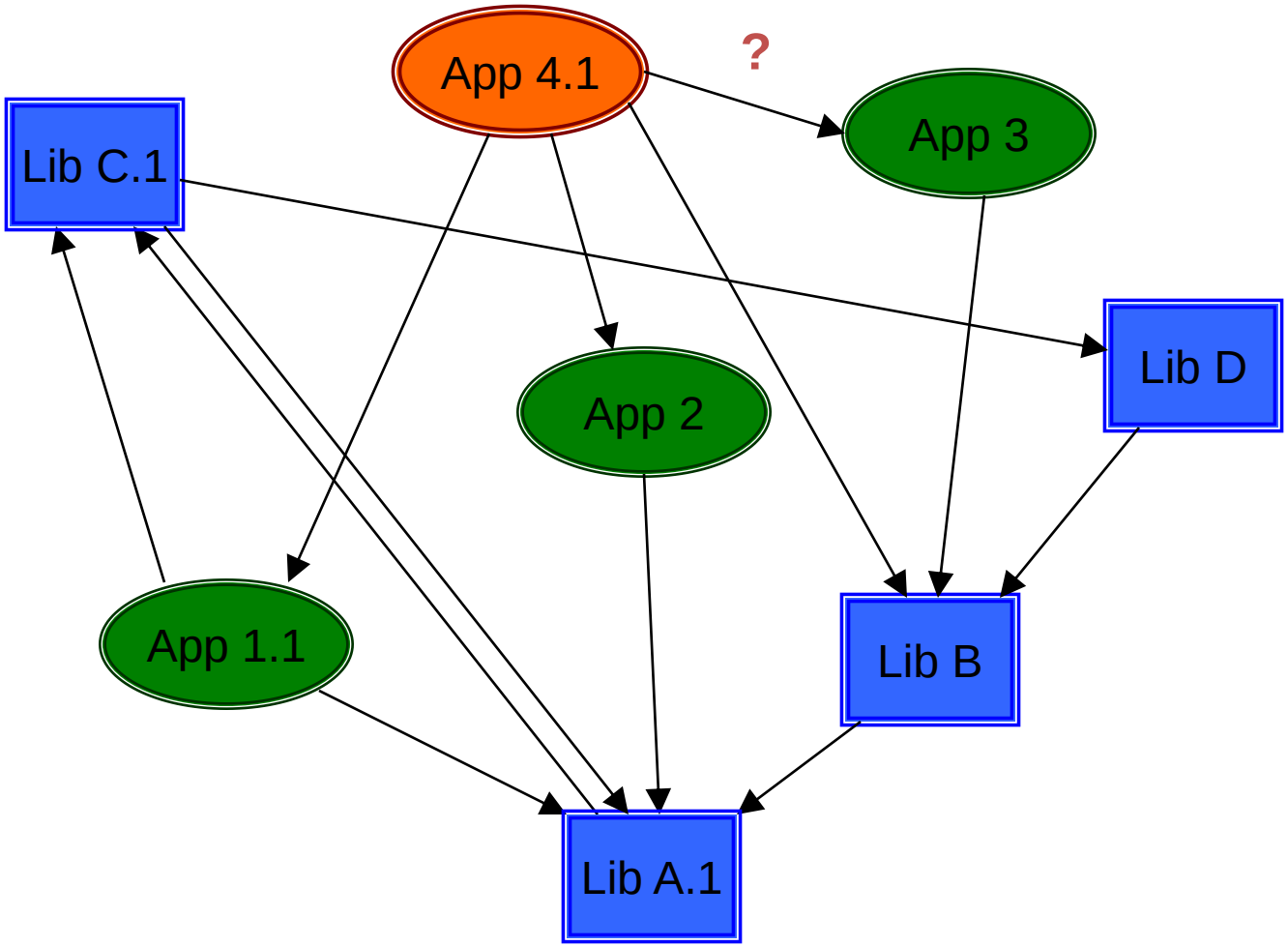

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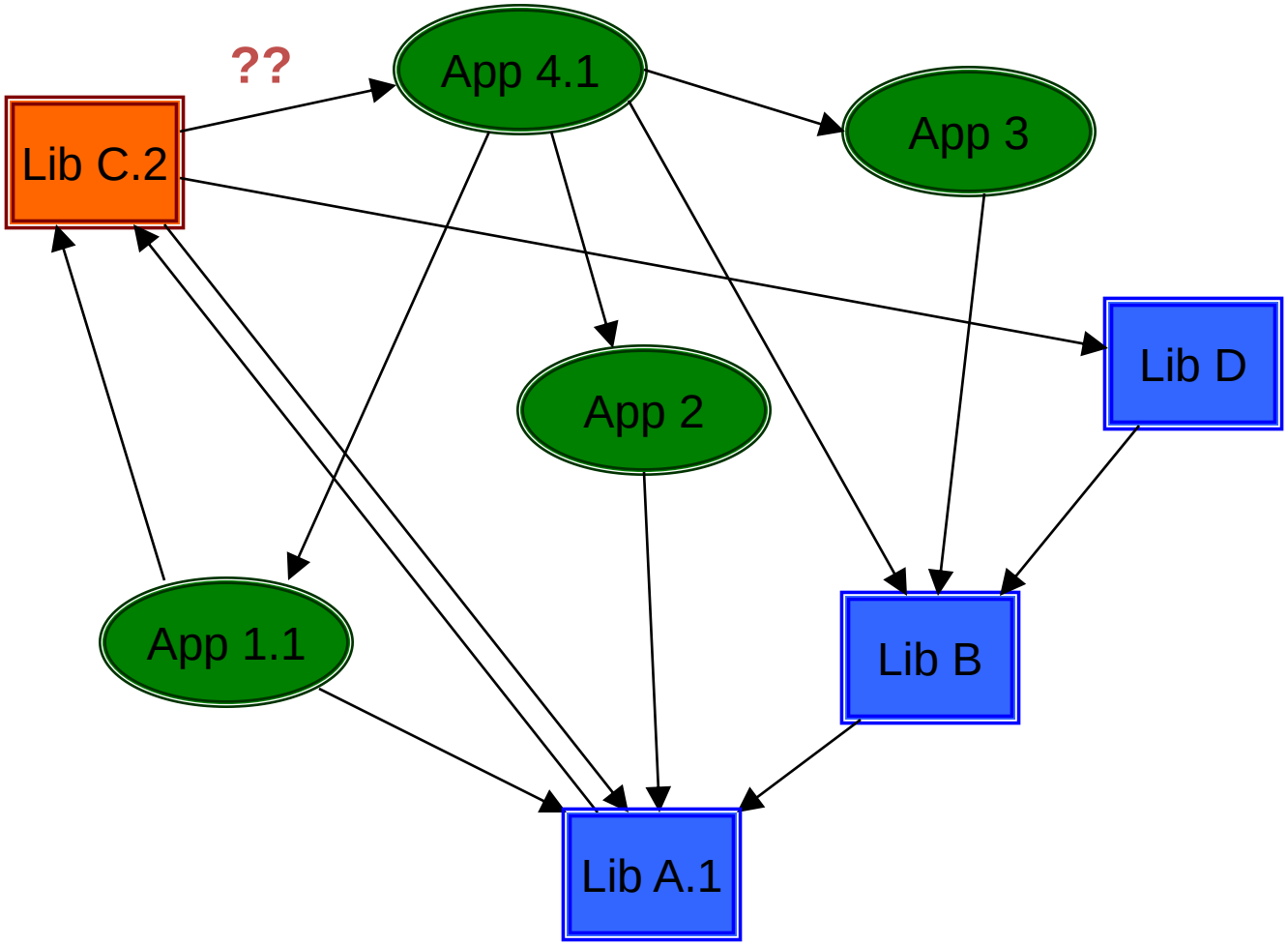
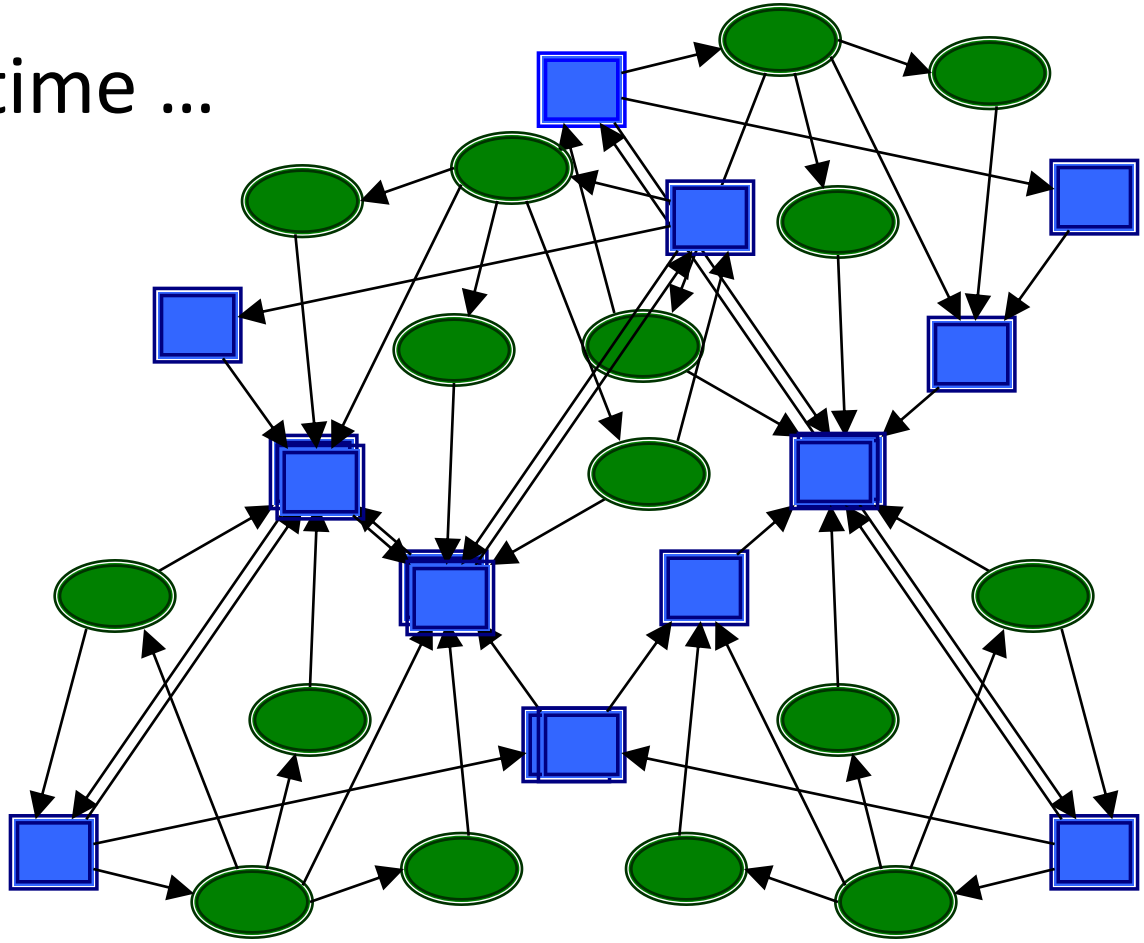


Creating a Big Ball of Mud

Over time …



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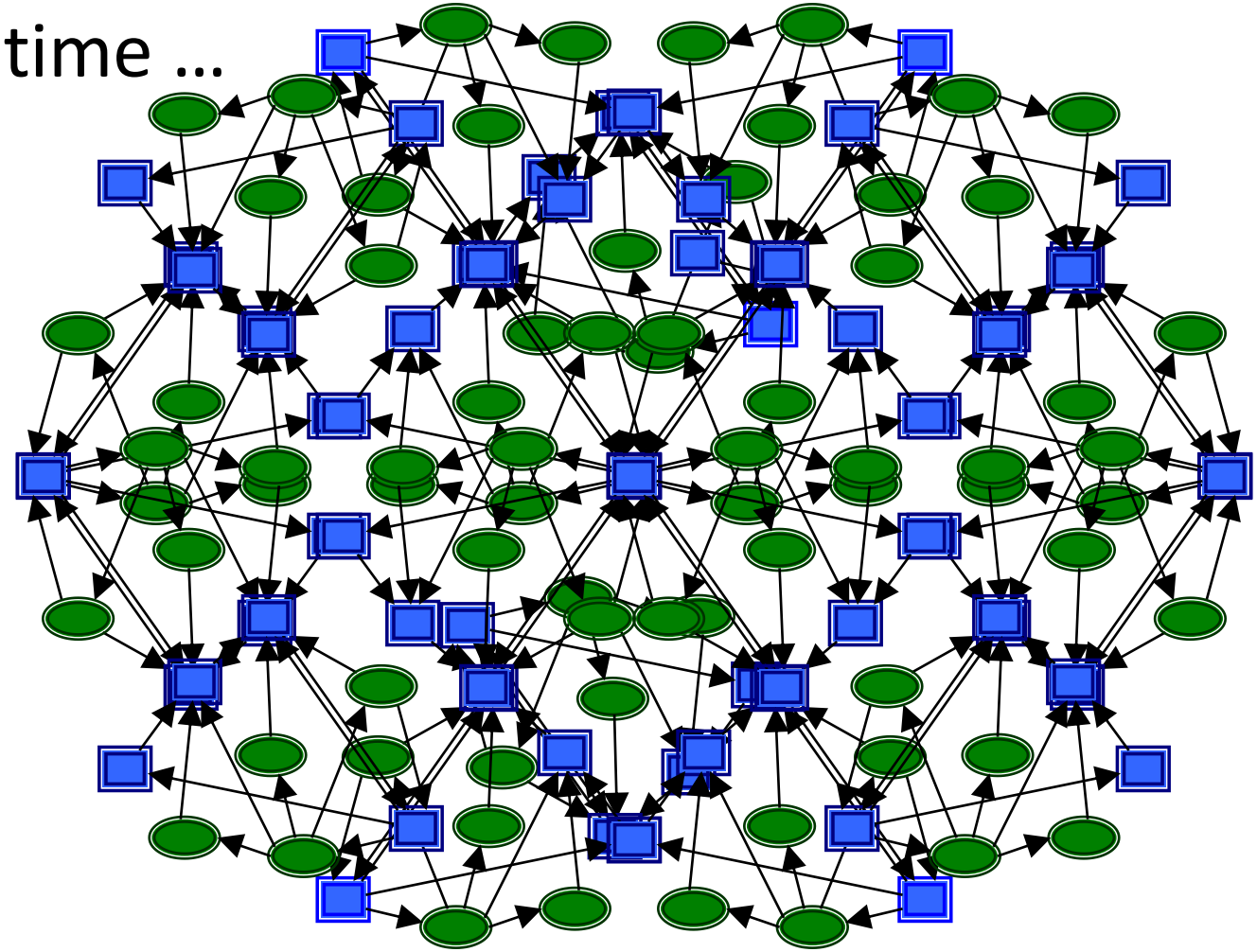

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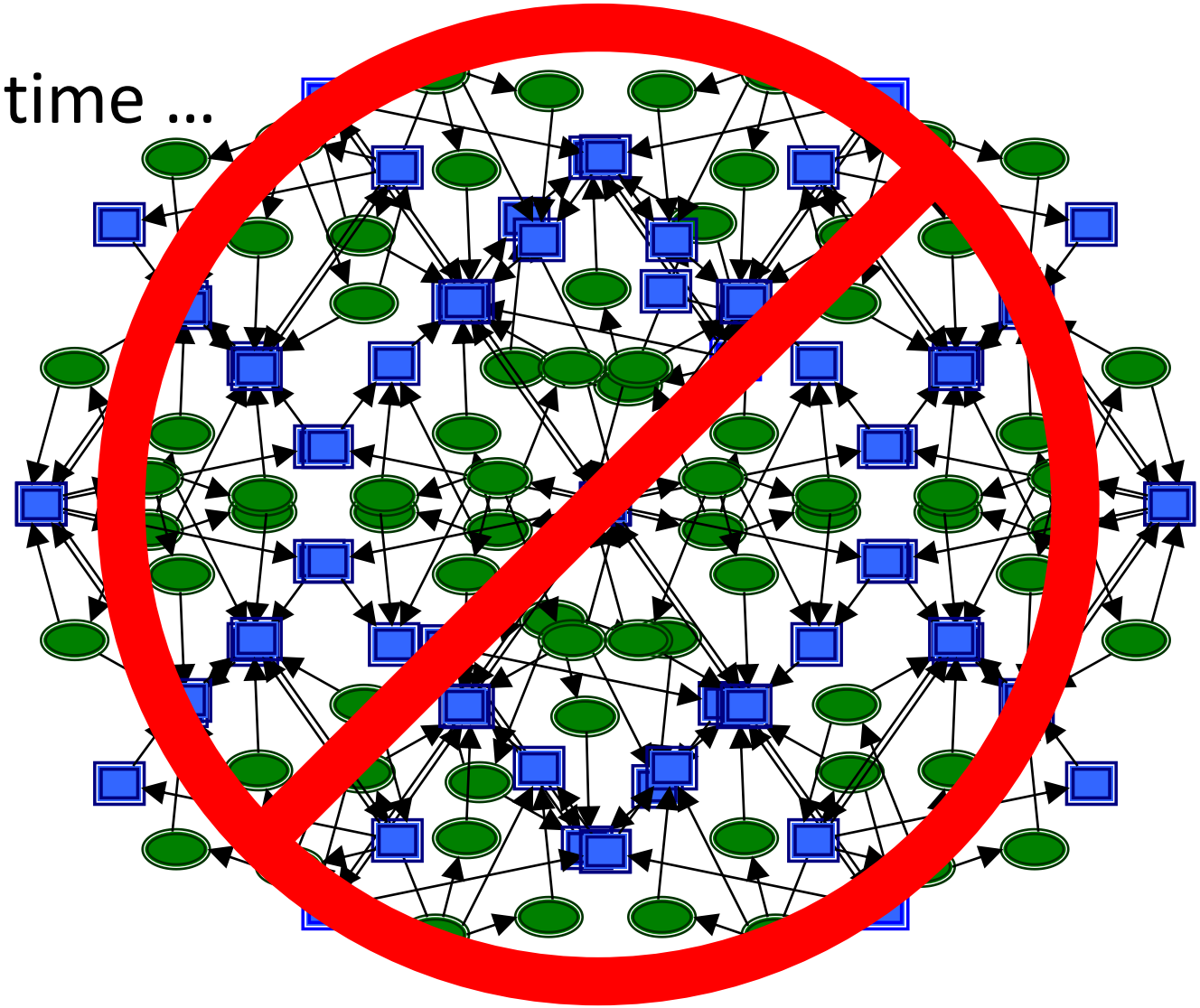

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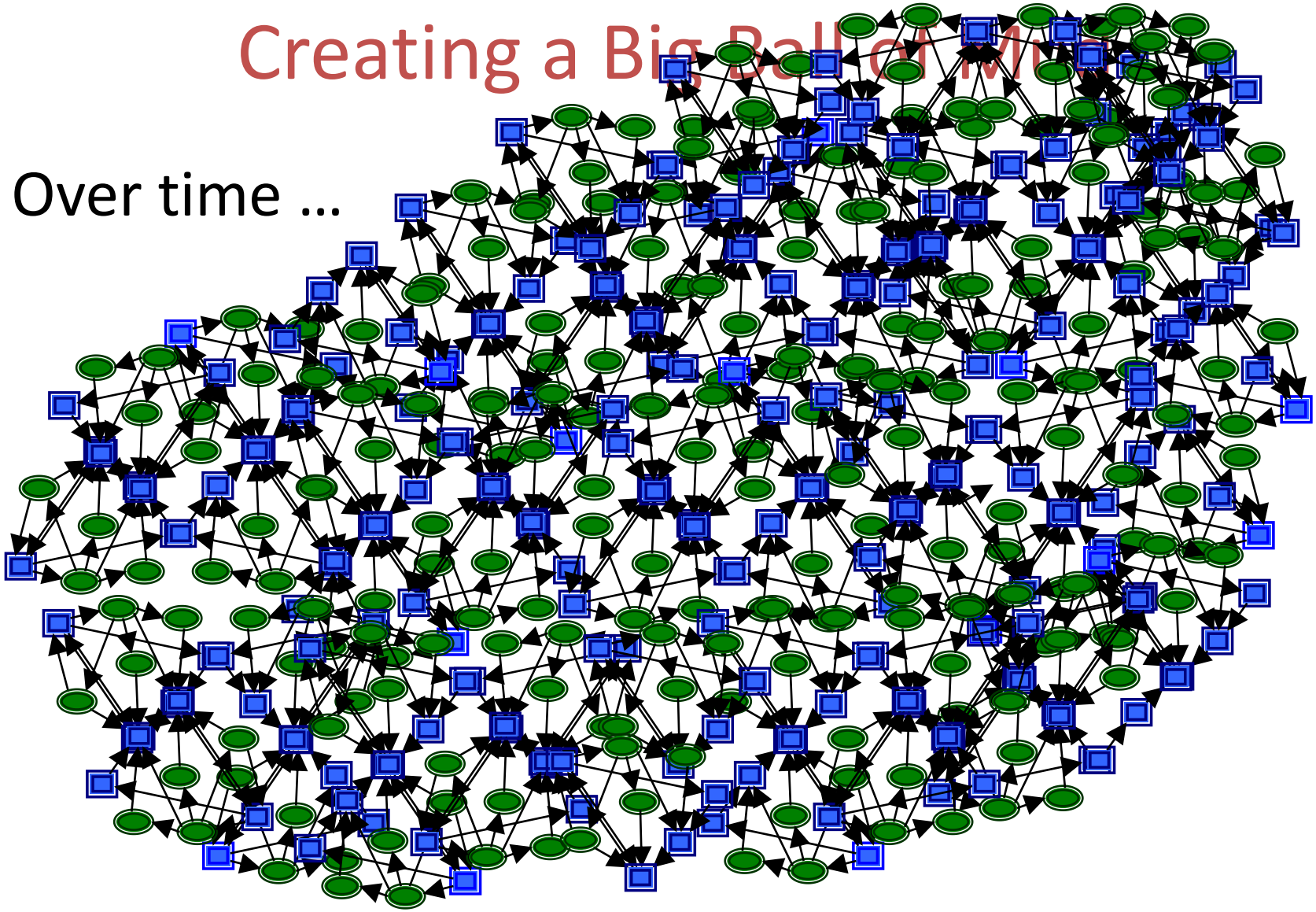

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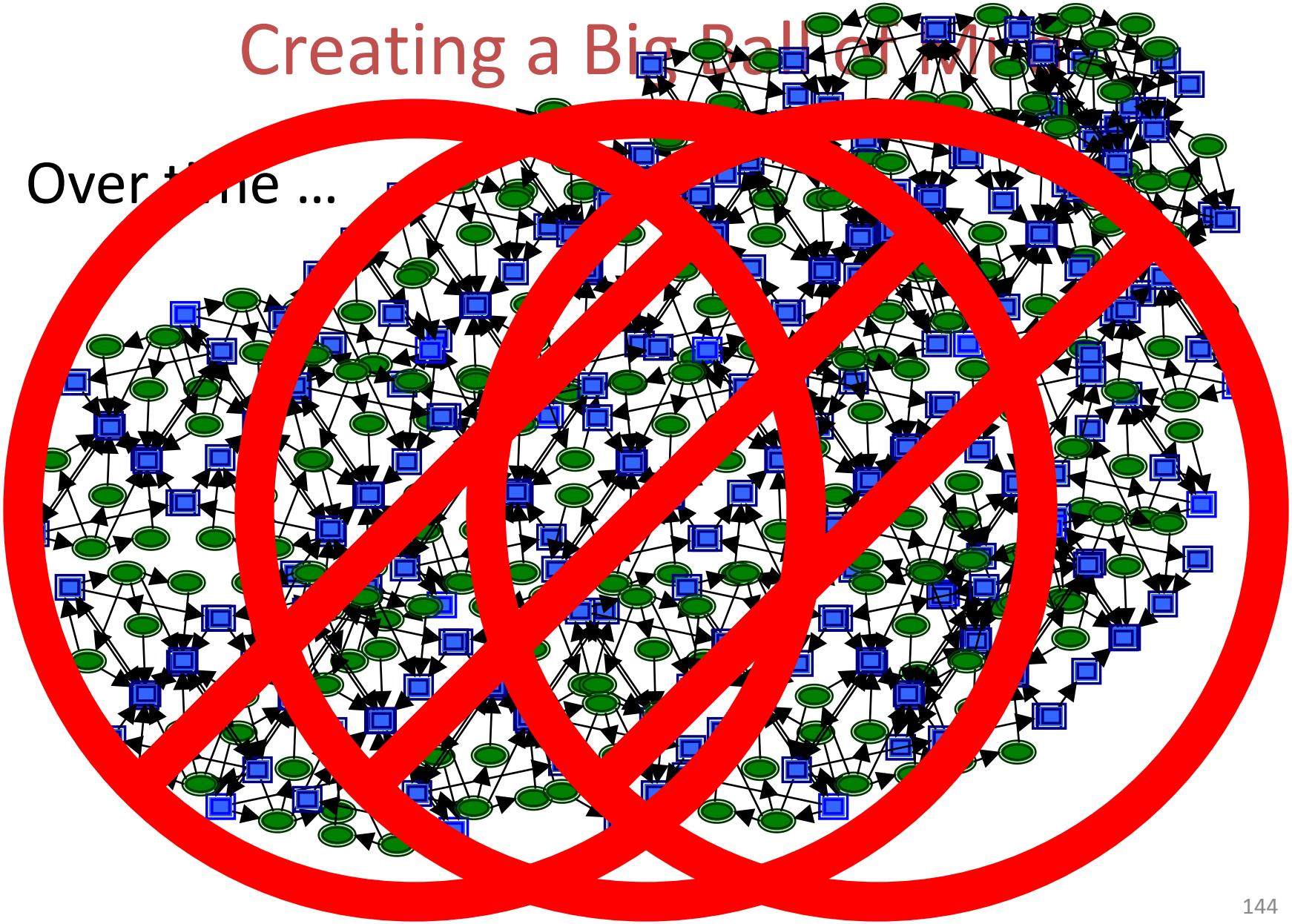

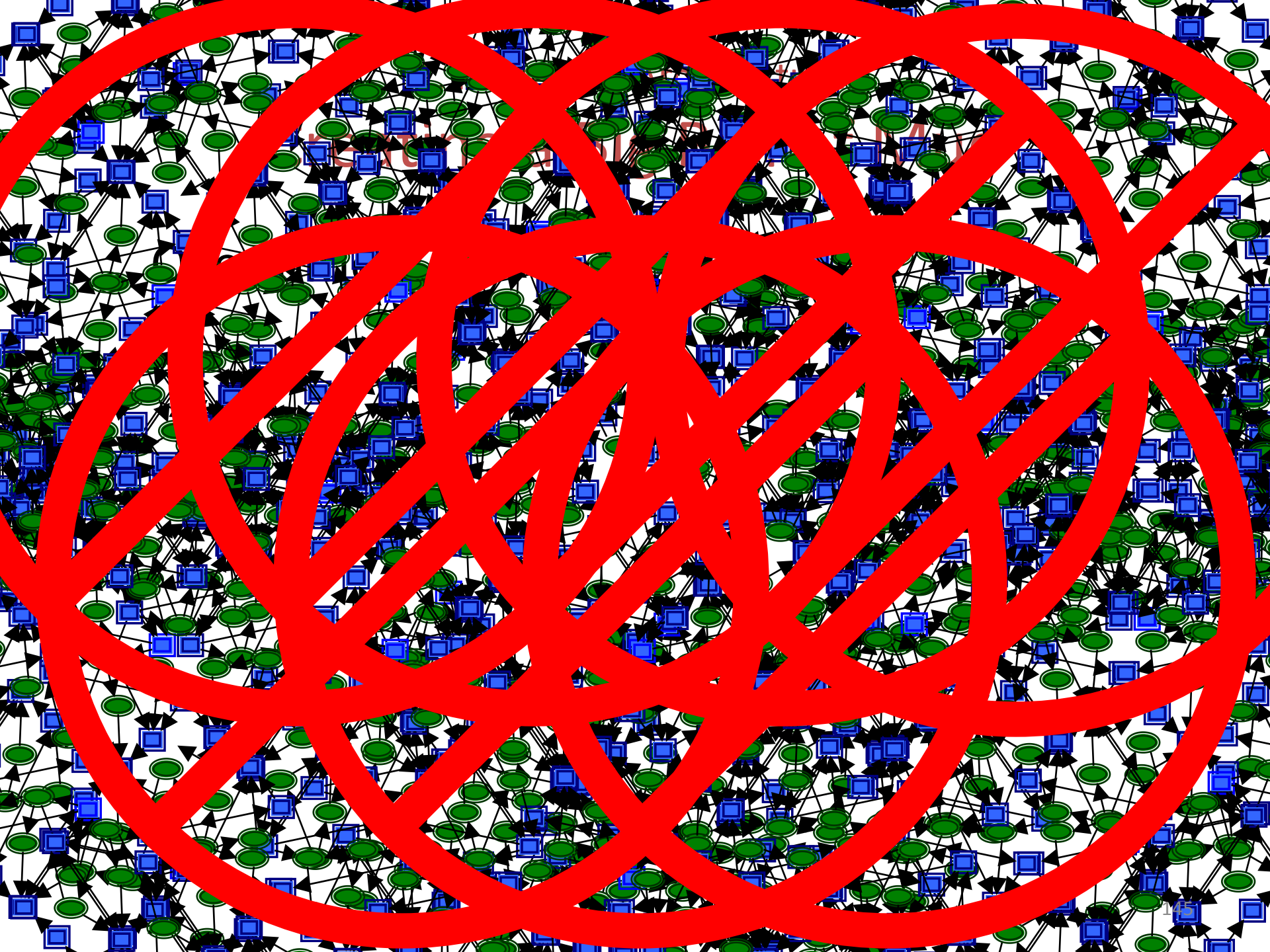
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