# Refactoring at Google Scale

## The Why and How

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Refactoring:
A controlled technique for improving the design of an existing code base. Its essence is applying a series of small behavior-preserving transformations, each of which "too small to be worth doing.”

-Martin Fowler

```
void foo(bool x) {
  // Analyse the colour of the fibre
  Frob(x);
}
```

```
void foo(bool x) {
  // Analyze the color of the fiber
  Frob(x);
}
```

```
class File {
  static string JoinPath(const string& path1, const string& path2);
}
```

```
string path1 = File::JoinPath(“a”, “b”);
assert(path1 == “a/b”);

string path2 = File::JoinPath(“a”, “/b”);
assert(path2 == “/b”);    // WAT
```

```
namespace file {
namespace internal {
  string JoinPathImpl(std::initializer_list<StringPiece> paths);
  string JoinPathAbsoluteImpl(
    std::initializer_list<StringPiece> paths);
}

template<typename… T>
string JoinPath(const T&... args) {
  return internal::JoinPathImpl({args…});
}

template<typename… T>
string JoinPathAbsolute(const T&... args) {
  return internal::JoinPathAbsoluteImpl({args…});
}
}
```

```
void foo(bool x) {
  string path = File::JoinPath(path1, path2);
}
```

```
void foo(bool x) {
  string path = file::JoinPath(path1, path2);
}
```

```
void foo(bool x) {
  string path = File::JoinPath(path1, path2);
}
```

```
void foo(bool x) {
  string path = file::JoinPathAbsolute(path1, path2);
}
```

```
void foo(bool x) {
  string path = File::JoinPath(path1, File::JoinPath(path2, path3));
}
```

```
void foo(bool x) {
  string path = file::JoinPath(path1, path2, path3);
}
```

```
void foo(bool x) {
  vector<string> v;
  SplitStringUsing(“a|b,c|d”, “|,”, &v);
}
```

```
void foo(bool x) {
  vector<string> v =
    strings::Split(“a|b,c|d”, strings::AnyOf(“|,”));
}
```

```
void foo(bool x) {
  vector<string> v;
  SplitStringUsing("a|b,c|d", ",", &v);
}
```

```
void foo(bool x) {
  vector<string> v =
    strings::Split("a|b,c|d", ",");
}
```

```
void foo(bool x) {
  vector<string> v;
  vector<string> v2;
  if (x)
    SplitStringUsing(“a,b,c,d”, “,”, &v2);
  SplitStringUsing(“a,b,c,d”, “,”, &v);
}
```

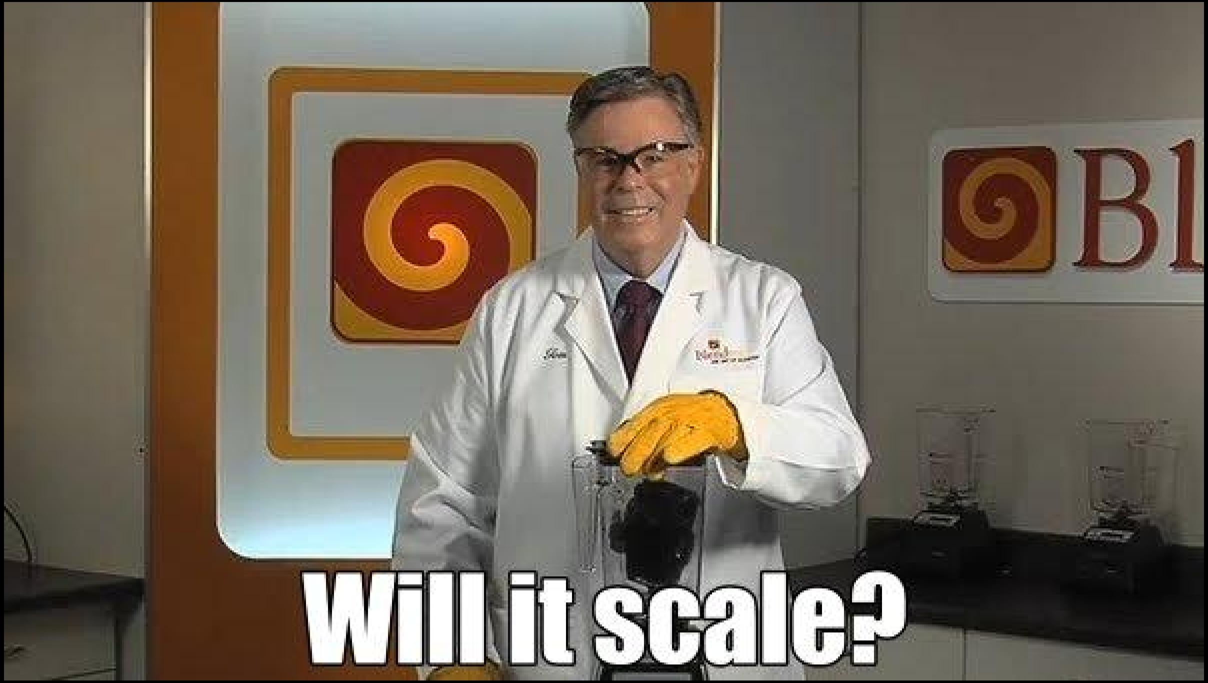
```
void foo(bool x) {
  vector<string> v2;
  if (x)
    SplitStringUsing(“a,b,c,d”, “,”, &v2);
  vector<string> v = strings::Split(“a,b,c,d”, “,”);
}
```

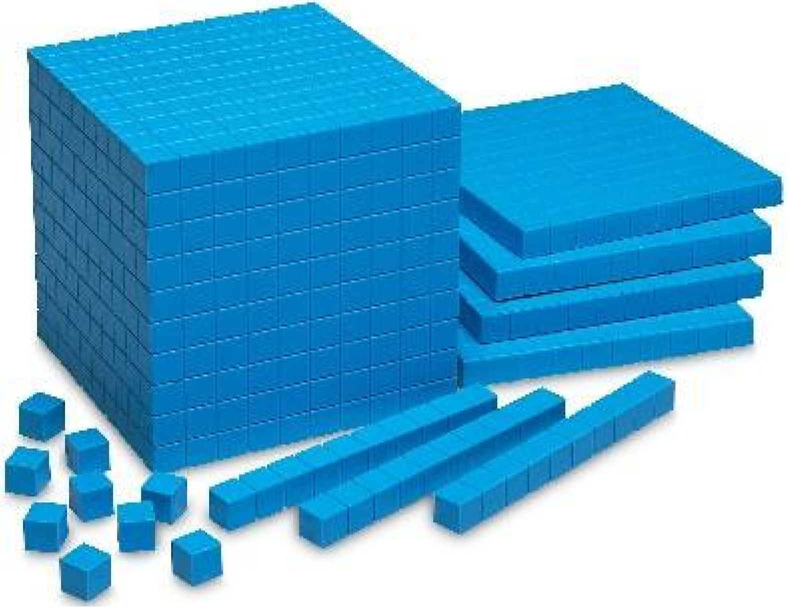
```
void foo(bool x) {
  std::unique_ptr<Foo> f(new Foo());
  f.get()->DoStuff();
}
```

```
void foo(bool x) {
  std::unique_ptr<Foo> f(new Foo());
  f->DoStuff();
}
```

```
void foo(bool x) {
  map<int, string> m = …;
  const string& foo = FindWithDefault(m, “key”, “default”);
}
```

```
void foo(bool x) {
  map<int, string> m = …;
  string default = “default”;
  const string& foo = FindWithDefault(m, “key”, default);
}
```


Will it scale?



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WHAT IF WE TRIED *MORE*?

# 10x

## 1 Monolithic Codebase

4,000+ C++ engineers
working concurrently

100M lines of code
developed over 15+ years

All changes subject to review-before-commit

## Massive testing and continuous integration infrastructure

Prefer the standard thing over homegrown solutions

~~By Hand~~

## ~~By Regular Expression~~

~~By IDE~~

1. Generate the change

```
void foo(bool x) {
  string path = File::JoinPath(path1, path2);
}
```

```
void foo(bool x) {
  string path = file::JoinPath(path1, path2);
}
```

```
void foo(bool x) {
  string path = File::JoinPath(path1, path2);
}
```

```
void foo(bool x) {
  string path = file::JoinPath(path1, path2);
}
```

OR

```
void foo(bool x) {
  string path = file::JoinPathAbsolute(path1, path2);
}
```

## ClangMR

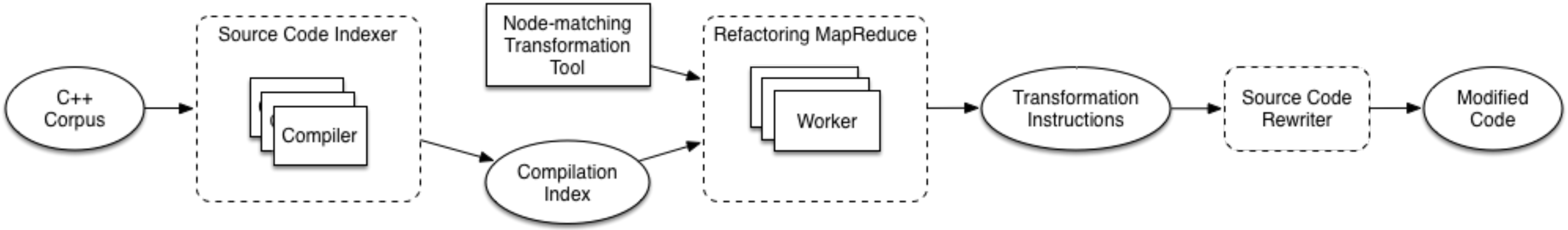
## ClangMR = Clang + MapReduce

Clang:

- Provides library infrastructure for AST node matching and traversal

MapReduce:

- A framework of processing data on a massively parallel scale [Dean & Ghemawat, OSDI ‘04]


C++ Corpus
Source Code Indexer
Compiler
Node-matching Transformation Tool
Compilation Index
Refactoring MapReduce
Worker
Transformation Instructions
Source Code Rewriter
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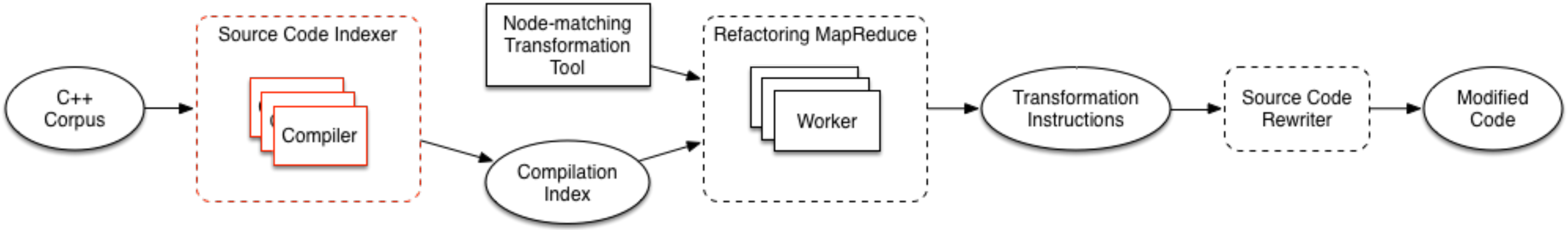
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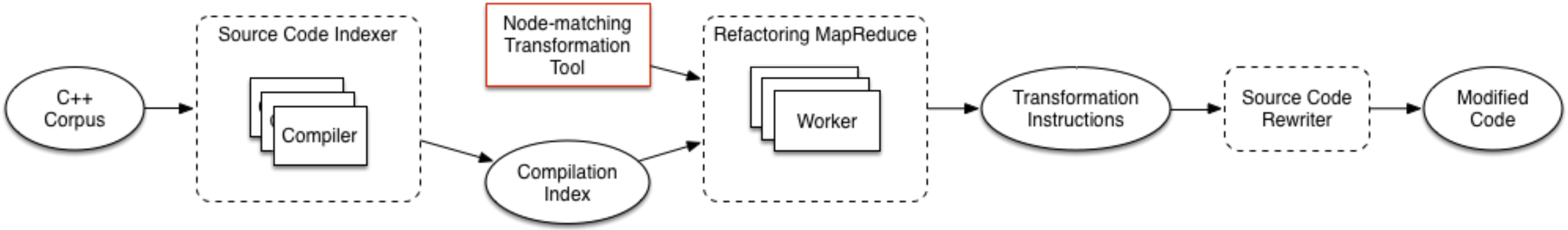
C++ Corpus
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Refactoring MapReduce
Worker
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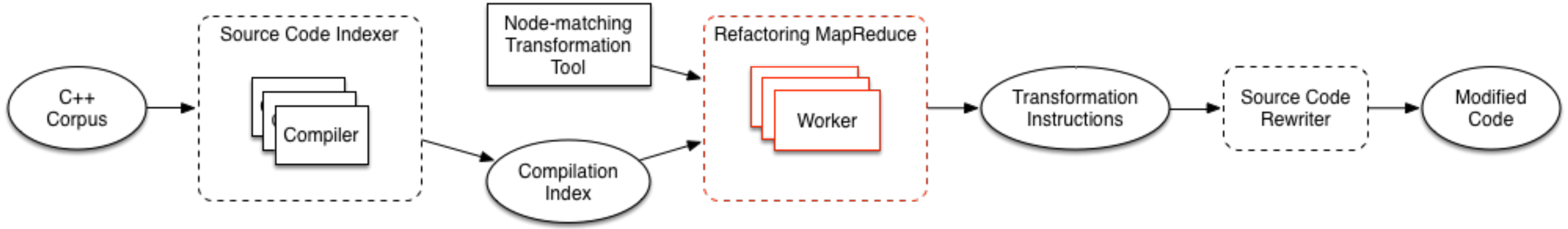
| | | |
|---|---|---|
| Matcher<Decl> | constructorDecl | Matcher<CXXConstructorDecl>... |
| Matcher<Decl> | decl | Matcher<Decl>... |
| Matcher<Decl> | declaratorDecl | Matcher<DeclaratorDecl>... |
| Matcher<Decl> | destructorDecl | Matcher<CXXDestructorDecl>... |

```
Matches explicit C++ destructor declarations.

Example matches Foo::~Foo()
  class Foo {
   public:
    virtual ~Foo();
  };
```

| | | |
|---|---|---|
| Matcher<Decl> | enumConstantDecl | Matcher<EnumConstantDecl>... |
| Matcher<Decl> | enumDecl | Matcher<EnumDecl>... |
| Matcher<Decl> | fieldDecl | Matcher<FieldDecl>... |
| Matcher<Decl> | friendDecl | Matcher<FriendDecl>... |
| Matcher<Decl> | functionDecl | Matcher<FunctionDecl>... |
| Matcher<Decl> | functionTemplateDecl | Matcher<FunctionTemplateDecl>... |
| Matcher<Decl> | methodDecl | Matcher<CXXMethodDecl>... |
| Matcher<Decl> | namedDecl | Matcher<NamedDecl>... |
| Matcher<Decl> | namespaceDecl | Matcher<NamespaceDecl>... |

```
StatementMatcher joinpath_call =
  callExpr(callee(functionDecl(hasName("::File::JoinPath"))));

// For nested JoinPath-calls, only refactor the innermost one.
StatementMatcher match =
  callExpr(
    callee(functionDecl(hasName("::File::JoinPath"))),
    unless(hasAnyArgument(hasDescendant(joinpath_call)))
      .bind("call");

match_finder->addMatcher(match, callback_.get());
```

```
const clang::CallExpr* call =
        result.Nodes.getStmtAs<clang::CallExpr>("call");
std::unique_ptr<cymbal::EditState> edit(CreateEditState(call));

const clang::Expr* arg2 = call->getArg(1);
switch (GetPathArgumentKind(result, arg2)) {
  // Argument specific behavior
}

Report(edit.get());
```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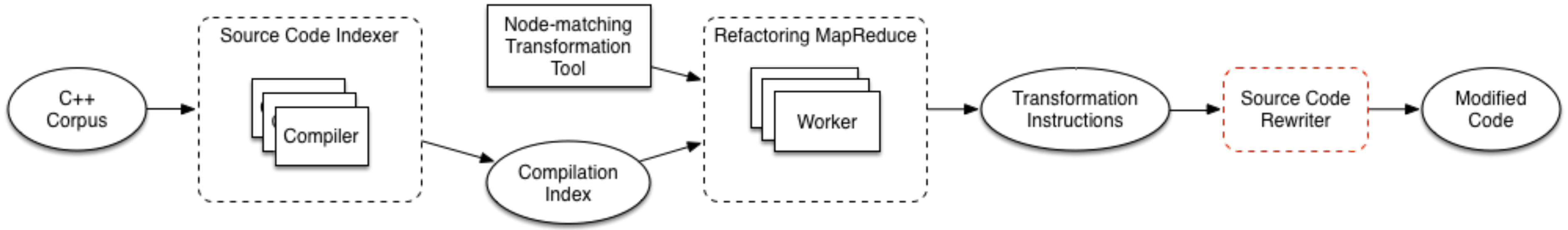
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## 1.5 Format the resulting change

2. Shard and test the change

3. Review each shard

4. Submit to the version control system

## Flaky Tests

## Fast moving codebase

Correct transformation isn’t always known

## War story: `shared_ptr` → `std::shared_ptr` migration

The Goal:

- Migrate all references from a custom `shared_ptr` class to use `std::shared_ptr` from `<memory>`

## War story: `shared_ptr` → `std::shared_ptr` migration

What worked:

- Old class defined in a common header file
- Old class implementation a strict subset of standard version
- `typedef`’ed the new type to the existing one
- Add `std::` prefix everywhere (and reformat line overflows)

## War story: `shared_ptr` → `std::shared_ptr` migration

What didn’t:

- Nothing (almost)

We got *really* lucky.

## War story: `scoped_ptr` → `std::unique_ptr` migration

The Goal:

- Migrate all references from a custom `scoped_ptr` class to use `std::unique_ptr` from `<memory>`

```cpp
void foo(bool x) {
  scoped_ptr<Foo> f(new Foo());
}
```

```cpp
#include <memory>

void foo(bool x) {
  std::unique_ptr<Foo> f(new Foo());
}
```

## War story: `scoped_ptr` → `std::unique_ptr` migration

The Problems:

- Subtle API differences between `scoped_ptr` and `std::unique_ptr`
- Use spanning API boundaries means changes are not independent
- Some code still built with non-C++11 toolchains
- Many different `scoped_ptr`s defined in our codebase, but only references to one should be updated

Given sufficient use,
there is no such thing as a private implementation.

Refactoring at Google Scale:
A typical problem that gets a whole lot more interesting.

## Questions?

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