„Which is which, and who is who?”

Building a new Swift unqualified name lookup library during GSoC 2024

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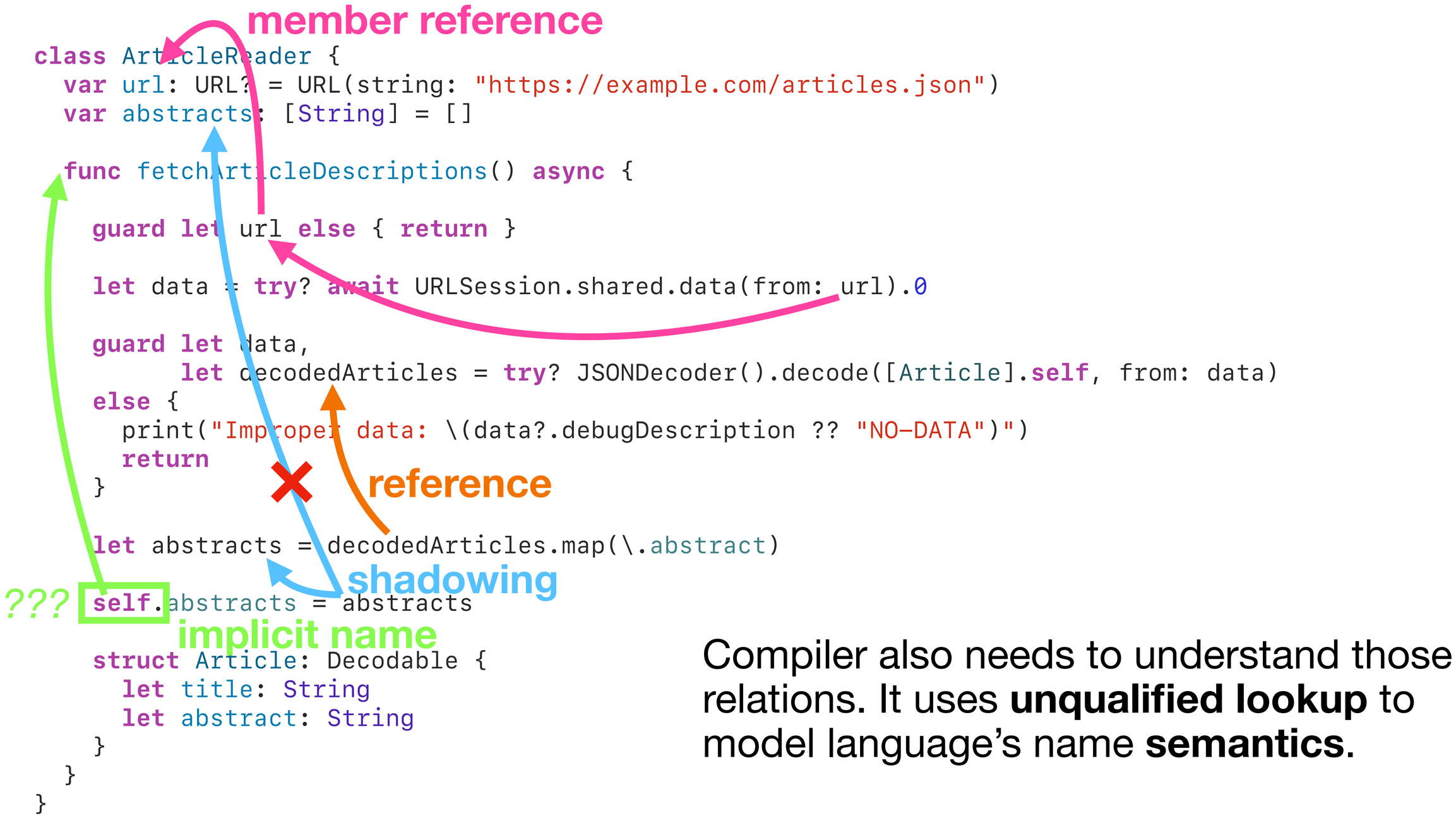


Compiler also needs to understand those relations. It uses **unqualified lookup** to model language's name **semantics**.

SwiftLexicalLookup

Lookup API

- Lightweight, stateless API
- Syntax nodes as entry points
- Returns an array of results
- Enum based data structure
- A result associates extracted names with their source scopes

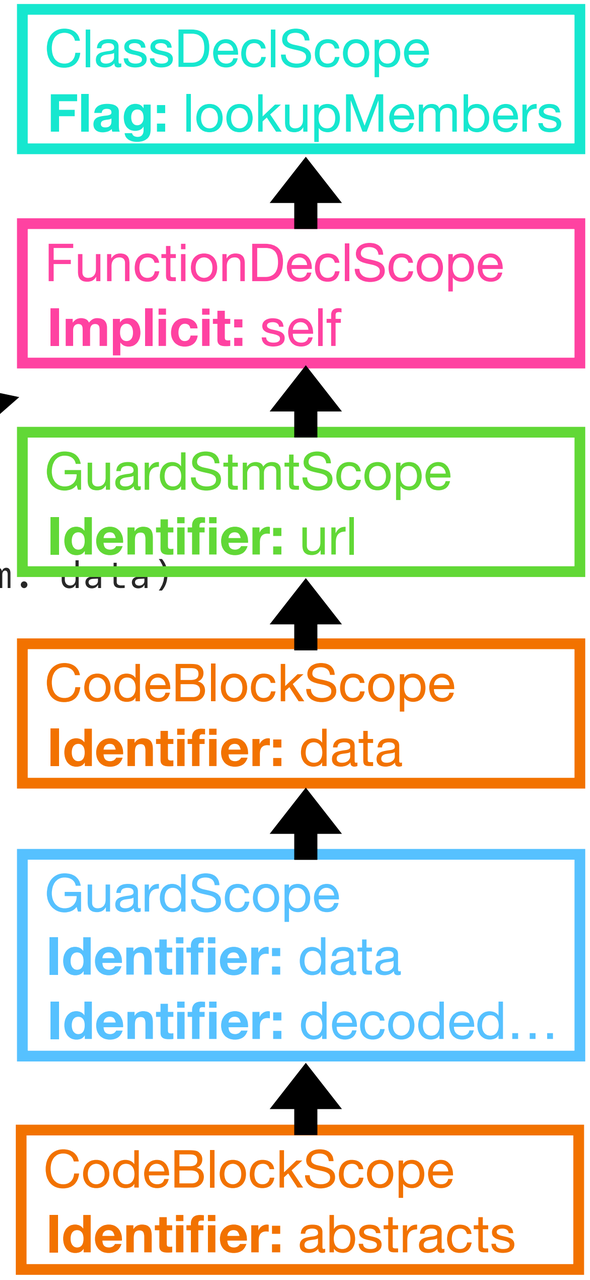
```swift
extension SyntaxProtocol {
  public func lookup(
    _ identifier: Identifier?,
    with config: LookupConfig = LookupConfig()
  ) -> [LookupResult] {
    scope?.lookup(identifier, at: self.position, with: config) ?? []
  }
}
```

```swift
public enum LookupResult {
  /// Scope and the names that matched lookup.
  case fromScope(ScopeSyntax, withNames: [LookupName])
  /// File scope and names that matched lookup.
  case fromFileScope(SourceFileSyntax, withNames: [LookupName])
  /// Names that matched lookup, but are not
  /// visible in the associated scope.
  case almostVisible(ScopeSyntax, withNames: [LookupName])
  /// Indicates where to perform member lookup.
  case lookInMembers(LookInMembersScopeSyntax)
```

```swift
public enum LookupName {
  /// Identifier associated with the name.
  /// Could be an identifier of a variable, function or closure parameter and more.
  case identifier(IdentifiableSyntax, accessibleAfter: AbsolutePosition?)
  /// Declaration associated with the name.
  /// Could be class, struct, actor, protocol, function and more.
  case declaration(NamedDeclSyntax)
  /// Name introduced implicitly by certain syntax nodes.
  case implicit(ImplicitDecl)
```

```swift
class ArticleReader {
  var url: URL? = URL(string: "https://example.com/articles.json")
  var abstracts: [String] = []

  func fetchArticleDescriptions() async {

    guard let url else { return }

    let data = try? await URLSession.shared.data(from: url).0

    guard let data,
          let decodedArticles = try? JSONDecoder().decode([Article].self, from: data)
    else {
      print("Improper data: \(data?.debugDescription ?? "NO-DATA")")
      return
    }

    let abstracts = decodedArticles.map(\.abstract)

    self.abstracts = abstracts

    struct Article: Decodable {
      let title: String
      let abstract: String
    }
  }
}
```

Something is missing here…



Unit tests

Cheap and easy to write

- Tests specific scope behavior
- Standard XCTests with a custom reusable harness
- Assertions defined through a custom data structure mimicking the actual expected result

```
func testImplicitErrorInCatchClause() {
  assertLexicalNameLookup(
    source: """
      func foo() {
        let 1️⃣error = 0

        do {
          try x.bar()
          2️⃣error
        } 6️⃣catch SomeError {
          3️⃣error
        } 4️⃣catch {
          5️⃣error
        }
      }
      """,
    references: [
      "2️⃣": [
        .fromScope(CodeBlockSyntax.self, expectedNames: [
          NameExpectation.identifier("1️⃣")
        ])
      ],
      "3️⃣": [
        .fromScope(CodeBlockSyntax.self, expectedNames: [
          NameExpectation.identifier("1️⃣")
        ])
      ],
      "5️⃣": [
        .fromScope(CatchClauseSyntax.self, expectedNames: [
          NameExpectation.implicit(.error("4️⃣"))
        ]),
        .fromScope(CodeBlockSyntax.self, expectedNames: [
          NameExpectation.identifier("1️⃣")
        ]),
      ],
    ]
  )
}
```

```
class ArticleReader {
  var url: URL? = URL(string: "https://example.com/articles.json")
  var abstracts: [String] = []

  func fetchArticleDescriptions() async {

    guard let url else { return }

    let data = try? await URLSession.shared.data(from: url).0

    guard let data,
          let decodedArticles = try? JSONDecoder().decode([Article].self, from: data)
    else {
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    }

    let abstracts = decodedArticles.map(\.abstract)

    self.abstracts = abstracts

    struct Article: Decodable {
      let title: String
      let abstract: String
    }
  }
}
```

```swift
class ArticleReader {
  func fetchArticleDescriptions() async {

    guard let url else { return }

    let data = try? await URLSession.shared.data(from: url).0

    guard let data,
          let decodedArticles = try? JSONDecoder().decode([Article].self, from: data)
    else { return }

    let abstracts = decodedArticles.map(\.abstract)

    self.abstracts = abstracts
  }
}
```

```
func testExample() {
    assertLexicalNameLookup(
      source: """
        class ArticleReader {
          func fetchArticleDescriptions() async {

            guard let url else { return }

            let data = try? await URLSession.shared.data(from: url).0

            guard let data,
                  let decodedArticles = try? JSONDecoder().decode([Article].self, from: data)
            else { return }

            let abstracts = decodedArticles.map(\\.abstract)

            self.abstracts = abstracts
          }
        }
        """
    )
  }
```

```
func testExample() {
    assertLexicalNameLookup(
      source: """
        class ArticleReader {
          7️⃣func fetchArticleDescriptions() async {

            guard let 6️⃣url else { return }

            let 5️⃣data = try? await URLSession.shared.data(from: url).0

            guard let 4️⃣data,
                  let 3️⃣decodedArticles = try? JSONDecoder().decode([Article].self, from: data)
            else { return }

            let 2️⃣abstracts = decodedArticles.map(\\.abstract)

            self.abstracts = 1️⃣abstracts
          }
        }
        """
    )
  }
```

```
func testExample() {
    assertLexicalNameLookup(
      source: """
        class ArticleReader {
          7️⃣func fetchArticleDescriptions() async {

            guard let 6️⃣url else { return }

            let 5️⃣data = try? await URLSession.shared.data(from: url).0

            guard let 4️⃣data,
                  let 3️⃣decodedArticles = try? JSONDecoder().decode([Article].self, from: data)
            else { return }

            let 2️⃣abstracts = decodedArticles.map(\\.abstract)

            self.abstracts = 1️⃣abstracts
          }
        }
        """,
      references: [
        "1️⃣": [],
      ]
    )
  }
```

```
func testExample() {
    assertLexicalNameLookup(
      source: """
        class ArticleReader {
          7️⃣func fetchArticleDescriptions() async {

            guard let 6️⃣url else { return }

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            guard let 4️⃣data,
                  let 3️⃣decodedArticles = try? JSONDecoder().decode([Article].self, from: data)
            else { return }

            let 2️⃣abstracts = decodedArticles.map(\\.abstract)

            self.abstracts = 1️⃣abstracts
          }
        }
        """,
      references: [
        "1️⃣": [
          .fromScope(CodeBlockSyntax.self, expectedNames: ["2️⃣"]),
          .fromScope(GuardStmtSyntax.self, expectedNames: ["3️⃣", "4️⃣"]),
          .fromScope(CodeBlockSyntax.self, expectedNames: ["5️⃣"]),
          .fromScope(GuardStmtSyntax.self, expectedNames: ["6️⃣"]),
          .fromScope(FunctionDeclSyntax.self, expectedNames: [NameExpectation.implicit(.self("7️⃣"))]),
          .lookInMembers(ClassDeclSyntax.self),
        ],
      ],
      useNilAsTheParameter: true
    )
  }
```

Integration tests

Run inside the compiler

- Used to ensure equality of both implementations
- Easy to run for real world code
- Validates SLL agains the compiler
- Produces glanceable tables
- Accounts for some funky compiler behavior…

```
-----> Lookup started at: 1706:7 ("debugPrint") finishInSequentialScope: false
     |            ASTScope            |      SwiftLexicalLookup
> ✅ |          k 1699:10             |          k 1699:10
> ✅ |          v 1699:13             |          v 1699:13
> ❌ |         first 1698:9           |         type 1690:18
> ❌ |        result 1697:9           |         self 1689:17
> ❌ |         type 1690:18           |         ↕️ V 1689:49
> ❌ |         self 1689:17           |         ↕️ K 1689:46
> ℹ️ | Omitted SwiftLexicalLookup name: Self 1683:1
> ❌ |          V 1689:49             |      Look memb: 1684:11
> ❌ |          K 1689:46             |           -----
> ℹ️ | Omitted ASTScope name: K 1689:46
> ℹ️ | Omitted ASTScope name: V 1689:49
> ❌ | End here: Look memb: 1684:11 |           -----
```

Interesting cases…

Sequential scopes

```
class ArticleReader {
  var url: URL? = URL(string: "https://example.com/articles.json")
  var abstracts: [String] = []

  func fetchArticleDescriptions() async {

    guard let url else { return }

    let data = try? await URLSession.shared.data(from: url).0

    guard let data,
          let decodedArticles = try? JSONDecoder().decode([Article].self, from: data)
    else {
      print("Improper data: \(data?.debugDescription ?? "NO-DATA")")
      return
    }

    let abstracts = decodedArticles.map(\.abstract)

    self.abstracts = abstracts

    struct Article: Decodable {
      let title: String
      let abstract: String
    }
  }
}
```

Names introduced in guard are visible for consecutive conditions.

Sequential scopes

```
class ArticleReader {
  var url: URL? = URL(string: "https://example.com/articles.json")
  var abstracts: [String] = []

  func fetchArticleDescriptions() async {

    guard let url else { return }

    let data = try? await URLSession.shared.data(from: url).0

    guard let data,
          let decodedArticles = try? JSONDecoder().decode([Article].self, from: data)
    else {
      print("Improper data: \(data?.debugDescription ?? "NO-DATA")")
      return
    }

    let abstracts = decodedArticles.map(\.abstract)

    self.abstracts = abstracts

    struct Article: Decodable {
      let title: String
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    }
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}
```

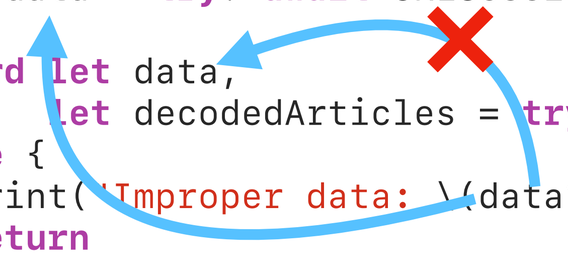

Introduced names are not visible inside the guard scope body.

Sequential scopes

```
class ArticleReader {
  var url: URL? = URL(string: "https://example.com/articles.json")
  var abstracts: [String] = []

  func fetchArticleDescriptions() async {

    guard let url else { return }

    let data = try? await URLSession.shared.data(from: url).0

    guard let data,
          let decodedArticles = try? JSONDecoder().decode([Article].self, from: data)
    else {
      print("Improper data: \(data?.debugDescription ?? "NO-DATA")")
      return
    }

    let abstracts = decodedArticles.map(\.abstract)

    self.abstracts = abstracts

    struct Article: Decodable {
      let title: String
      let abstract: String
    }
  }
}
```

!!!

Nominal types declared in code blocks are visible across the whole scope body.

Macro declarations

A bug on the compiler side

- Compiler incorrectly first introduces generic parameters before function parameters
- Issue #77141
- Exemplifies the hard process of bringing the two implementations together

```
@freestanding(expression)
public macro externalMacro<T>(
  module: String,
  type: String
) -> T = Builtin.ExternalMacro
```

```
-----> Lookup started at: 4:9 ("String") finishInSequentialScope: false
     |          ASTScope          |      SwiftLexicalLookup
> ❌ |           T 5:6            |         module 3:3
> ℹ️ | Omitted ASTScope name: T 5:6
> ❌ |         module 3:3         |          type 4:3
> ❌ |          type 4:3          |            T 5:6
```

How ~~to~~ did I contribute to Swift?

First contribution roadmap

- Pre-GSoC confusion
- Experimenting with swift-syntax
- Building a demo
- Writing the proposal

- Initial planning
- Developing the library in isolation
- Unit testing
- Test Driven Development

- Working with the main repo
- Exponential growth of complexity
- Testing against the compiler
- Validating the implementation

- Stabilizing the api
- Improving performance
- Publishing RFC last week
- Building functionality around SLL

Thank you

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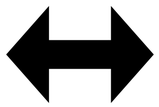
Equivalent names

```swift
var state = LoadingState.notStarted

func getLoadingDetails() -> String? {
  switch state {
  case .success(let details):
    return details
  case .failure(let details):
    return details
  case .running:
    return nil
  case .notStarted:
    return nil
  }
}
```



```swift
var state = LoadingState.notStarted

func getLoadingDetails() -> String? {
  switch state {
  case .success(let details), .failure(let details):
    return details
  case .running, .notStarted:
    return nil
  }
}
```

!!!

A name recursively associated with **multiple** names with the **same semantic meaning** and the first one acting as the **representative**.

Helpful links

Jump start your contributions!

- QuickStart guide: https://www.swift.org/quickstart-contribution/
- Contributing to swift-syntax: https://github.com/swiftlang/swift-syntax/blob/main/CONTRIBUTING.md
- Contributing to the swift main repository: https://github.com/swiftlang/swift/blob/main/CONTRIBUTING.md
- Getting started with the main Swift repository: https://github.com/swiftlang/swift/blob/main/docs/HowToGuides/GettingStarted.md
- Tool for visualizing swift syntax tree: https://swift-ast-explorer.com/

Further reading

- Deeper dive in SwiftLexicalLookup: https://forums.swift.org/t/gsoc-2024-swiftlexicallookup-a-new-lexical-name-lookup-library/75889
- SwiftLexicalLookup documentation: https://swiftpackageindex.com/swiftlang/swift-syntax/main/documentation/swiftlexicallookup
- Issue #77141 „Wrong result order in ASTScope::unqualifiedLookup for macro declarations.”: https://github.com/swiftlang/swift/issues/77141
- GSoC 2024 work product submission: https://www.jakubflorek.com/posts/gsoc-2024