Storing Clang Data

For IDEs and static analysis

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AGENDA

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3 What do we want to store

4 What kind of format

5 Discussions

Introductions

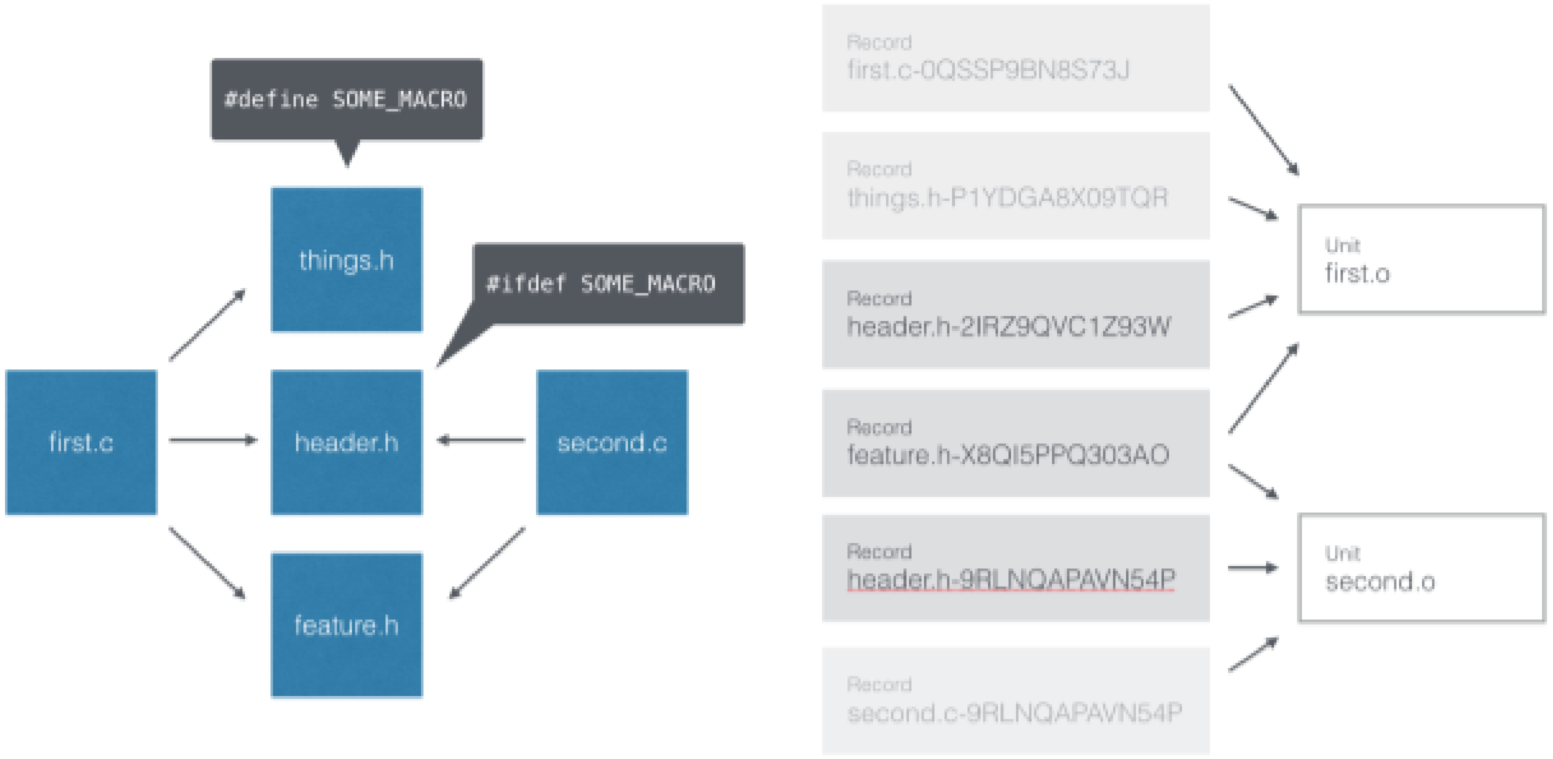
› Marc-André Laperle
  - Software Developer at Ericsson since 2013
  - Eclipse committer for CDT (C/C++) and several other projects
  - New-ish LLVM/Clang contributor (early 2017)
  - Enthusiastic about C/C++, IDEs and tooling in general (Not a compiler expert! Yet?)

Your turn!

What is being done now

- Some ongoing things in Clang and Clang “extra”
  - Xcode 9’s “Index-while-building”
  - Clangd’s indexing
  - Clang Static Analyzer’s “Cross-TU” feature
  - Regular improvements to Clang/Index

Xcode 9 “Index-while-building”



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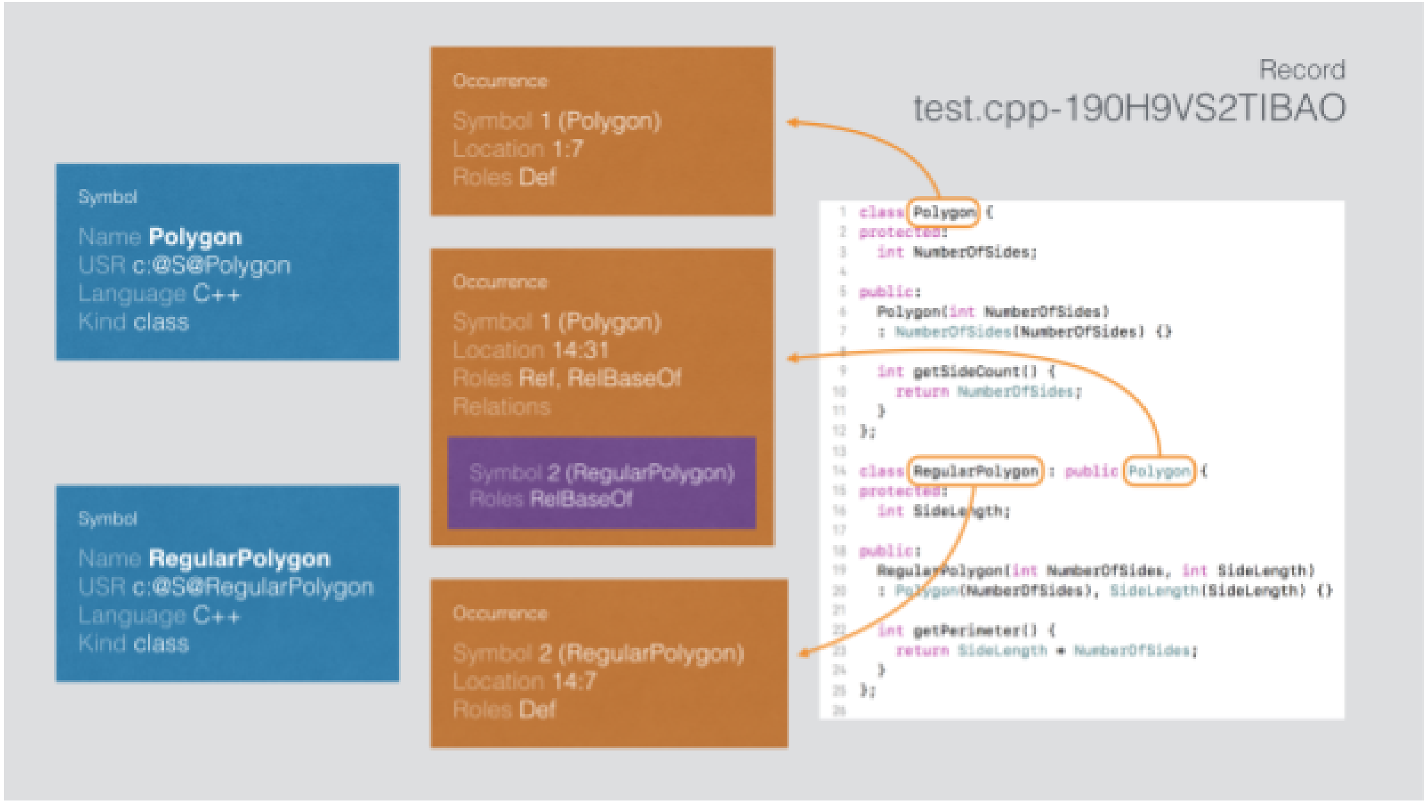
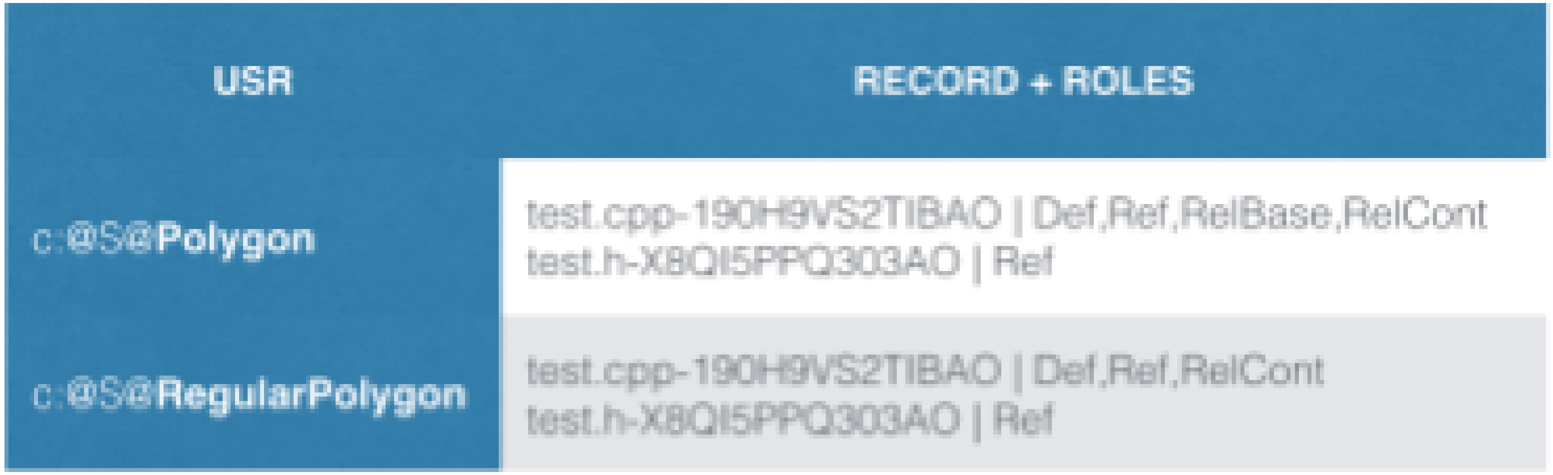
Xcode 9 “Index-while-building”



```
1  class Polygon {
2  protected:
3    int NumberOfSides;
4
5  public:
6    Polygon(int NumberOfSides)
7    : NumberOfSides(NumberOfSides) {}
8
9    int getSideCount() {
10     return NumberOfSides;
11   }
12 };
13
14 class RegularPolygon : public Polygon {
15 protected:
16   int SideLength;
17
18 public:
19   RegularPolygon(int NumberOfSides, int SideLength)
20   : Polygon(NumberOfSides), SideLength(SideLength) {}
21
22   int getPerimeter() {
23     return SideLength * NumberOfSides;
24   }
25 };
26
```

Source: https://docs.google.com/document/d/1cH2sTpgSnJZCkZtJI1aY-rzy4uGPcrI-6RrUpdATO2Q/

Xcode 9 “Index-while-building”



USR	RECORD + ROLES
c:@S@**Polygon**	test.cpp-190H9VS2TIBAO | Def,Ref,RelBase,RelCont test.h-X8QI5PPQ303AO | Ref
c:@S@**RegularPolygon**	test.cpp-190H9VS2TIBAO | Def,Ref,RelCont test.h-X8QI5PPQ303AO | Ref

Source: https://docs.google.com/document/d/1cH2sTpgSnJZCkZtJl1aY-rzy4uGPcrI-6RrUpdATO2Q/

Clangd’s ClangdIndexDataStorage

- Malloc-like interface to writing in a file
- Stores raw bytes, ints, string and pointers (to other locations in the file)
- Inspired from CDT’s database

Clangd’s ClangdIndexDataStorage

File layout

0	File version
4	Linked list to free blocks of 8 bytes
8	Linked list to free blocks of 16 bytes
...	
2048	Linked list to free blocks of 4096B
2052	“User” data (Blocks)

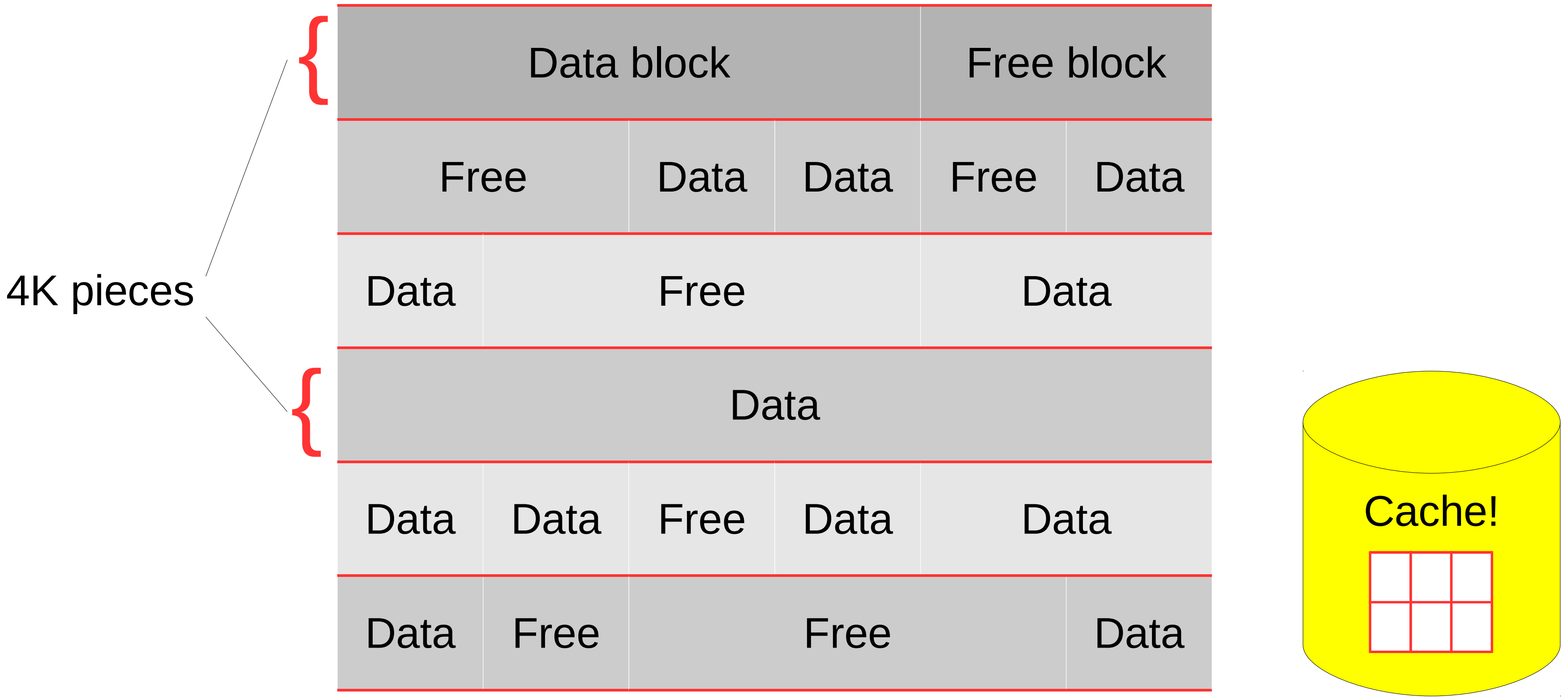
Data block

0	Block size
2..size	Any “user” data

Free block

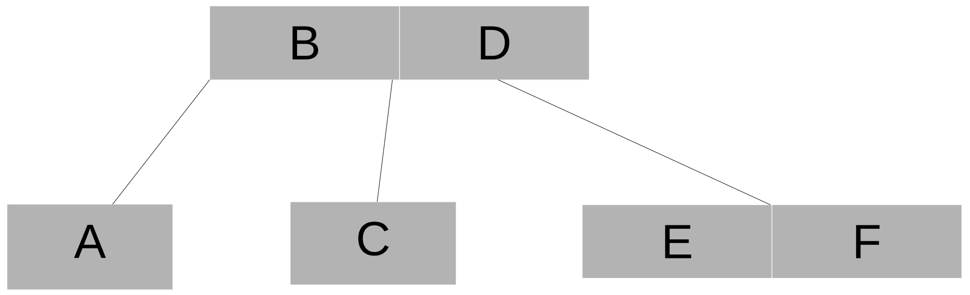
0	Free block size
2	Pointer to next free block of same size
6..size	Unused (until it becomes a data block)

Clangd's ClangdIndexDataStorage



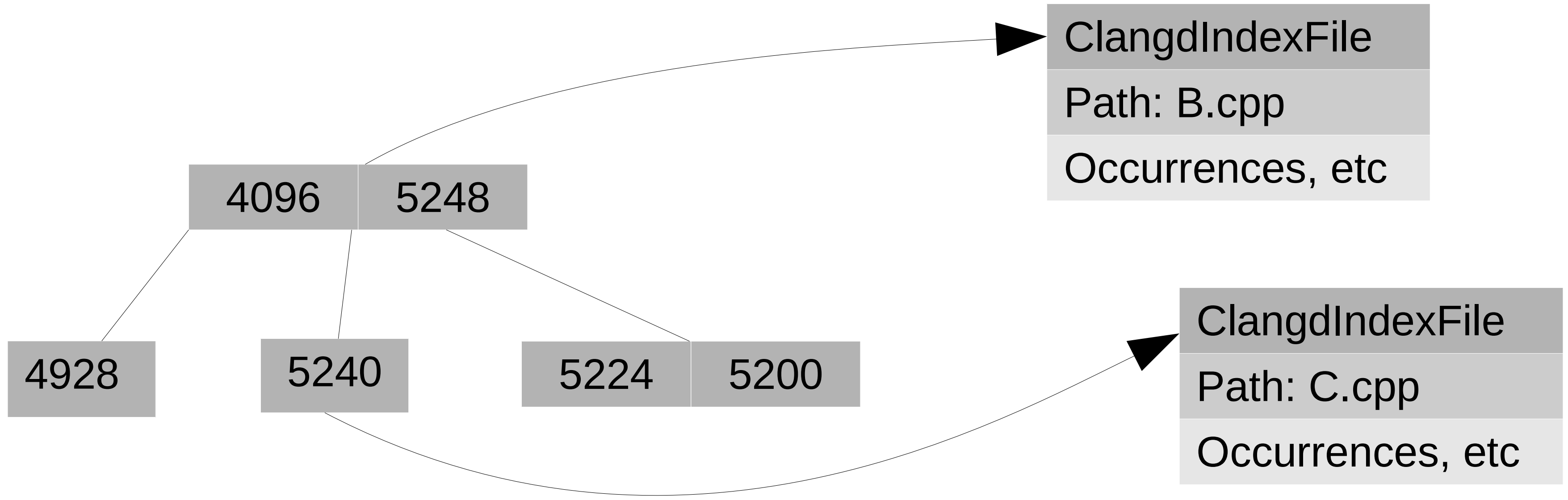
Clangd’s BTree

- Tree with nodes containing multiple children
- Balanced
- Logarithmic insertion, search, deletion

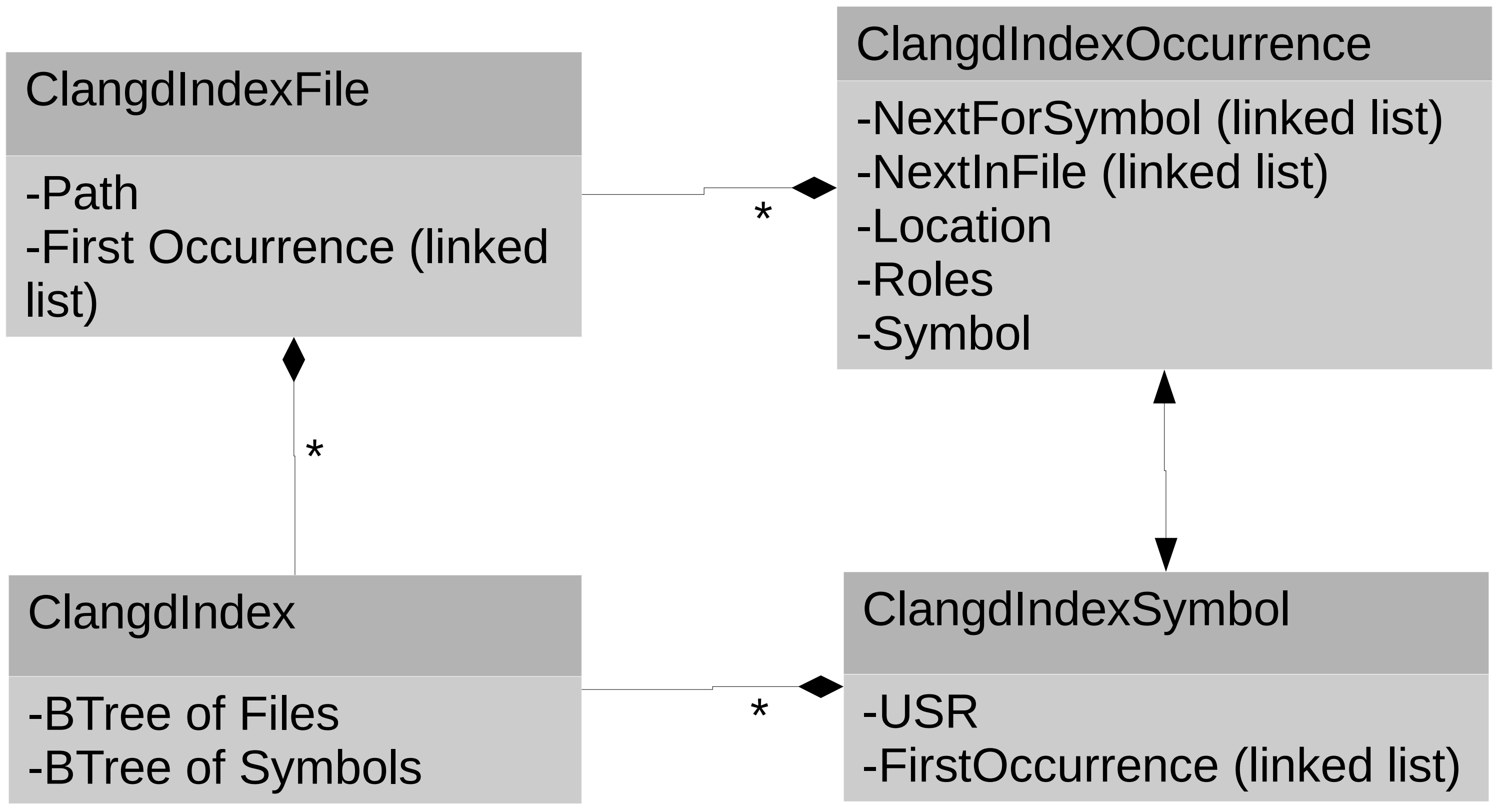


Clangd’s BTree

- Keys are pointers to data in ClangdIndexDataStorage



Clangd's Index Model



Clang Static Analyzer

- When an analysis is executed, a “function to file location” mapping is generated in a file “externalFnMap.txt”
- Other stored information would be useful for performance:
  - A call graph would help incremental Cross-TU analysis
  - An “include graph” would help to know which build commands need to be re-analyzed when a file changes

What do we want to store

- Symbols
- Occurrences (calls, references, definitions, declarations, relations)
- File dependencies
- Static analysis checker-specific information (per symbol, per function function definition, etc). I.e. make the model extensible
- Ability to not store some information (field occurrences, etc)

What kind of format

- Xcode’s libIndexStore (LLVM Bitstream)
  - Not **yet** fully upstreamed to Clang (Swift Github)
  - Format used for “Index-while-building”
  - Needs liblmdb as new dependency for mappings (or need to replace with something else)

What kind of format

- Clangd’s IndexStorage
  - Not yet upstreamed to Clang (Github)
  - Stand-alone (no new dependency)
  - Not production ready yet
  - Not created with “Index-while-building” in mind, but libIndexStore could be used as input

What kind of format

- “Third-party” Databases
  - Some are just too big dependencies to include in Clang (MySQL, PostgreSQL, etc)
  - Smaller ones interesting: SQLite, LMDB. LMDB is quite simple and fast, could be used in combination of other formats (libIndexStore, ClangdIndexStorage)
  - How likely would a third-party database be accepted in LLVM repos?

What kind of format

- How could other tools reuse this?
  - Link libclangIndex?
  - Link libclangDaemon
  - Launch Clangd, communicate with JSON-RPC
  - All of the above?

Things considered for Clangd

- “Index-While-Building” feature in Xcode 9 should be reused. The index store could be used (instead of ClangdIndexStorage). Or used as input to ClangdIndexStorage.
- Move some indexing logic to Clang/Index instead of Clangd, for others to reuse
- Make indexing extensible enough so that other tools can add information to the index (Clang Static Analyzer)
- Use liblmdb, for symbol mapping, similar to Xcode
- Support for multiple “indexes” for merging different projects, libraries, etc
- Use linking information (compile_commands.json) in order to solve the multiple definitions problem

References

- Clangd: https://clang.llvm.org/extra/clangd.html
- Clang Static Analyzer: https://clang-analyzer.llvm.org/
- Clang mailing list: https://lists.llvm.org/mailman/listinfo/cfe-dev
- Xcode’s Index-while-building: https://docs.google.com/document/d/1cH2sTpgSnJZCkZtJl1aY-rzy4uGPcrI-6RrUpdATO2Q/

BoF Notes/Minutes