LevelDB Study
Introduction 3

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Presented by Min-guk Choi

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- Previous Homework
  - ✓ Solutions
    - Question 1, 2 - Jongki Park
    - Question 3, 5 - Suhwan Shin
    - Question 4 - Zhu Yongjie
  - ✓ Review

Question 1, 2

1. Why do LSM-tree and LevelDB use leveled structure?

Hint 1 - Stackoverflow

- Why does LevelDB needs more than two levels?
- Why rocksDB needs multiple levels?
- Why does LevelDB make its lower level 10 times bigger than upper one?

Hint 2 – Memory hierarchy

Hint 3 - Patrick O'Neil, The Log-Structured Merge-Tree (LSM-Tree), 1996

2. In leveldb, max size of level i is 10^iMB. But max size of level 0 is 8MB. Why?

Hint 1 - leveldb source code

- *leveldb/db/version_set.cc:VersionSet::Finalize*
- *leveldb/db/dbformat.h:kL0_CompactionTrigger*

Hint 2 - leveldb-handbook, Compaction (Use google chrome translator)

```
void VersionSet::Finalize(Version* v) {
  // Precomputed best level for next compaction
  int best_level = -1;
  double best_score = -1;

  for (int level = 0; level < config::kNumLevels - 1; level++) {
    double score;
    if (level == 0) {
      // We treat level-0 specially by bounding the number of files
      // instead of number of bytes for two reasons:
      //
      // (1) With larger write-buffer sizes, it is nice not to do too
      // many level-0 compactions.
      //
      // (2) The files in level-0 are merged on every read and
      // therefore we wish to avoid too many files when the individual
      // file size is small (perhaps because of a small write-buffer
      // setting, or very high compression ratios, or lots of
      // overwrites/deletions).
```

The Log-Structured Merge-Tree (LSM-Tree)

Patrick O'Neil[1], Edward Cheng[2]
Dieter Gawlick[3], Elizabeth O'Neil[1]
To be published: Acta Informatica

ABSTRACT. High-performance transaction system applications typically insert rows in a History table to provide an activity trace; at the same time the transaction system generates log records for purposes of system recovery. Both types of generated information can benefit from efficient indexing. An example in a well-known setting is the TPC-A benchmark application, modified to support efficient queries on the History for account activity for specific accounts. This requires an index by account-id on the fast-growing History table. Unfortunately, standard disk-based index structures such as the B-tree will effectively double the I/O cost of the transaction to maintain an index such as this in real time, increasing the total system cost up to fifty percent. Clearly a method for maintaining a real-time index at low cost is desirable. The Log-Structured Merge-tree (LSM-tree) is a disk-based data structure designed to provide low-cost indexing for a file experiencing a high rate of record inserts (and deletes) over an extended period. The LSM-tree uses an algorithm that defers and batches index changes, cascading the changes from a memory-based component through one or more disk components in an efficient manner reminiscent of merge sort. During this process all index values are continuously accessible to retrievals (aside from very short locking periods), either through the memory component or one of the disk components. The algorithm has greatly reduced disk arm movements compared to a traditional access methods such as B-trees, and will improve cost-performance in domains where disk arm costs for inserts with traditional access methods overwhelm storage media costs. The LSM-tree approach also generalizes to operations other than insert and delete. However, indexed finds requiring immediate response will lose I/O efficiency in some cases, so the LSM-tree is most useful in applications where index inserts are more common than finds that retrieve the entries. This seems to be a common property for History tables and log files, for example. The conclusions of Section 6 compare the hybrid use of memory and disk components in the LSM-tree access method with the commonly understood advantage of the hybrid method to buffer disk pages in memory.

Question 3, 4, 5

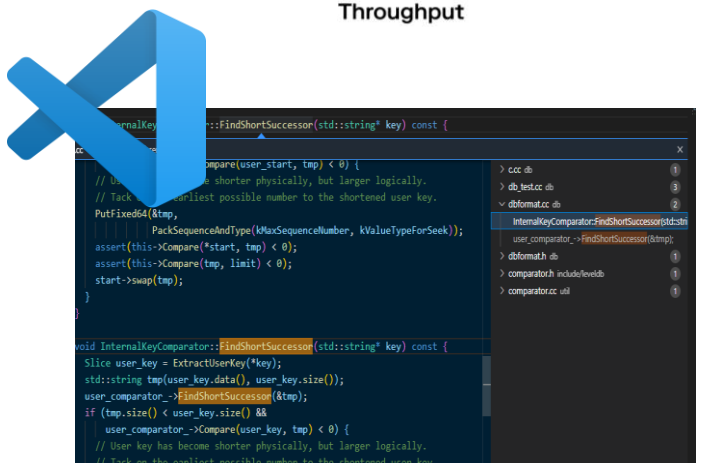
4. Practice 2

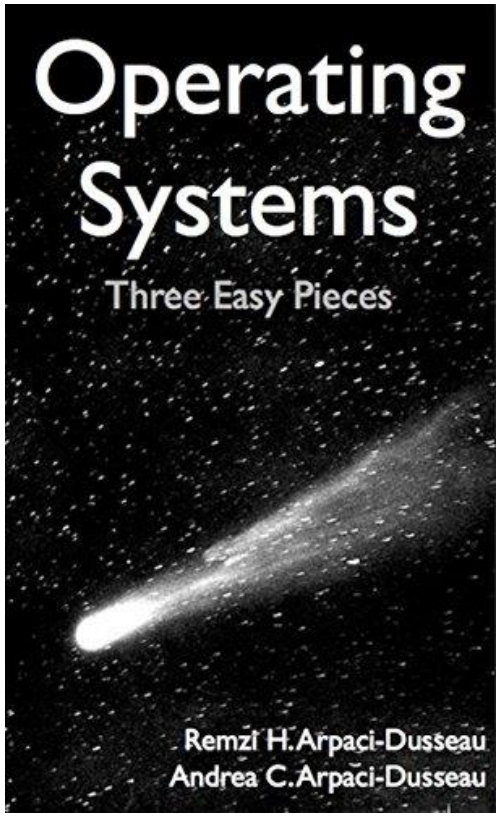
```
[Load] $ ./db_bench --benchmarks="fillrandom" --use_existing_db=0

[A] $ ./db_bench --benchmarks="readseq" --use_existing_db=1
[B] $ ./db_bench --benchmarks="readrandom" --use_existing_db=1
[C] $ ./db_bench --benchmarks="seekrandom" --use_existing_db=1
```

> Note - Before running A, B, and C, run db_load benchmark.
>
> Q1. Which user key-value interface does each benchmark use? (Put, Get, Iterator, ...)
> Hint 1 - *leveldb/doc/index.md*
> Hint 2 - *leveldb/benchmarks/db_bench.cc*

> Q2. Compare throughput and latency of each benchmark and explain why.
> Hint - Seek Time



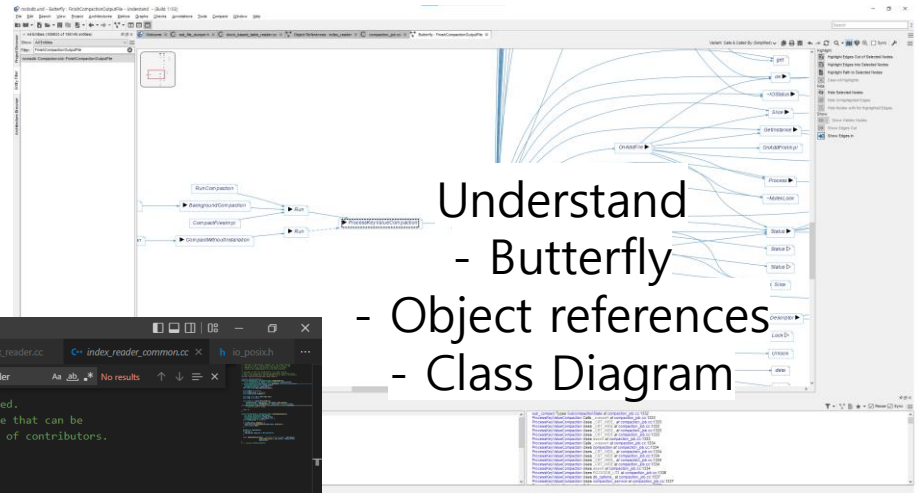


- How to analyze LevelDB
  - ✓ How to analyze LevelDB
  - ✓ How I use
  - ✓ What/When to use?
  - ✓ Where to start?
  - ✓ Source Code

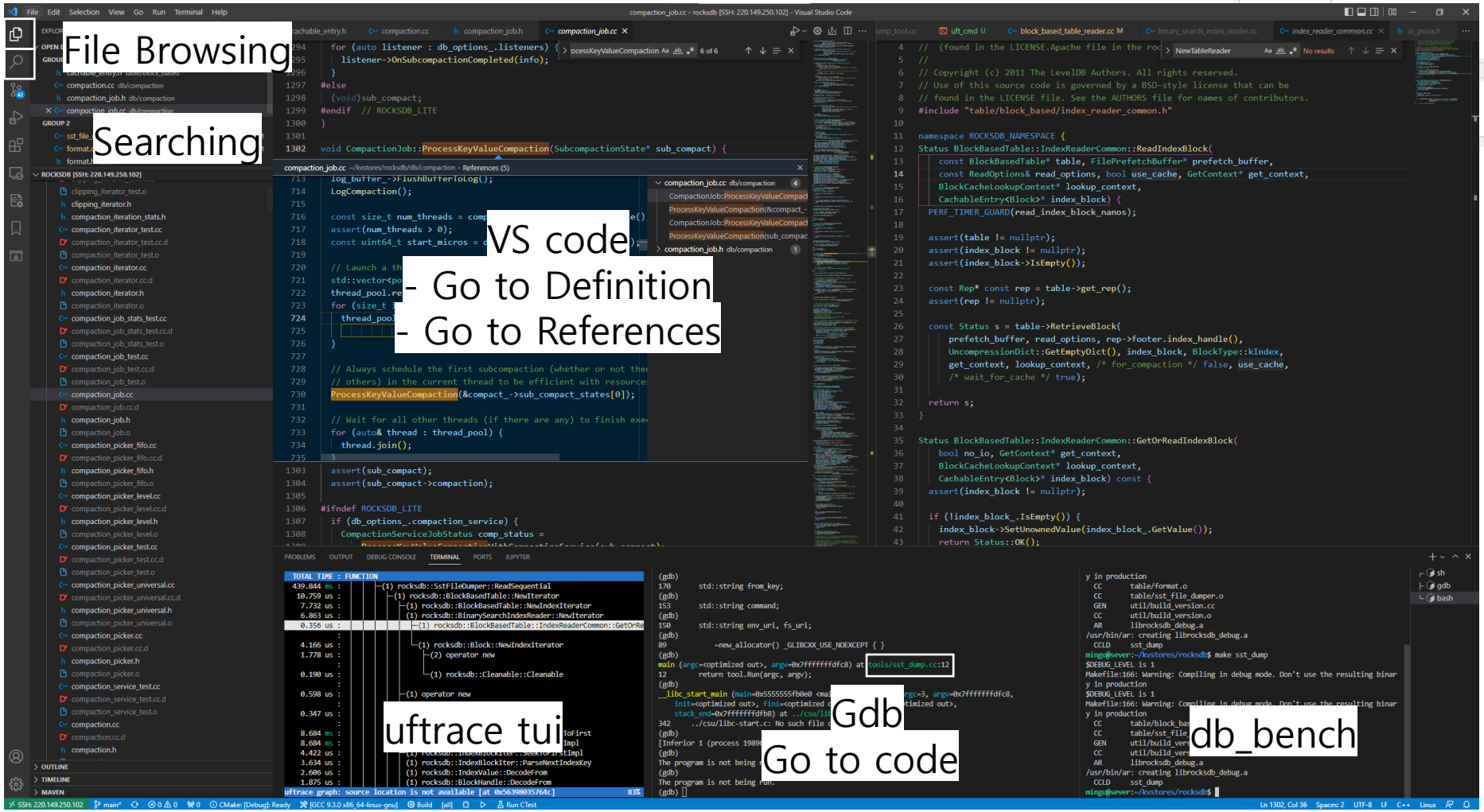
How to analyze LevelDB

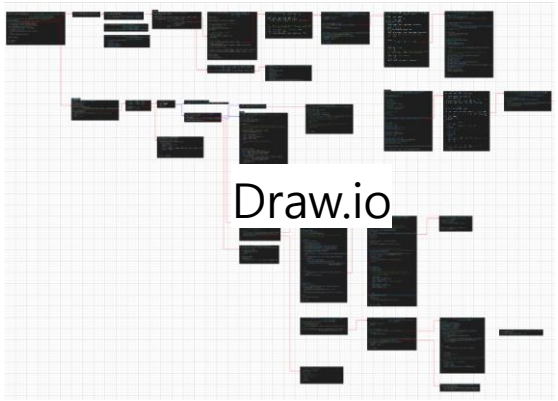
1. Do a research
   - Documents, Lectures.
2. Remarks, Code
   - VS code, Understand
3. Code Tracing
   - GDB, Uftrace
4. Draw figures
   - Structure, Class, Code Flow
   - Draw.io, PPT
5. Write a markdown document
6. Prepare 15-minute presentation

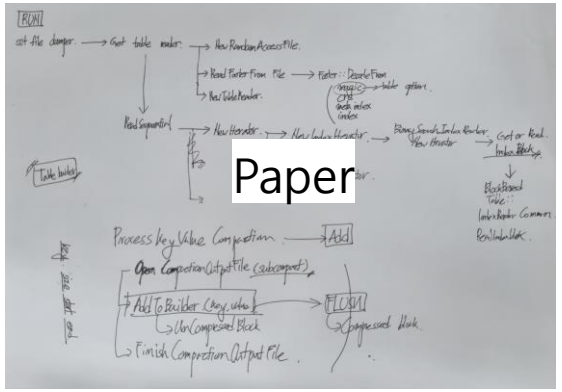
How I use



Understand
- Butterfly
- Object references
- Class Diagram





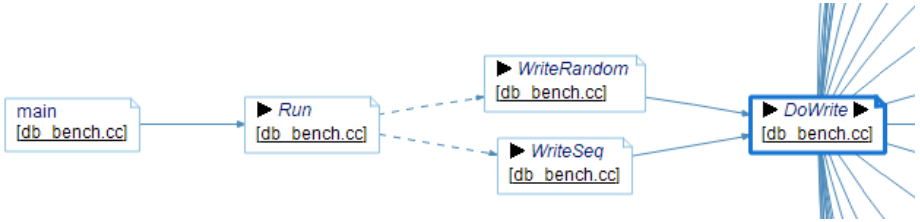


What/When to use?

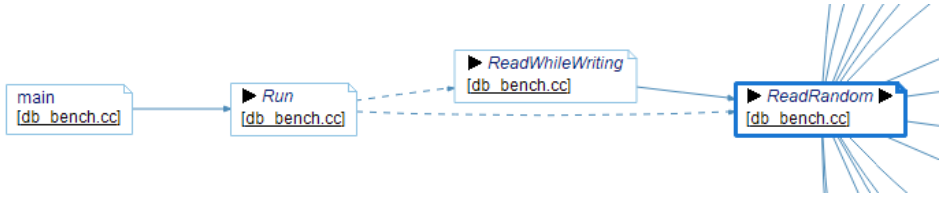
	1	2
Static Analysis Tool **- Remarks & Code**	VS code - Go to Definition - Go to References - Search - File Explorer	Understand - Class Diagram ~~- Object References~~ ~~- Butter Fly~~
Dynamic Analysis Tool **- Code Flow/Tracing**	Uftrace - Record - Replay - Tracing	GDB - Break point - Step into / Next - Print / Display - Line by Line - Argument, Variable

Where to start?

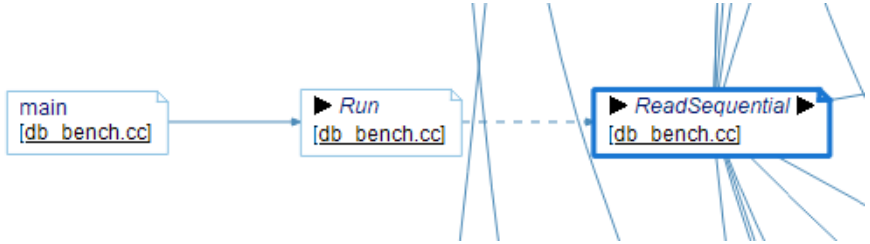
- Start with basic operations
  - Put(Write) operations
    - db_bench –benchmarks="fillseq, fillrandom"
    - db_bench.cc:DoWrite



  - Get(Read) operations
    - db_bench --benchmarks="readrandom"
    - db_bench.cc:ReadRandom



  - Seek(Scan) operations
    - db_bench –benchmarks="readseq"
    - db_bench.cc:ReadSequential

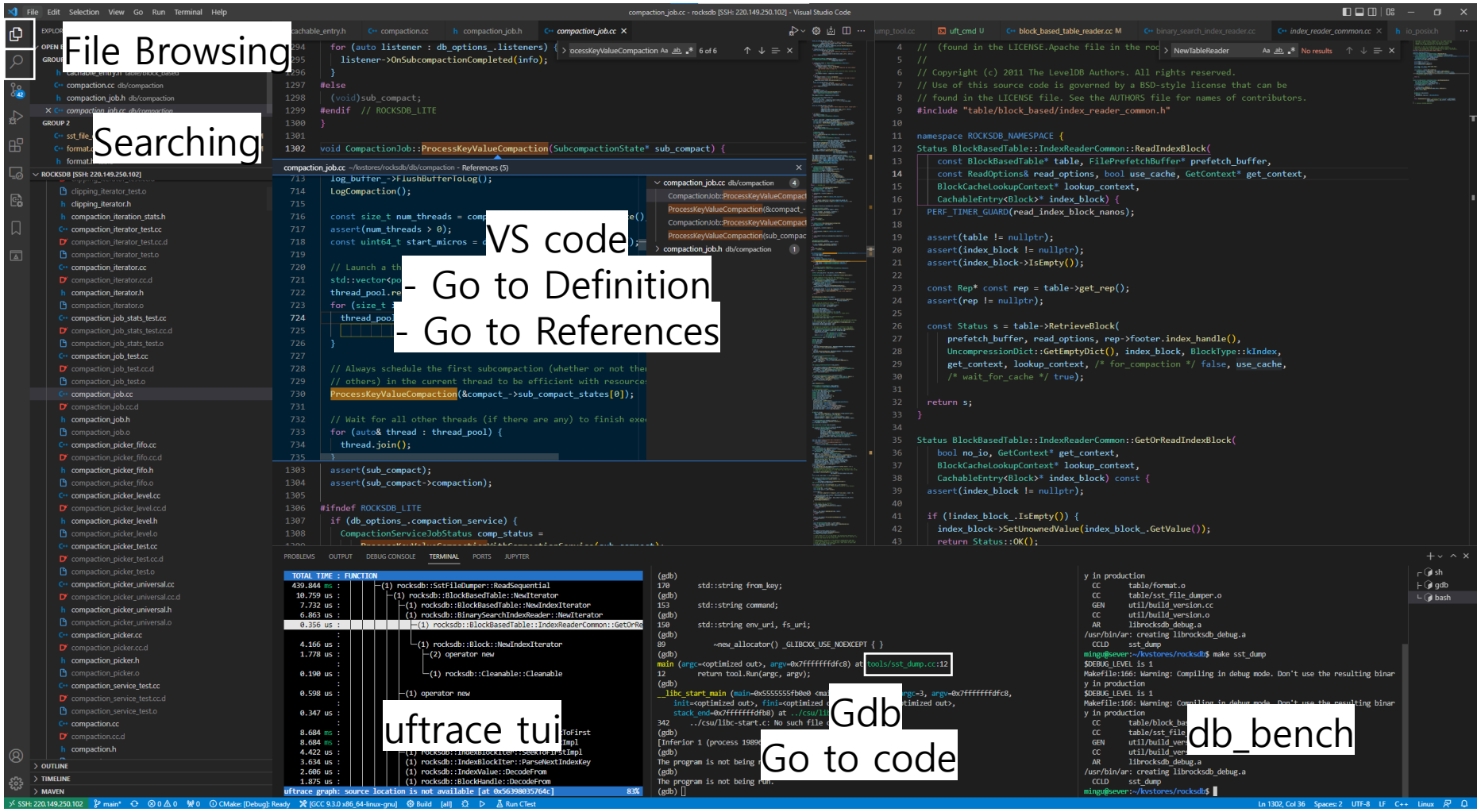


Source Code

Subject	files	Subject	files
WAL/Manifest	version_set.h version_edit.h write_batich.cc db_impl.h Repair.cc	**SSTable**	table/
MemTable	Skiplist.h memtable.h db_impl.h Arena.h	**BloomFiliter**	c.cc Dbformat.cc filter_block.cc filter_block_test.cc filter_policy.h
Compaction	db_impl.h	**Cache**	cache.h table.cc table_cache.h hash.h db_impl.h

- VS Code
  - ✓ References

VS Code


File Browsing
Searching
VS code
- Go to Definition
- Go to References
uftrace tui
Gdb
Go to code
db_bench

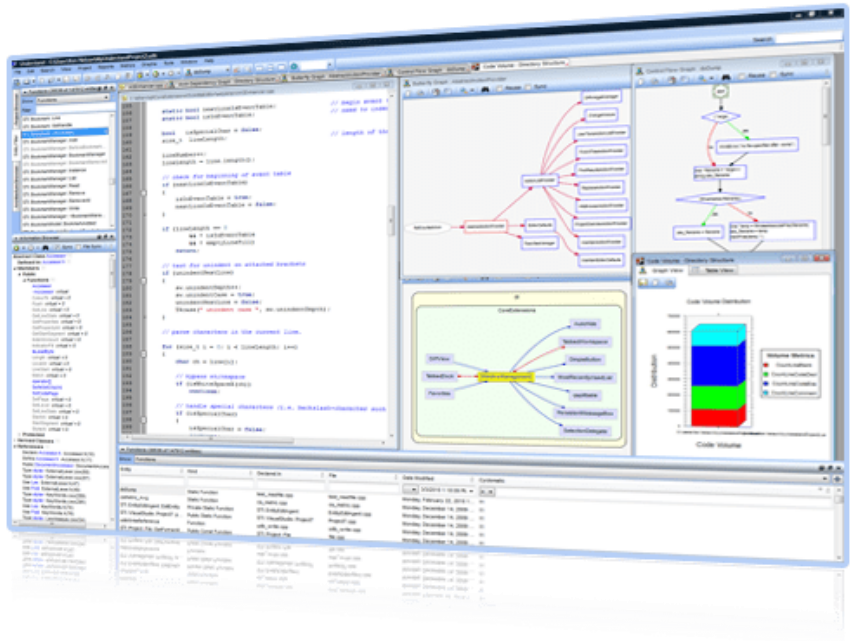
VS Code

- References
  - 25 VS Code Productivity Tips and Speed Hacks
    - https://youtu.be/ifTF3ags0XI
  - 코딩시간을 절반으로 줄여주는 VSCode 9개 기능
    - https://youtu.be/mh-0twurNRE
  - 비쥬얼 스튜디오 코드 필수 단축키 정리 (Visual Studio Code 꿀템🍯🦋)
    - https://youtu.be/EVxCdenPbFs
  - Visual Studio Code 기본 사용법
    - https://youtu.be/K8qVH8V0VvY

- Understand
  - ✓ Introduction
  - ✓ Features
    - Class diagram
    - Object references
    - Control flow
    - Butterfly
  - ✓ Installation

Understand

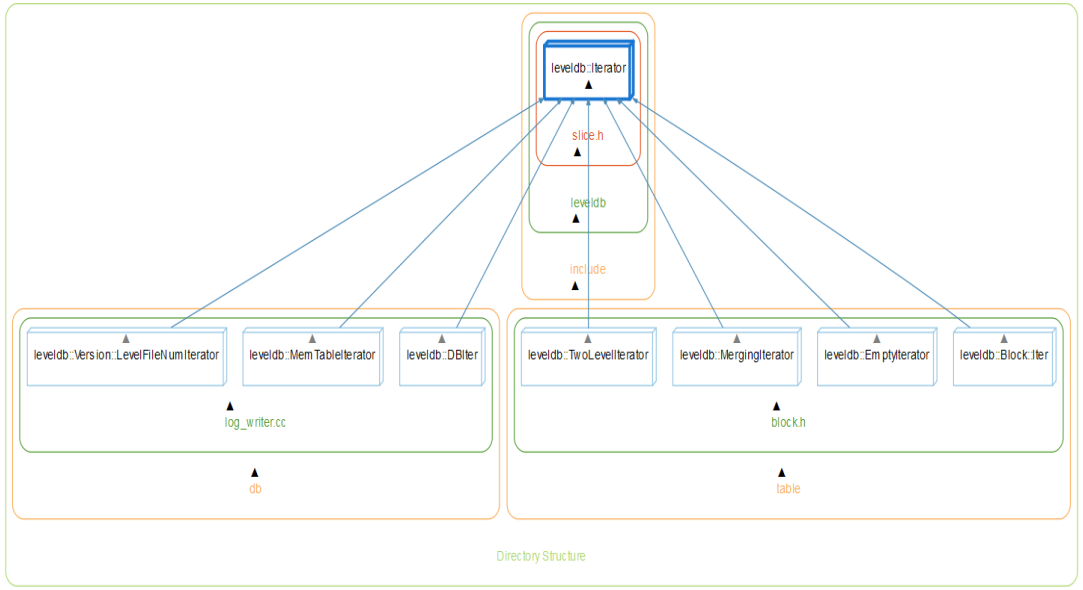
- Understand by SciTools
  - https://www.scitools.com/ (ENG.)
  - https://www.slexn.com/understand/ (KOR.)



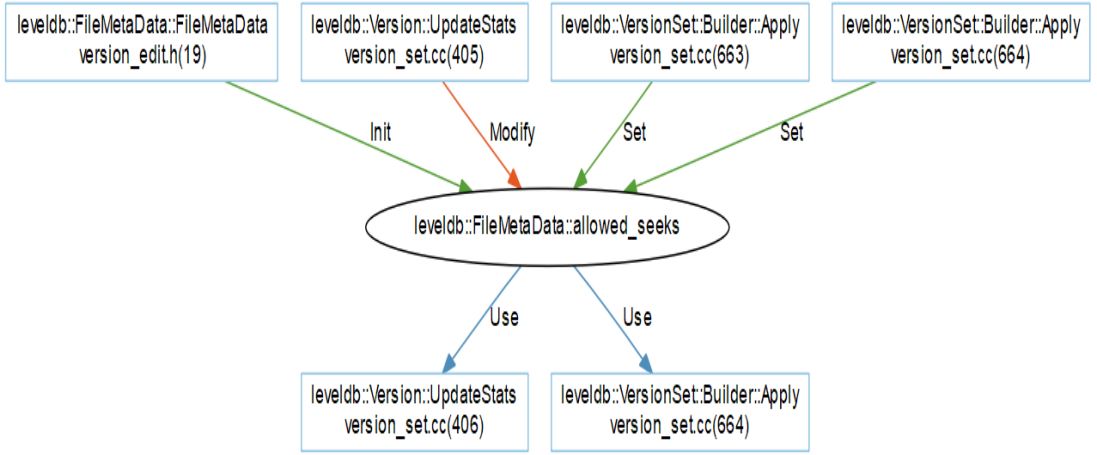
- Static analysis tool
  - understanding of complex open-source code
  - Graphing
    - code dependencies, code flows, function calls, and more

Understand

- LevelDB example



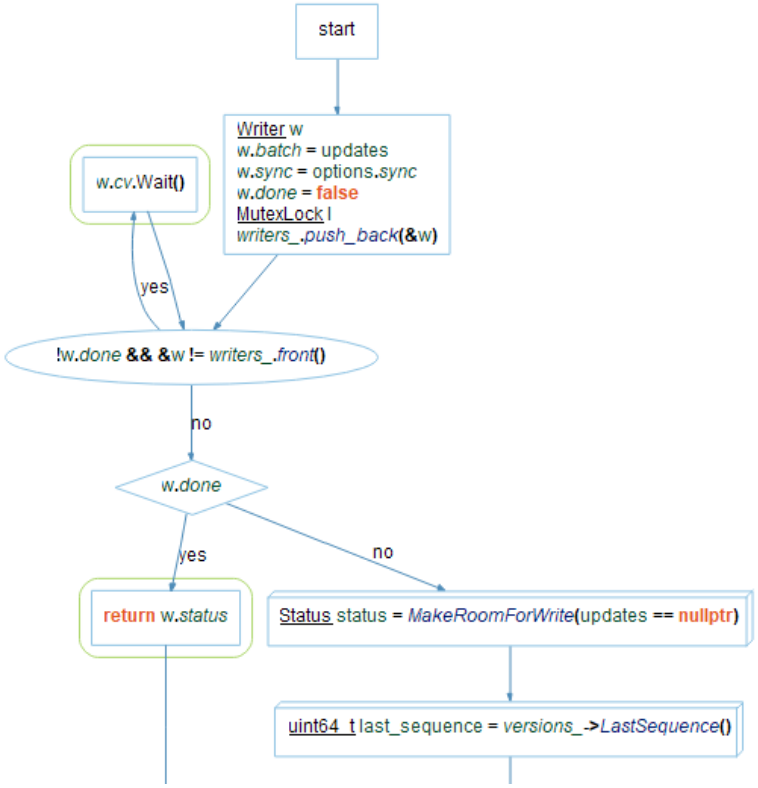
UML Class Diagram: Iterator



Object References

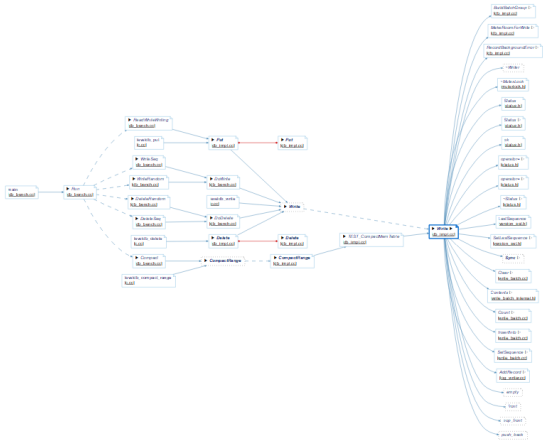
Understand

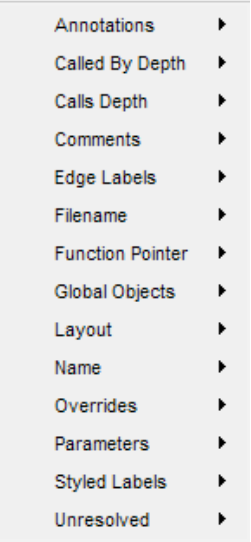
- LevelDB example
  - Control flow: db_impl.cc:Write
    - suggest to read code using VS code
    - Use “Go to Definition” (F12)

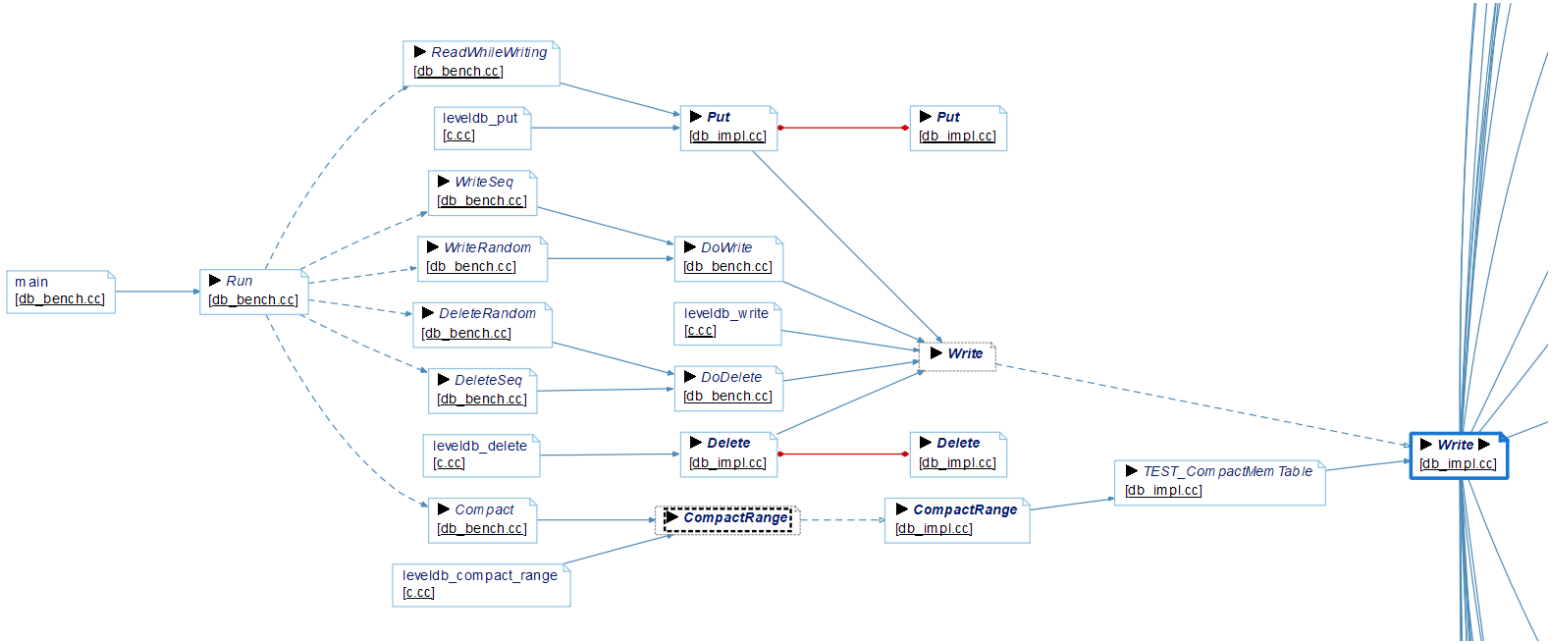


Understand

- LevelDB example
  - Butterfly: db_impl.cc:Get
    - Calls, called by

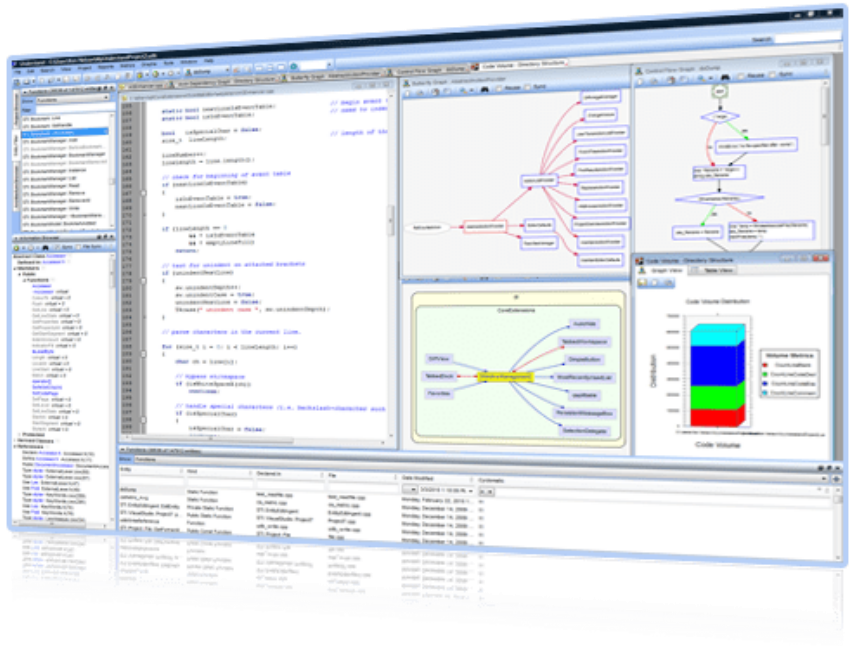






Understand

- How to install
  - Register with university email
    - https://licensing.scitools.com/register
  - Free trial link
    - https://www.scitools.com/pricing
  - Download link
    - https://licensing.scitools.com/download



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Understand

- How to use understand?
  - https://support.scitools.com/support/solutions

General (12)

- Does Understand run on Windows 11?
- Maximizing Performance on a Large Code Base
- Using Understand from the Command Line …
- Information Browser
- Git Integration

View all 12

Videos (19)

- Context Menu Video
- Graph Overview Video
- Architecture Designer Video
- Introduction to Understand
- Creating a New Project From Source

View all 19

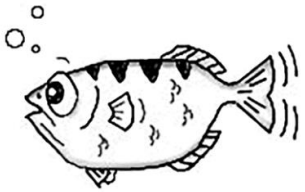
Graphs (8)

- Graph for Assignments and Assigned By
- What's Changed with Graphs in 6.1?
- UML Class Diagram
- UML Sequence Diagram
- Cluster Graph Styles

View all 8

- GDB
  - ✓ Introduction
  - ✓ Command
  - ✓ Example
    - Compaction Merge Iterator

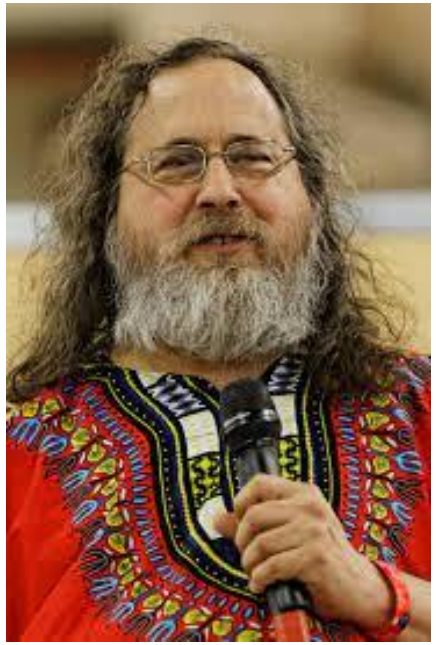
gdb



GDB
The GNU Project Debugger

- What is GDB?
  - GNU Project debugger
  - see what is going on `inside' another program while it executes
  - see what another program was doing at the moment it crashed.

- Key features
  - Start your program, specifying anything that might affect its behavior.
  - Make your program stop on specified conditions.
  - Examine what has happened, when your program has stopped.
  - Change things in your program, so you can experiment with correcting the effects of one bug and go on to learn about another.



GNU

gdb

- Run

  $ gdb <program>

  $ gdb --args <program> <arg1> <arg2> ...

- Break Point

>b <file_name>:<line>	> b <file_name>:<function>
>i b	>info break
>d <breakpoint #>	>delete <breakpoint #>
>en <breakpoint #>	>enable <breakpoint #>
>dis <breakpoint #>	>disable <breakpoint #>

gdb

- Process

  >r >run

  >c >continue

  >n >next

  >s >step

  >fin >finish

- Print

  >p <val> >print <val>

  >display <val>

  >info locals

  >info variables

  >info f

LevelDB Example: Merge Iterator

```
mingu@server:~/leveldb_release/build$ gdb --args ./db_bench --benchmarks="fillrandom"
GNU gdb (Ubuntu 9.2-0ubuntu1~20.04.1) 9.2
Copyright (C) 2020 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.
Type "show copying" and "show warranty" for details.
This GDB was configured as "x86_64-linux-gnu".
Type "show configuration" for configuration details.
For bug reporting instructions, please see:
<http://www.gnu.org/software/gdb/bugs/>.
Find the GDB manual and other documentation resources online at:
    <http://www.gnu.org/software/gdb/documentation/>.

For help, type "help".
Type "apropos word" to search for commands related to "word"...
Reading symbols from ./db_bench...
(gdb) b db_impl.cc:894
Breakpoint 1 at 0x12213: file /home/mingu/leveldb_release/db/db_impl.cc, line 894.
(gdb) i b
Num     Type           Disp Enb Address            What
1       breakpoint     keep y   0x0000000000012213 in leveldb::DBImpl::DoCompactionWork(leveldb::DBImpl::CompactionState*)
at /home/mingu/leveldb_release/db/db_impl.cc:894
(gdb)
```

Open file in Editor (Ctrl + Click)

LevelDB Example: Merge Iterator

```
(gdb) r
Starting program: /home/mingu/leveldb_release/build/db_bench --benchmarks=fillrandom
[Thread debugging using libthread_db enabled]
Using host libthread_db library "/lib/x86_64-linux-gnu/libthread_db.so.1".
LevelDB:    version 1.23
Date:       Fri Jul 15 15:57:24 2022
CPU:        16 * Intel(R) Core(TM) i7-10700K CPU @ 3.80GHz
CPUCache:   16384 KB
Keys:       16 bytes each
Values:     100 bytes each (50 bytes after compression)
Entries:    1000000
RawSize:    110.6 MB (estimated)
FileSize:   62.9 MB (estimated)
WARNING: Optimization is disabled: benchmarks unnecessarily slow
WARNING: Assertions are enabled; benchmarks unnecessarily slow
------------------------------------------------
[New Thread 0x7ffff79bd700 (LWP 7544)]
[New Thread 0x7ffff6eca700 (LWP 7545)]
[Switching to Thread 0x7ffff6eca700 (LWP 7545)]

Thread 3 "db_bench" hit Breakpoint 1, leveldb::DBImpl::DoCompactionWork (this=0x5555555dbc70, compact=0x7fffe8000c20)
    at /home/mingu/leveldb_release/db/db_impl.cc:894
894       int64_t imm_micros = 0;  // Micros spent doing imm_ compactions
(gdb)
```

LevelDB Example: Merge Iterator

```
1013        input->Next();
(gdb) s
leveldb::(anonymous namespace)::MergingIterator::Next (this=
    0x555555590fee <leveldb::(anonymous namespace)::TwoLevelIterator::value() const+96>)
    at /home/mingu/leveldb_release/table/merger.cc:55
55        void Next() override {
(gdb) n
56          assert(Valid());
(gdb)
63          if (direction_ != kForward) {
(gdb)
77          current_->Next();
(gdb)
78          FindSmallest();
(gdb) s
leveldb::(anonymous namespace)::MergingIterator::FindSmallest (
    this=0x555555590f8c <leveldb::(anonymous namespace)::TwoLevelIterator::key() const+96>)
    at /home/mingu/leveldb_release/table/merger.cc:148
148     void MergingIterator::FindSmallest() {
(gdb)
```

LevelDB Example: Merge Iterator

```
(gdb) display smallest
1: smallest = (leveldb::IteratorWrapper *) 0x0
(gdb) display child
2: child = (leveldb::IteratorWrapper *) 0x7fffe8010438
(gdb) n
150       for (int i = 0; i < n_; i++) {
1: smallest = (leveldb::IteratorWrapper *) 0x7fffe8010438
(gdb)
151         IteratorWrapper* child = &children_[i];
1: smallest = (leveldb::IteratorWrapper *) 0x7fffe8010438
2: child = (leveldb::IteratorWrapper *) 0x7fffe8010438
(gdb) display *smallest
3: *smallest = {iter_ = 0x7fffe8012110, valid_ = true, key_ = {
    data_ = 0x7fffe8012b70 '0' <repeats 13 times>, "198\001\225X\002", size_ = 24}}
(gdb) display *child
4: *child = {iter_ = 0x7fffe8012110, valid_ = true, key_ = {
    data_ = 0x7fffe8012b70 '0' <repeats 13 times>, "198\001\225X\002", size_ = 24}}
(gdb) n
152         if (child->Valid()) {
1: smallest = (leveldb::IteratorWrapper *) 0x7fffe8010438
2: child = (leveldb::IteratorWrapper *) 0x7fffe8010458
3: *smallest = {iter_ = 0x7fffe8012110, valid_ = true, key_ = {
    data_ = 0x7fffe8012b70 '0' <repeats 13 times>, "198\001\225X\002", size_ = 24}}
4: *child = {iter_ = 0x7fffe800ff50, valid_ = true, key_ = {
    data_ = 0x7fffe8012e30 '0' <repeats 14 times>, "40\001\213\206\001", size_ = 24}}
(gdb)
```

```
void MergingIterator::FindSmallest() {
  IteratorWrapper* smallest = nullptr;
  for (int i = 0; i < n_; i++) {
    IteratorWrapper* child = &children_[i];
    if (child->Valid()) {
      if (smallest == nullptr) {
        smallest = child;
      } else if (comparator_->Compare(child->key(),
        smallest = child;
      }
    }
  }
  current_ = smallest;
}
```

LevelDB Example: Merge Iterator

```
void MergingIterator::FindSmallest() {
  IteratorWrapper* smallest = nullptr;
  for (int i = 0; i < n_; i++) {
    IteratorWrapper* child = &children_[i];
    if (child->Valid()) {
      if (smallest == nullptr) {
        smallest = child;
      } else if (comparator_->Compare(child->key(),
        smallest = child;
      }
    }
  }
  current_ = smallest;
}
```

```
156             smallest = child;
3: *smallest = {iter_ = 0x7fffe800ff50, valid_ = true, key_ = {
    data_ = 0x7fffe8012e30 '0' <repeats 14 times>, "40\001\213\206\001", size_ = 24}}
4: *child = {iter_ = 0x7fffe80100a0, valid_ = true, key_ = {
    data_ = 0x7fffe800fa30 '0' <repeats 14 times>, "30\001\211\024\002", size_ = 24}}
(gdb)
150         for (int i = 0; i < n_; i++) {
3: *smallest = {iter_ = 0x7fffe80100a0, valid_ = true, key_ = {
    data_ = 0x7fffe800fa30 '0' <repeats 14 times>, "30\001\211\024\002", size_ = 24}}
```

LevelDB Example: Merge Iterator

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  IteratorWrapper* smallest = nullptr;
  for (int i = 0; i < n_; i++) {
    IteratorWrapper* child = &children_[i];
    if (child->Valid()) {
      if (smallest == nullptr) {
        smallest = child;
      } else if (comparator_->Compare(child->key(),
        smallest = child;
      }
    }
  }
  current_ = smallest;
}
```

```
160       current_ = smallest;
3: *smallest = {iter_ = 0x7fffe80100a0, valid_ = true, key_ = {
    data_ = 0x7fffe800fa30 '0' <repeats 14 times>, "30\001\211\024\002", size_ = 24}}
7: *current_ = {iter_ = 0x7fffe800ff50, valid_ = true, key_ = {
    data_ = 0x7fffe8012e30 '0' <repeats 14 times>, "40\001\213\206\001", size_ = 24}}
(gdb)
161     }
3: *smallest = {iter_ = 0x7fffe80100a0, valid_ = true, key_ = {
    data_ = 0x7fffe800fa30 '0' <repeats 14 times>, "30\001\211\024\002", size_ = 24}}
7: *current_ = {iter_ = 0x7fffe80100a0, valid_ = true, key_ = {
    data_ = 0x7fffe800fa30 '0' <repeats 14 times>, "30\001\211\024\002", size_ = 24}}
```

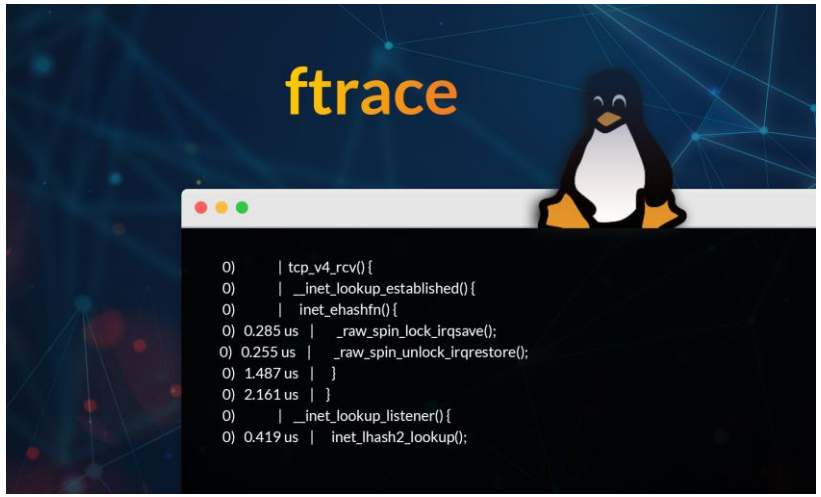
References

- KOR
  - gdb 디버거 사용법 및 다양한 기능 설명
    - https://edward0im.github.io/technology/2020/09/29/gdb/
  - gdb - 간단한 명령어/사용법/단축어 정리(cheat sheet)
    - https://dining-developer.tistory.com/13’

- Uftrace
  - ✓ Features
    - Record
    - Replay
    - Filter
    - TUI
  - ✓ Shell Script
  - ✓ Install

uftrace

- To trace and analyze execution of a program written in C/C++
- Heavily inspired by the ftrace framework of the Linux kernel
- Supports user-space programs and kernel
- Various kind of commands and filters



Features

- Record
  - Run a program and saves the trace data
- Replay
  - Show program execution in the trace data
- Graph/Tui
  - Show function call graph in the trace data
- Filter

Replay: Write()

```
# DURATION     TID     FUNCTION
            [  5471] | leveldb::DBImpl::Write() {
            [  5471] |   leveldb::DBImpl::Writer::Writer()
   0.030 us [  5471] |     leveldb::Status::Status();
            [  5471] |     leveldb::port::CondVar::CondVar
   0.164 us [  5471] |       std::condition_variable::cond
   0.296 us [  5471] |     } /* leveldb::port::CondVar::Co
   0.508 us [  5471] |   } /* leveldb::DBImpl::Writer::Wri
            [  5471] |   leveldb::MutexLock::MutexLock() {
            [  5471] |     leveldb::port::Mutex::Lock() {
            [  5471] |       std::mutex::lock() {
            [  5471] |         __gthread_mutex_lock() {
   0.040 us [  5471] |           __gthread_active_p();
   0.313 us [  5471] |           pthread_mutex_lock();
   1.758 us [  5471] |         } /* __gthread_mutex_lock */
   2.058 us [  5471] |       } /* std::mutex::lock */
   2.133 us [  5471] |     } /* leveldb::port::Mutex::Lock
   2.217 us [  5471] |   } /* leveldb::MutexLock::MutexLoc
            [  5471] |   std::deque::push_back() {
   0.029 us [  5471] |     std::move();
            [  5471] |     std::deque::emplace_back() {
   0.031 us [  5471] |       std::forward();
            [  5471] |       std::allocator_traits::constr
   0.029 us [  5471] |         std::forward();
```

- Record

  $ uftrace record ./db_bench benchmarks="fillrandom" \

  --num=100000

- Replay

  $ uftrace replay

  > /leveldb::DBImpl::Write

  $ uftrace replay –F leveldb::DBImpl::Write

Filter: Write()

```
# DURATION     TID     FUNCTION
            [  5471] | leveldb::DBImpl::Write() {
            [  5471] |   leveldb::DBImpl::Writer::Writer() {
   0.030 us [  5471] |     leveldb::Status::Status();
            [  5471] |     leveldb::port::CondVar::CondVar() {
   0.164 us [  5471] |       std::condition_variable::condition_variable();
   0.296 us [  5471] |     } /* leveldb::port::CondVar::CondVar */
   0.508 us [  5471] |   } /* leveldb::DBImpl::Writer::Writer */
            [  5471] |   leveldb::MutexLock::MutexLock() {
            [  5471] |     leveldb::port::Mutex::Lock() {
            [  5471] |       std::mutex::lock() {
            [  5471] |         __gthread_mutex_lock() {
   0.040 us [  5471] |           __gthread_active_p();
   0.313 us [  5471] |           pthread_mutex_lock();
   1.758 us [  5471] |         } /* __gthread_mutex_lock */
   2.058 us [  5471] |       } /* std::mutex::lock */
   2.133 us [  5471] |     } /* leveldb::port::Mutex::Lock */
   2.217 us [  5471] |   } /* leveldb::MutexLock::MutexLock */
            [  5471] |   std::deque::push_back() {
   0.029 us [  5471] |     std::move();
            [  5471] |     std::deque::emplace_back() {
   0.031 us [  5471] |       std::forward();
            [  5471] |       std::allocator_traits::construct() {
   0.029 us [  5471] |         std::forward();
```

No Filter

```
# DURATION     TID     FUNCTION
            [ 14234] | leveldb::DBImpl::Write() {
            [ 14234] |   leveldb::DBImpl::Writer::Writer() {
   0.311 us [ 14234] |     leveldb::port::CondVar::CondVar();
   0.493 us [ 14234] |   } /* leveldb::DBImpl::Writer::Writer */
   1.963 us [ 14234] |   leveldb::MutexLock::MutexLock();
            [ 14234] |   leveldb::DBImpl::MakeRoomForWrite() {
   0.262 us [ 14234] |     leveldb::VersionSet::NumLevelFiles();
   0.651 us [ 14234] |     leveldb::MemTable::ApproximateMemoryUsage();
   1.637 us [ 14234] |   } /* leveldb::DBImpl::MakeRoomForWrite */
   0.079 us [ 14234] |   leveldb::VersionSet::LastSequence();
            [ 14234] |   leveldb::DBImpl::BuildBatchGroup() {
   0.161 us [ 14234] |     leveldb::WriteBatchInternal::ByteSize();
   1.423 us [ 14234] |   } /* leveldb::DBImpl::BuildBatchGroup */
   0.315 us [ 14234] |   leveldb::WriteBatchInternal::SetSequence();
   0.221 us [ 14234] |   leveldb::WriteBatchInternal::Count();
   0.328 us [ 14234] |   leveldb::WriteBatchInternal::Contents();
            [ 14234] |   leveldb::log::Writer::AddRecord() {
            [ 14234] |     leveldb::log::Writer::EmitPhysicalRecord() {
   0.757 us [ 14234] |       leveldb::_GLOBAL__N_1::PosixWritableFile::Append();
   0.578 us [ 14234] |       leveldb::_GLOBAL__N_1::PosixWritableFile::Append();
```

Filter

Filiter

COMMON OPTIONS

-F *FUNC*, --filter=*FUNC* : Set filter to trace selected functions and their children functions. This option can be used more than once. See *FILTERS*.

-N *FUNC*, --notrace=*FUNC* : Set filter not to trace selected functions and their children functions. This option can be used more than once. See *FILTERS*.

-C *FUNC*, --caller-filter=*FUNC* : Set filter to trace callers of selected functions only. This option can be used more than once. See *FILTERS*.

-T *TRG*, --trigger=*TRG* : Set trigger on selected functions. This option can be used more than once. See *TRIGGERS*.

-D *DEPTH*, --depth *DEPTH* : Set trace limit in nesting level. See *FILTERS*.

-t *TIME*, --time-filter=*TIME* : Do not show functions which run under the time threshold. If some functions explicitly have the 'trace' trigger applied, those are always traced regardless of execution time. See *FILTERS*.

--no-libcall : Do not show library calls.

COMMON ANALYSIS OPTIONS

-H *FUNC*, --hide=*FUNC* : Set filter not to trace selected functions. It doesn't affect their subtrees, but hides only the given functions. This option can be used more than once. See *FILTERS*.

--kernel-full : Show all kernel functions and events occurred outside of user functions.

--kernel-only : Show kernel functions only without user functions.

--event-full : Show all (user) events outside of user functions.

--tid=*TID*[,*TID*,...] : Only print functions called by the given tasks. To see the list of tasks in the data file, you can use `uftrace report --task` or `uftrace info`. This option can also be used more than once.

[Uftrace/doc/uftrace-replay.md]

Tui: Write()

```
 TOTAL TIME : FUNCTION
  11.538  s : (1) db_bench
   5.502  s : (85352) leveldb::DBImpl::Write
  26.224 ms :  ├─(85352) leveldb::DBImpl::Writer::Writer
  12.326 ms :   (85352) leveldb::port::CondVar::CondVar
          :
  39.723 ms :  ├─(85352) leveldb::MutexLock::MutexLock
          :
  72.355 ms :  ├─(85352) leveldb::DBImpl::MakeRoomForWrite
  10.459 ms :     ├─(85358) leveldb::VersionSet::NumLevelFiles
          :     │
  16.385 ms :     ├─(85355) leveldb::MemTable::ApproximateMemoryUsage
          :     │
   0.090 us :     ├─(3) leveldb::VersionSet::PrevLogNumber
          :     │
   0.100 us :     ├─(3) leveldb::VersionSet::NewFileNumber
          :     │
   6.257 us :     ├─(3) leveldb::LogFileName
   5.965 us :      (3) leveldb::MakeFileName
          :     │
  71.581 us :     ├─(3) leveldb::_GLOBAL__N_1::PosixEnv::NewWritableFile
   8.899 us :      (3) leveldb::_GLOBAL__N_1::PosixWritableFile::PosixWritableFile
   0.103 us :       ├─(3) leveldb::WritableFile::WritableFile
          :       │
   4.749 us :       ├─(3) leveldb::_GLOBAL__N_1::PosixWritableFile::IsManifest
   2.985 us :        (3) leveldb::_GLOBAL__N_1::PosixWritableFile::Basename
          :       │
   2.038 us :       └─(3) leveldb::_GLOBAL__N_1::PosixWritableFile::Dirname
          :
   0.093 us :     ├─(3) leveldb::log::Writer::~Writer
          :     │
  10.424 us :     ├─(3) leveldb::_GLOBAL__N_1::PosixWritableFile::~PosixWritableFile
   8.303 us :      (3) leveldb::_GLOBAL__N_1::PosixWritableFile::~PosixWritableFile
   6.650 us :       ├─(3) leveldb::_GLOBAL__N_1::PosixWritableFile::Close
uftrace graph: session 241c4796d8967ad9 (/home/mingu/leveldb_release/build/db_bench)
```

- Tui
  - Back-trace
  - Call Graph

- Run uftrace

$ uftrace record ./db_bench – benchmarks=“fillrandom” \

--num=100000

$ uftrace tui

>/ leveldb::DBImpl::Write

>g

Tui: SkipList::Insert

```
          :========== Back-trace ==========
  5.188  s : (100000) leveldb::SkipList::Insert
  5.188  s : (100000) leveldb::MemTable::Add
  5.188  s : (100000) leveldb::_GLOBAL__N_1::MemTableInserter::Put
  5.188  s : (100000) leveldb::WriteBatch::Iterate
  5.188  s : (100000) leveldb::WriteBatchInternal::InsertInto
  5.188  s : (100000) leveldb::DBImpl::Write
  5.188  s : (100000) leveldb::Benchmark::DoWrite
  5.188  s : (100000) leveldb::Benchmark::WriteRandom
  5.188  s : (100000) leveldb::Benchmark::ThreadBody
          :
          :========== Call Graph ==========
  5.188  s : (100000) leveldb::SkipList::Insert
  4.824  s :  ├─(100000) leveldb::SkipList::FindGreaterOrEqual
 13.450 ms :  │  ├─(100000) leveldb::SkipList::GetMaxHeight
          :  │  │
473.144 ms :  │  ├─(2495692) leveldb::SkipList::Node::Next
          :  │  │
  4.121  s :  │  └─(2495692) leveldb::SkipList::KeyIsAfterNode
  3.903  s :  │    (2404364) leveldb::MemTable::KeyComparator::operator()
993.576 ms :  │    ├─(4808728) leveldb::GetLengthPrefixedSlice
          :  │    │
  2.544  s :  │    └─(2404364) leveldb::InternalKeyComparator::Compare
492.141 ms :  │      (2404364) leveldb::_GLOBAL__N_1::BytewiseComparatorImpl::Compare
          :  │
 25.035 ms :  ├─(100000) leveldb::SkipList::RandomHeight
 16.364 ms :  (133759) leveldb::Random::OneIn
  4.255 ms :  (133759) leveldb::Random::Next
          :
 11.891 ms :  ├─(100026) leveldb::SkipList::GetMaxHeight
          :
 30.790 ms :  ├─(100000) leveldb::SkipList::NewNode
  5.508 ms :  │  ├─(100000) leveldb::Arena::AllocateAligned
  1.455 ms :  │  (890) leveldb::Arena::AllocateFallback
  1.384 ms :  │  (890) leveldb::Arena::AllocateNewBlock
```

```
Help: (press any key to exit)

 ARROW        Navigation
 PgUp/Dn
 Home/End
 Enter        Fold/unfold graph or Select session
 G            Show (full) call graph
 g            Show call graph for this function
 R            Show uftrace report
 r            Show uftrace report for this function
 s            Sort by the next column in report
 I            Show uftrace info
 S            Change session
 O            Open editor
 c/e          Collapse/Expand direct children graph
 C/E          Collapse/Expand all descendant graph
 n/p          Next/Prev sibling
 u            Move up to parent
 l            Move to the longest executed child
 j/k          Move down/up
 z            Set current line to the center of screen
 /            Search
 </>/N/P      Search next/prev
 v            Show debug message
 f            Customize fields in graph or report mode
 h/?          Show this help
 q            Quit
```

Shell script

```
#!/bin/sh

default_func=""

if [ -z "$1" ]
then
    echo '[USAGE] : sh uft_cmd [COMMAND] [TARGET FUNC]'
    echo '[COMMAND] : replay, report, graph, tui'
    exit
fi

if [ -n "$2" ]
then
    func="-F ${2}"
else
    if [ -z "$default_func" ]
    then
        func=""
    else
        func="-F ${default_func}"
    fi
fi

uftrace $1 \
$func \
--no-libcall \
-N leveldb::MutexLock \
-N leveldb::ExtractUserKey \
-N leveldb::Arena::MemoryUsage \
-N __gthread_mutex_unlock \
-N __gthread_mutex_lock \
-N ^leveldb::Slice:: \
-N ^leveldb::port::Mutex \
-N ^leveldb::crc32c:: \
```

- Shell script
  - Easy to use filter
  - uftrace_script.sh

- Run Shell script

$ uftrace record ./db_bench benchmarks=“fillrandom” \

--num=100000

$ sh uftrace_script.sh replay

$ sh uftrace_script.sh tui

Install Guide

- Install uftrace
  - uftrace/INSTALL.md
    - https://github.com/namhyung/uftrace/blob/master/INSTALL.md
- Bind with leveldb
  - uftrace wiki – LevelDB/RocksDB (YCSB)
    - https://github.com/namhyung/uftrace/wiki/uftrace-for-LevelDB-RocksDB-with-YCSB
- Tutorial
  - https://uftrace.github.io/slide/#1
- Wiki
  - https://github.com/namhyung/uftrace/wiki

QUICK GUIDE

On Linux distros, following commands will build and install uftrace from source.

```
$ sudo misc/install-deps.sh    # optional for advanced features
$ ./configure                  # --prefix can be used to change install dir
$ make
$ sudo make install
```

namhyung / uftrace Public

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Code | Issues 254 | Pull requests 37 | Discussions | Actions | Wiki | Security | Insights

uftrace for LevelDB RocksDB with YCSB

Edit | New Page

Min-guk Choi edited this page 19 days ago · 6 revisions

This document is written by Min-guk Choi.

LevelDB

1. Download LevelDB

```
git clone --recurse-submodules https://github.com/google/leveldb.git
```

2. Add -pg option on leveldb/CMakeList.txt for uftrace

```
+ # Add -pg option for uftrace
+ set(CMAKE_CXX_FLAGS "${CMAKE_CXX_FLAGS} -pg")

if(CMAKE_CXX_COMPILER_ID STREQUAL "MSVC")
  # Disable C++ exceptions.
```

3. Build

Pages 37

- # Homework

✓ Submit your topic until 7/20 11AM

- Your team will be announced until 7/20 2PM
- Slack

✓ Upload presentation file through pull request

- until Tuesday, 7/26 11AM
- Title: [topic]benchmark_experiment.pdf
- PPT format: presentation.ppt

Choose your topic

Team Selection #3

Open **korea-choi** opened this issue 8 days ago · 14 comments

korea-choi commented 8 days ago Member

How's it going?

You will be divided into groups next week.
Each team will study one of the six internal topics as listed below:

1. WAL/Manifest
2. Memtable
3. Compaction
4. SSTable
5. Bloom Filter
6. Cache

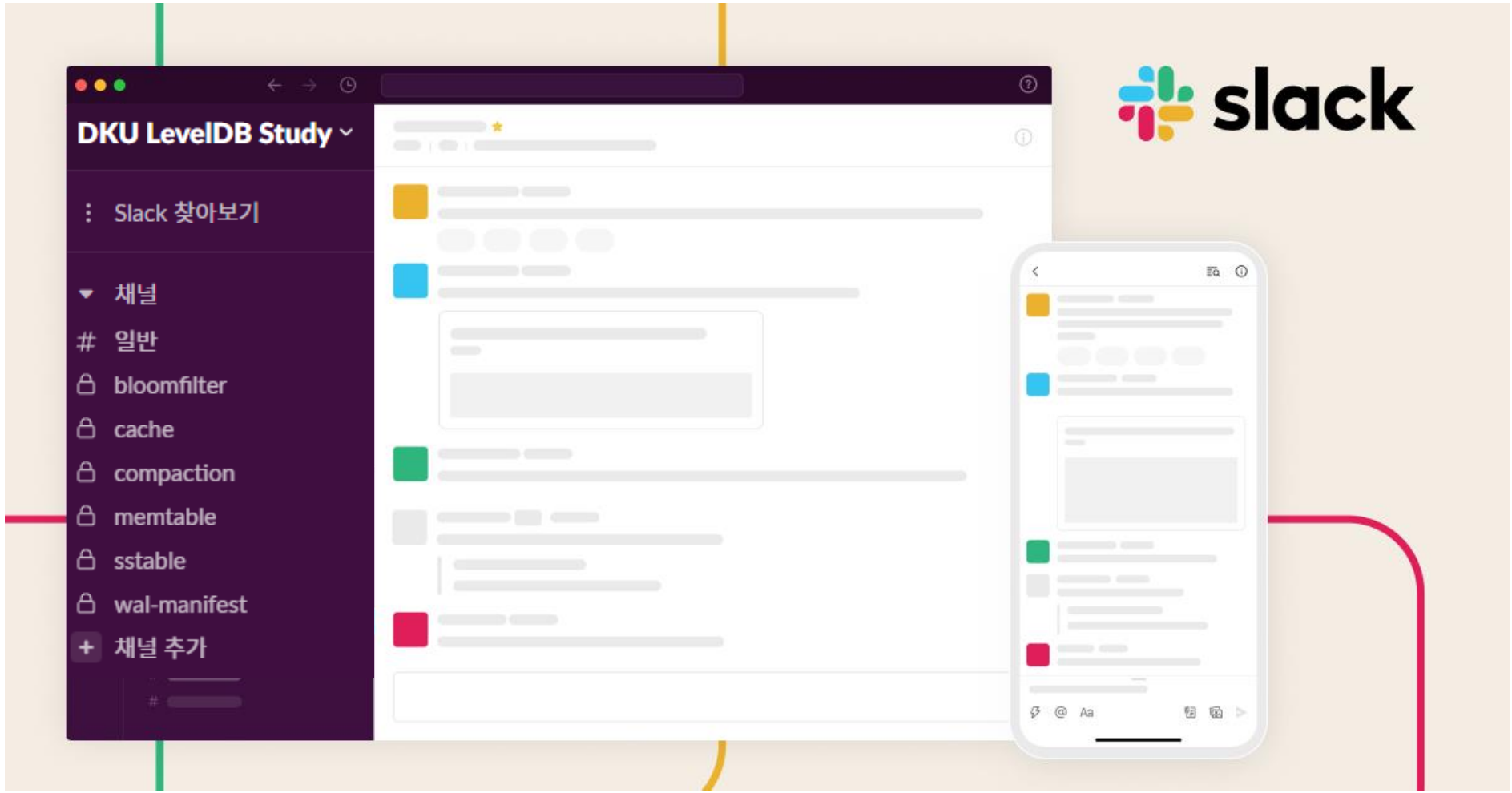
Submit your preferred topics in sorted order, starting with your most preferred topic.
Aside from your preferences, other factors will be considered in making the team to balance the teams with the available topics.

Please, write a comment until **7/13 11:00 AM**.
If you don't leave a comment, it will be assumed that you don't have any preferences.

See you next week!

https://github.com/DKU-StarLab/leveldb-study/issues/3

Slack


DKU LevelDB Study
Slack 찾아보기
채널
일반
bloomfilter
cache
compaction
memtable
sstable
wal-manifest
채널 추가
slack

Benchmark Experiment

Notice

- Upload your presentation file through pull reqeust.
  - Pull request until **Tuesday, 7/26 11AM**.
  - Title: [topic]benchmark_experiment.pdf
  - PPT format: presentation.ppt
- Upload your experiment document at DKU-StarLab/leveldb-wiki repository through pull reqeust.
  - Pull request until **Tuesday, 8/2 11AM**.
- Check previous study presentation files.
  - https://github.com/DKU-StarLab/RocksDB_Festival

https://github.com/DKU-StarLab/leveldb-study/blob/main/benchmarks/README.md

Benchmark Experiment

Topics / Benchmarks / Options

No	Topic	Benchmarks	Options	Result
1	WAL/Manifest	--disable_wal --wal_bytes_per_sync	fillseq/random readrandom	PPT
2	Memtable	--write_buffer_size --max_file_size	fillseq/random readrandom	PPT
3	Compaction	--base_background_compactions --compaction_style	fillseq/random readrandom	PPT
4	SSTable	--write_buffer_size --max_file_size --block_size	fillseq/random readseq/random seekrandom	PPT
5	Bloom Filter	--bloom_bits	readhot/random seekrandom	PPT
6	Cache	--cache_size --block_size	readhot/random seekrandom	PPT

https://github.com/DKU-StarLab/leveldb-study/blob/main/benchmarks/README.md

Thank you