

Lab 1: SimpleDB

布置日期: 2023/03/02

截止日期: 2023/03/19, 23:59:59

In the lab assignments

you will write a basic database management system called

SimpleDB. For this lab, you will focus on implementing the core

modules required to access stored data on disk; in future labs, you will add support for various query processing operators, as well as transactions, locking, and concurrent queries.

SimpleDB is written in Java. We have provided you with a set of

mostly unimplemented classes and interfaces. You will need to write the

code for these classes. We will grade your code by running a set of system tests written using [JUnit](#). We have

also provided a number of unit tests, which we will not use for grading but that you may find useful in verifying that your code works.

The remainder of this document describes the basic architecture of SimpleDB, gives some suggestions about how to start coding, and discusses how to hand in your lab.

We **strongly recommend** that you **start as early as possible** on this lab.

It requires you to write a fair amount of code!

0. Find bugs, be patient

SimpleDB is a relatively complex piece of code.

It is very possible you are going to find bugs, inconsistencies, and bad, outdated, or incorrect documentation, etc.

We ask you, therefore, to do this lab with an adventurous mindset. Don't get mad if something is not clear, or even wrong; rather, try to figure it out yourself or send us a friendly email. We promise to help out by posting bug fixes, new commits to the repo, etc., as bugs and issues are reported.

0. Environment Setup

Start by downloading the code for lab from the course GitLab repository [DBIS-NKU/SimpleDB](#). Then create a private repository called "SimpleDB" on GitLab and initialize the repository from the code.

Another way is using GitLab Import. Create a private repository called "SimpleDB" and import the code from the course GitLab repository [DBIS-NKU/SimpleDB](#).

These instructions are written for Athena or any other Unix-based platform (e.g., Linux, MacOS, etc.) Because the code is written in Java, it should work under Windows as well, although the directions in this document may not apply.

We have included [Section 1.2](#) on using the project with Eclipse.

1. Getting started

SimpleDB uses the [Ant build tool](#) to compile the code and run tests.

Ant is similar to [make](#), but

the build file is written in XML and is somewhat better suited to Java code.

Most modern Linux distributions include Ant. Under Athena,

it is included in the `sipb` locker, which you can

get to by typing `add sipb` at the Athena prompt. Note that

on some versions of Athena you must also run `add -f java` to set

the environment correctly for Java programs. See the

[Athena documentation](#)

[on using Java](#) for more details.

To help you during development, we have provided a set of unit tests in addition to the end-to-end tests that we use for grading. These are by no means comprehensive, and you should not rely on them exclusively to verify the correctness of your project.

To run the unit tests use the `test` build target:

```
$ cd [project-directory]
$ # run all unit tests
$ ant test
$ # run a specific unit test
$ ant runtest -Dtest=TupleTest
```

You should see output similar to:

```
build output...

test:
[junit] Running simpledb.CatalogTest
[junit] Testsuite: simpledb.CatalogTest
[junit] Tests run: 2, Failures: 0, Errors: 2, Time elapsed: 0.037 sec
[junit] Tests run: 2, Failures: 0, Errors: 2, Time elapsed: 0.037 sec

... stack traces and error reports ...
```

The output above indicates that two errors occurred during compilation; this is because the code we have given you doesn't yet work. As you complete parts of the lab, you will work towards passing additional unit tests.

If you wish to write new unit tests as you code, they should be added to the `test/simpledb` directory.

For more details about how to use Ant, see the [manual](<http://ant.apache.org/manual/>). The [Running Ant](<http://ant.apache.org/manual/running.html>) section provides details about using the `ant` command. However, the quick reference table below should be sufficient for working on the labs.

| Command | Description |
|--------------------------------|---|
| ant | Build the default target (for simpledb, this is dist). |
| ant -projecthelp | List all the targets in <code>build.xml</code> with descriptions. |
| ant dist | Compile the code in <code>src</code> and package it in <code>dist/simpledb.jar</code> . |
| ant test | Compile and run all the unit tests. |
| ant runtest -Dtest=testname | Run the unit test named <code>testname</code> . |
| ant systemtest | Compile and run all the system tests. |
| ant runsystest -Dtest=testname | Compile and run the system test named <code>testname</code> . |

If you are under windows system and don't want to run ant tests from command line, you can also run them from eclipse. Right click `build.xml`, in the targets tab, you can see "runtest" "runsystest" etc. For example, select runtest would be equivalent to "ant runtest" from command line.

Arguments such as "-Dtest=testname" can be specified in the "Main" Tab, "Arguments" textbox. Note

that you can also create a shortcut to runtest

by copying from build.xml, modifying targets and arguments and renaming it to, say, runtest_build.xml.

1.1. Running end-to-end tests

We have also provided a set of end-to-end tests that will eventually be used for grading. These tests are structured as JUnit tests that live in the `test/simplydb/systemtest` directory. To run all the system tests, use the `systemtest` build target:

```
$ ant systemtest
```

```
... build output ...
```

```
[junit] Testcase: testSmall took 0.017 sec
[junit]     Caused an ERROR
[junit] expected to find the following tuples:
[junit]     19128
[junit]
[junit] java.lang.AssertionError: expected to find the following tuples:
[junit]     19128
[junit]
[junit]     at simplydb.systemtest.SystemTestUtil.matchTuples(SystemTestUtil.java:122)
[junit]     at simplydb.systemtest.SystemTestUtil.matchTuples(SystemTestUtil.java:83)
[junit]     at simplydb.systemtest.SystemTestUtil.matchTuples(SystemTestUtil.java:75)
[junit]     at simplydb.systemtest.ScanTest.validateScan(ScanTest.java:30)
[junit]     at simplydb.systemtest.ScanTest.testSmall(ScanTest.java:40)
```

```
... more error messages ...
```

This indicates that this test failed, showing the stack trace where the error was detected. To debug, start by reading the source code where the error occurred. When the tests pass, you will see something like the following:

```
$ ant systemtest
```

```
... build output ...
```

```
[junit] Testsuite: simpledb.systemtest.ScanTest
[junit] Tests run: 3, Failures: 0, Errors: 0, Time elapsed: 7.278 sec
[junit] Tests run: 3, Failures: 0, Errors: 0, Time elapsed: 7.278 sec
[junit]
[junit] Testcase: testSmall took 0.937 sec
[junit] Testcase: testLarge took 5.276 sec
[junit] Testcase: testRandom took 1.049 sec
```

```
BUILD SUCCESSFUL
```

```
Total time: 52 seconds
```

1.1.1 Creating dummy tables

It is likely you'll want to create your own tests and your own data tables to test your own implementation of SimpleDB. You can create any `.txt` file and convert it to a `.dat` file in SimpleDB's `HeapFile` format using the command:

```
$ java -jar dist/simpledb.jar convert file.txt N
```

where `file.txt` is the name of the file and `N` is the number of columns in the file. Notice that `file.txt` has to be in the following format:

```
int1,int2,...,intN
int1,int2,...,intN
int1,int2,...,intN
int1,int2,...,intN
```

...where each `intN` is a non-negative integer.

To view the contents of a table, use the `print` command:

```
$ java -jar dist/simpledb.jar print file.dat N
```

where `file.dat` is the name of a table created with the `convert` command, and `N` is the number of columns in the file.

1.2. Working in Eclipse

[Eclipse](#) is a graphical software development environment that you might be more comfortable with working in. The instructions we provide were generated by using Eclipse 3.5.2 (Galileo) for Java Developers (not the enterprise edition) with Java 1.6.0_20 on Ubuntu 10.04 LTS. They should also work under Windows or on MacOS.

Setting the Lab Up in Eclipse

- Once Eclipse is installed, start it, and note that the first screen asks you to select a location for your workspace (we will refer to this directory as \$W). Select the directory containing your simple-db-hw repository.
- In Eclipse, select File->New->Project->Java->Java Project, and push Next.
- Enter "simple-db-hw" as the project name.
- On the same screen that you entered the project name, select "Create project from existing source," and browse to \$W/simple-db-hw.
- Click finish, and you should be able to see "simple-db-hw" as a new project in the Project Explorer tab on the left-hand side of your screen. Opening this project reveals the directory structure discussed above - implementation code can be found in "src," and unit tests and system tests found in "test."

Note: that this class assumes that you are using the official Oracle release of Java. This is the default on MacOS X, and for most Windows Eclipse installs; but many Linux distributions default to alternate Java runtimes (like OpenJDK). Please download the latest Java8 updates from [Oracle Website](#), and use that Java version. If you don't switch, you may see spurious test failures in some of the performance tests in later labs.

Running Individual Unit and System Tests

To run a unit test or system test (both are JUnit tests, and can be initialized the same way), go to the Package Explorer tab on the left side of your screen. Under the "simple-db-hw" project, open the "test" directory. Unit tests are found in the "simplifiedb" package, and system tests are found in the "simplifiedb.systemtests" package. To run one of these tests, select the test (they are all called *Test.java - don't select TestUtil.java or SystemTestUtil.java), right click on it, select "Run As," and select "JUnit Test." This will bring up a JUnit tab, which will tell you the status of the individual tests within the JUnit test suite, and will show you exceptions and other errors that will help you debug problems.

Running Ant Build Targets

If you want to run commands such as "ant test" or "ant systemtest," right click on build.xml in the Package Explorer. Select "Run As," and then "Ant Build..." (note: select the option with the ellipsis (...), otherwise you won't be presented with a set of build targets to run). Then, in the "Targets" tab of the next screen, check off the targets you want to run (probably "dist" and one of "test" or "systemtest"). This should run the build targets and show you the results in Eclipse's console window.

1.3. Implementation hints

Before beginning to write code, we **strongly encourage** you to read through this entire document to **get a feel for the high-level design of SimpleDB.**

You will need to fill in any piece of code that is not implemented. It will be obvious where we think you should write code. You may need to add private methods and/or helper classes. You may change APIs, but make sure our [grading](#grading) tests still run and make sure to mention, explain, and defend your decisions in your writeup.

In addition to the methods that you need to fill out for this lab, the class interfaces contain numerous methods that you need not implement until subsequent labs. These will either be indicated per class:

```
// Not necessary for lab1.  
public class Insert implements DbIterator {
```

or per method:

```
public boolean deleteTuple(Tuple t) throws DbException {  
    // some code goes here  
    // not necessary for lab1  
    return false;  
}
```

The code that you submit should compile without having to modify these methods.

We suggest **exercises along this document to guide your implementation,** but you may find that a different order makes more sense for you.

Here's a rough outline of one way you might proceed with your SimpleDB implementation:

- Implement the classes to manage tuples, namely Tuple, TupleDesc. We have already implemented Field, IntField, StringField, and Type for you. Since you only need to support integer and (fixed length) string fields and fixed length tuples, these are straightforward.
- Implement the Catalog (this should be very simple).
- Implement the BufferPool constructor and the getPage() method.
- Implement the access methods, HeapPage and HeapFile and associated ID classes. A good portion of these files has already been written for you.
- Implement the operator SeqScan.
- At this point, you should be able to pass the ScanTest system test, which is the goal for this lab.

Section 2 below walks you through these implementation steps and the unit tests corresponding to each one in more detail.

1.4. Transactions, locking, and recovery

As you look through the interfaces we have provided you, you will see a number of references to locking, transactions, and recovery. You do not need to support these features in this lab, but you should keep these parameters in the interfaces of your code because you will be implementing transactions and locking in a future lab. The test code we have provided you with generates a fake transaction ID that is passed into the operators of the query it runs; you should pass this transaction ID into other operators and the buffer pool.

2. SimpleDB Architecture and Implementation Guide

SimpleDB consists of:

- Classes that represent fields, tuples, and tuple schemas;
- Classes that apply predicates and conditions to tuples;
- One or more access methods (e.g., heap files) that store relations on disk and provide a way to iterate through tuples of those relations;
- A collection of operator classes (e.g., select, join, insert, delete, etc.) that process tuples;

- A buffer pool that caches active tuples and pages in memory and handles concurrency control and transactions (neither of which you need to worry about for this lab); and,
- A catalog that stores information about available tables and their schemas.

SimpleDB does not include many things that you may think of as being a part of a "database." In particular, SimpleDB **does not have:**

- Views.
- Data types except integers and fixed length strings.
- (In this lab), a SQL front end or parser that allows you to type queries directly into SimpleDB. Instead, queries are built up by chaining a set of operators together into a hand-built query plan (see [Section 2.7](#)). We will provide a simple parser for use in later labs.
- (In this lab) Query optimizer.
- (In this lab) Indices.

In the rest of this Section, we describe each of the main components of SimpleDB that you will need to implement in this lab. You should use the exercises in this discussion to guide your implementation. This document is by no means a complete specification for SimpleDB; you will need to make decisions about how to design and implement various parts of the system. Note that for Lab 1 you do not need to implement any operators (e.g., select, join, project) except sequential scan. You will add support for additional operators in future labs.

2.1. The Database Class

The Database class provides access to a collection of static objects that are the global state of the database. In particular, this **includes methods to access the catalog** (the list of all the tables in the database), **the buffer pool** (the collection of database file pages that are currently resident in memory), and **the log file**. You will not need to worry about the log file in this lab. We have implemented the Database class for you. You should take a look at this file as you will need to access these objects.

2.2. Fields and Tuples

Tuples in SimpleDB are quite basic. They consist of a collection of `Field`` objects, one per field in the `Tuple``. `Field`` is an interface that different data types (e.g., integer, string) implement. `Tuple`` objects are created by the underlying access methods (e.g., heap files, or B-trees), as described in the next section. Tuples also have a type (or schema), called a `_tuple descriptor_`, represented by a `TupleDesc`` object. This object consists of a collection of `Type`` objects, one per field in the tuple, each of which describes the type of the corresponding field.

Exercise 1

Implement the skeleton methods in:

- `src/simpliedb/TupleDesc.java`
- `src/simpliedb/Tuple.java`

At this point, your code should pass the unit tests `TupleTest` and `TupleDescTest`. At this point, `modifyRecordId()` should fail because you haven't implemented it yet.

2.3. Catalog

The catalog (class `Catalog` in `SimpleDB`) consists of a list of the tables and schemas of the tables that are currently in the database. You will need to support the ability to add a new table, as well as getting information about a particular table. Associated with each table is a `TupleDesc` object that allows operators to determine the types and number of fields in a table.

The global catalog is a single instance of `Catalog` that is allocated for the entire `SimpleDB` process. The global catalog can be retrieved via the method `Database.getCatalog()`, and the same goes for the global buffer pool (using `Database.getBufferPool()`).

Exercise 2

Implement the skeleton methods in:

- `src/simpliedb/Catalog.java`

At this point, your code should pass the unit tests in `CatalogTest`.

2.4. BufferPool

The buffer pool (class `BufferPool` in SimpleDB) is responsible for caching pages in memory that have been recently read from disk. All operators read and write pages from various files on disk through the buffer pool. It consists of a fixed number of pages, defined by the `numPages` parameter to the `BufferPool` constructor. In later labs, you will implement an eviction policy. For this lab, you only need to implement the constructor and the `BufferPool.getPage()` method used by the SeqScan operator. The BufferPool should store up to `numPages` pages. For this lab, if more than `numPages` requests are made for different pages, then instead of implementing an eviction policy, you may throw a `DbException`. In future labs you will be required to implement an eviction policy. The `Database` class provides a static method, `Database.getBufferPool()`, that returns a reference to the single BufferPool instance for the entire SimpleDB process.

Exercise 3

Implement the `getPage()` method in:

- `src/simplydb/BufferPool.java`

We have not provided unit tests for BufferPool. The functionality you implemented will be tested in the implementation of HeapFile below.

You should use the `DbFile.readPage` method to access pages of a DbFile.

Notice that `BufferPool` asks you to implement a `flush_all_pages()` method. This is not something you would ever need in a real implementation of a buffer pool. However, we need this method for testing purposes. You really should never call this method from anywhere in your code.

2.5. HeapFile access method

Access methods provide a way to read or write data from disk that is arranged in a specific way. Common access methods include heap files (unsorted files of tuples) and B-trees; for this assignment, you will only implement a heap file access method, and we have written some of the code for you.

A `HeapFile` object is arranged into a set of pages, each of which consists of a fixed number of bytes for storing tuples, (defined by the constant `BufferPool.DEFAULT_PAGE_SIZE`), including a header. In SimpleDB, there is one `HeapFile` object for each table in the database. Each page in a `HeapFile` is arranged as a set of slots, each of which can hold one tuple (tuples for a given table in SimpleDB are all of the same size). In addition to these slots, each page has a header that consists of a bitmap with one bit per tuple slot. If the bit corresponding to a particular tuple is 1, it indicates that the tuple is valid; if it is 0, the tuple is invalid (e.g., has been deleted or was never initialized.) Pages of `HeapFile` objects are of type `HeapPage` which implements the `Page` interface. Pages are stored in the buffer pool but are read and written by the `HeapFile` class.

SimpleDB stores heap files on disk in more or less the same format they are stored in memory. Each file consists of page data arranged consecutively on disk. Each page consists of one or more bytes representing the header, followed by the *page size* bytes of actual page content. Each tuple requires *tuple size* * 8 bits for its content and 1 bit for the header. Thus, the number of tuples that can fit in a single page is:

`_tuples per page_ = floor((_page size_ * 8) / (_tuple size_ * 8 + 1))`

Where `_tuple size_` is the size of a tuple in the page in bytes. The idea here is that each tuple requires one additional bit of storage in the header. We compute the number of bits in a page (by multiplying page size by 8), and divide this quantity by the number of bits in a tuple (including this extra header bit) to get the number of tuples per page. The floor operation rounds down to the nearest integer number of tuples (we don't want to store partial tuples on a page!)

Once we know the number of tuples per page, the number of bytes required to store the header is simply:

`headerBytes = ceiling(tupsPerPage/8)`

The ceiling operation rounds up to the nearest integer number of bytes (we never store less than a full byte of header information.)

The low (least significant) bits of each byte represents the status of the slots that are earlier in the file. Hence, the lowest bit of the first byte represents whether or not the first slot in the page is in use. The second lowest bit of the first byte represents whether or not the second slot in the page is in use, and so on. Also, note that the high-order bits of the last byte may not correspond to a slot that is actually in the file, since the number of slots may not be a multiple of 8. Also note that all Java virtual machines are [big-endian](<http://en.wikipedia.org/wiki/Endianness>).

Exercise 4

Implement the skeleton methods in:

- `src/simpliedb/HeapPageId.java`
- `src/simpliedb/RecordID.java`
- `src/simpliedb/HeapPage.java`

Although you will not use them directly in Lab 1, we ask you to implement `getNumEmptySlots()` and `isSlotUsed()` in `HeapPage`. These require pushing around bits in the page header. You may find it helpful to look at the other methods that have been provided in `HeapPage` or in `src/simpliedb/HeapFileEncoder.java` to understand the layout of pages.

You will also need to implement an iterator over the tuples in the page, which may involve an auxiliary class or data structure.

At this point, your code should pass the unit tests in `HeapPageIdTest`, `RecordIDTest`, and `HeapPageReadTest`.

After you have implemented `HeapPage`, you will write methods for `HeapFile` in this lab to calculate the number of pages in a file and to read a page from the file. You will then be able to fetch tuples from a file stored on disk.

Exercise 5

Implement the skeleton methods in:

- `src/simpliedb/HeapFile.java`

To read a page from disk, you will first need to calculate the correct offset in the file. Hint: you will need random access to the file in

order to read and write pages at arbitrary offsets. You should not call `BufferPool` methods when reading a page from disk.

You will also need to implement the `HeapFile.iterator()` method, which should iterate through the tuples of each page in the `HeapFile`. The iterator must use the `BufferPool.getPage()` method to access pages in the `HeapFile`. This method loads the page into the buffer pool and will eventually be used (in a later lab) to implement locking-based concurrency control and recovery. Do not load the entire table into memory on the `open()` call -- this will cause an out of memory error for very large tables.

At this point, your code should pass the unit tests in `HeapFileReadTest`.

2.6. Operators

Operators are responsible for the actual execution of the query plan. They implement the operations of the relational algebra. In SimpleDB, operators are iterator based; each operator implements the `DbFileIterator` interface.

Operators are connected together into a plan by passing lower-level operators into the constructors of higher-level operators, i.e., by 'chaining them together.' Special access method operators at the leaves of the plan are responsible for reading data from the disk (and hence do not have any operators below them).

At the top of the plan, the program interacting with SimpleDB simply calls `next` on the root operator; this operator then calls `next` on its children, and so on, until these leaf operators are called. They fetch tuples from disk and pass them up the tree (as return arguments to `next`); tuples propagate up the plan in this way until they are output at the root or combined or rejected by another operator in the plan.

For this lab, you will only need to implement one SimpleDB operator.

Exercise 6.

Implement the skeleton methods in:

- `src/simplydb/SeqScan.java`

This operator sequentially scans all of the tuples from the pages of the table specified by the `tableid` in the constructor. This operator should access tuples through the `DbFile.iterator()` method.

At this point, you should be able to complete the `ScanTest` system test. Good work!

You will fill in other operators in subsequent labs.

2.7. A simple query

The purpose of this section is to illustrate how these various components are connected together to process a simple query.

Suppose you have a data file, "some_data_file.txt", with the following contents:

```
1,1,1
2,2,2
3,4,4
```

You can convert this into a binary file that SimpleDB can query as follows:

```
``java -jar dist/simplydb.jar convert some_data_file.txt 3``
```

Here, the argument "3" tells convert that the input has 3 columns.

The following code implements a simple selection query over this file. This code is equivalent to the SQL statement ``SELECT * FROM some_data_file``.

```

package simplifiedb;
import java.io.*;

public class test {

    public static void main(String[] argv) {

        // construct a 3-column table schema
        Type types[] = new Type[]{ Type.INT_TYPE, Type.INT_TYPE, Type.INT_TYPE };
        String names[] = new String[]{ "field0", "field1", "field2" };
        TupleDesc descriptor = new TupleDesc(types, names);

        // create the table, associate it with some_data_file.dat
        // and tell the catalog about the schema of this table.
        HeapFile table1 = new HeapFile(new File("some_data_file.dat"), descriptor);
        Database.getCatalog().addTable(table1, "test");

        // construct the query: we use a simple SeqScan, which spoonfeeds
        // tuples via its iterator.
        TransactionId tid = new TransactionId();
        SeqScan f = new SeqScan(tid, table1.getId());

        try {
            // and run it
            f.open();
            while (f.hasNext()) {
                Tuple tup = f.next();
                System.out.println(tup);
            }
            f.close();
            Database.getBufferPool().transactionComplete(tid);
        } catch (Exception e) {
            System.out.println ("Exception : " + e);
        }
    }
}

```

The table we create has three integer fields. To express this, we create a `TupleDesc` object and pass it an array of `Type` objects, and optionally an array of `String` field names. Once we have created this `TupleDesc`, we initialize a `HeapFile` object representing the table stored in `some_data_file.dat`. Once we have created the table, we add it to the catalog. If this were a database server that was already running, we would have this catalog information loaded. We need to load it explicitly to make this code self-contained.

Once we have finished initializing the database system, we create a query plan. Our plan consists only of the `SeqScan` operator that scans the tuples from disk. In general, these operators are instantiated with references to the appropriate table (in the case of `SeqScan`) or child operator (in the case of e.g. `Filter`). The test program then repeatedly calls `hasNext` and `next` on the `SeqScan` operator. As tuples are output from the `SeqScan`, they are printed out on the command line.

We **strongly recommend** you try this out as a fun end-to-end test that will help you get experience writing your own test programs for `simplifiedb`. You should create the file `"test.java"` in the `src/simplifiedb` directory with the code above, and place the `some_data_file.dat` file in the top level directory. Then run:

```
ant
java -classpath dist/simplifiedb.jar simplifiedb.test
```

Note that `ant` compiles `test.java` and generates a new jarfile that contains it.

3. Logistics

3.1. Submitting your assignment

You may submit your code multiple times; we will use the latest version you submit that arrives before the deadline (before 11:59 PM on the due date).

Place the write-up in a file called `学号+姓名+Lab1.txt` or

`学号+姓名+Lab1.pdf` in the top level of your `SimpleDB` directory. **Important:**

In order for your write-up to be added to the git repo, you need to explicitly add it:

```
$ git add 学号+姓名+Lab1.txt
```

You also need to explicitly add any other files you create, such as new `*.java` files.

The criteria for your lab being submitted on time is that your code must be **tagged** and

pushed by the date and time. This means that if one of the TAs or the instructor were to open up GitLab, they would be able to see your solutions on the GitLab web page.

Just because your code has been committed on your local machine does not mean that it has been **submitted**; it needs to be on GitLab.

There is a bash script `turnInLab1.sh` in the root level directory of SimpleDB that commits your changes, deletes any prior tag for the current lab, tags the current commit, and pushes the branch and tag to GitLab. If you are using **Linux or Mac OSX**, you should be able to run the following:

```
$ ./turnInLab1.sh
```

You should see something like the following output:

```
$ ./turnInLab1.sh
[master b155ba0] Lab 1
1 file changed, 1 insertion(+)
Deleted tag 'lab1' (was b26abd0)
To git@gitlab.com:DBIS-NKU/SimpleDB.git
- [deleted]          lab1
Counting objects: 11, done.
Delta compression using up to 4 threads.
Compressing objects: 100% (4/4), done.
Writing objects: 100% (6/6), 448 bytes | 0 bytes/s, done.
Total 6 (delta 3), reused 0 (delta 0)
To git@gitlab.com:DBIS-NKU/SimpleDB.git
   ae31bce..b155ba0  master -> master
Counting objects: 1, done.
Writing objects: 100% (1/1), 152 bytes | 0 bytes/s, done.
Total 1 (delta 0), reused 0 (delta 0)
To git@gitlab.com:DBIS-NKU/SimpleDB.git
* [new tag]          lab1 -> lab1
```

If the above command worked for you, you can skip to item 6 below. If not, submit your solutions for lab 1 as follows:

1. Look at your current repository status.

```
$ git status
```

2. Add and commit your code changes (if they aren't already added and committed).

```
$ git commit -a -m 'Lab 1'
```

3. Delete any prior local and remote tag (*this will return an error if you have not tagged previously; this allows you to submit multiple times*)

```
$ git tag -d lab1
$ git push origin :refs/tags/lab1
```

4. Tag your last commit as the lab to be graded

```
$ git tag -a lab1 -m 'lab1'
```

5. This is the most important part: **push** your solutions to GitLab.

```
$ git push origin master
$ git push origin lab1
```

6. The last thing that we strongly recommend you do is to go to GitLab to make sure that your solutions has been uploaded.

Word of Caution

Git is a distributed version control system. This means everything operates offline until you run `git pull` or `git push`. This is a great feature.

The bad thing is that you may forget to `git push` your changes. This is why we strongly, **strongly** suggest that you check GitLab to be sure that what you want us to see matches up with what you expect.

3.2. 分数组成

在跑测试代码的时候，我们会从 GitLab 上拉取大家提交后的代码，并将 `build.xml` 测试代码替换成最初的版本。如果你对程序的 API 做了任何改动导致无法通过测试，一定要在作业报告和代码讲解的过程中主动提出来。

- 50% 源代码（通过测试，代码风格）
- 10% Git Commit History（截图放在报告中）
- 20% 作业报告（思考题，设计思路，重难点，改动部分）
- 20% 代码讲解

代码讲解有期中和期末两次，安排在 lab2 和 lab4 完成后的一周内，到时候会提前通知大家预约时间。

3.3. 提交说明

邀请助教加入到私有仓库。进入 GitLab 项目主页，左侧边栏 Project information -> Members -> 右上角蓝色按钮 Invite members -> GitLab member or email address 中填写 xhyzsd03@163.com，点击右下角 Invite 按钮即可邀请助教加入到项目当中。

源代码直接把项目打包并命名为“学号_姓名_lab1.zip”，报告导出 pdf 并命名为“学号_姓名_lab1.pdf”，发送到邮箱 xuhongyuan@dbis.nankai.edu.cn，邮件的主题为“数据库上机作业_学号_姓名_lab1”。（此邮箱对主题包含“数据库上机作业”开启自动回复）

代码 push 到 GitLab 的截止时间为3月19日周日23:59:59，代码和报告发送到邮箱的截止时间为3月20日周一23:59:59。晚交的同学会酌情扣分。