CS307 Project Part II

Basic Information

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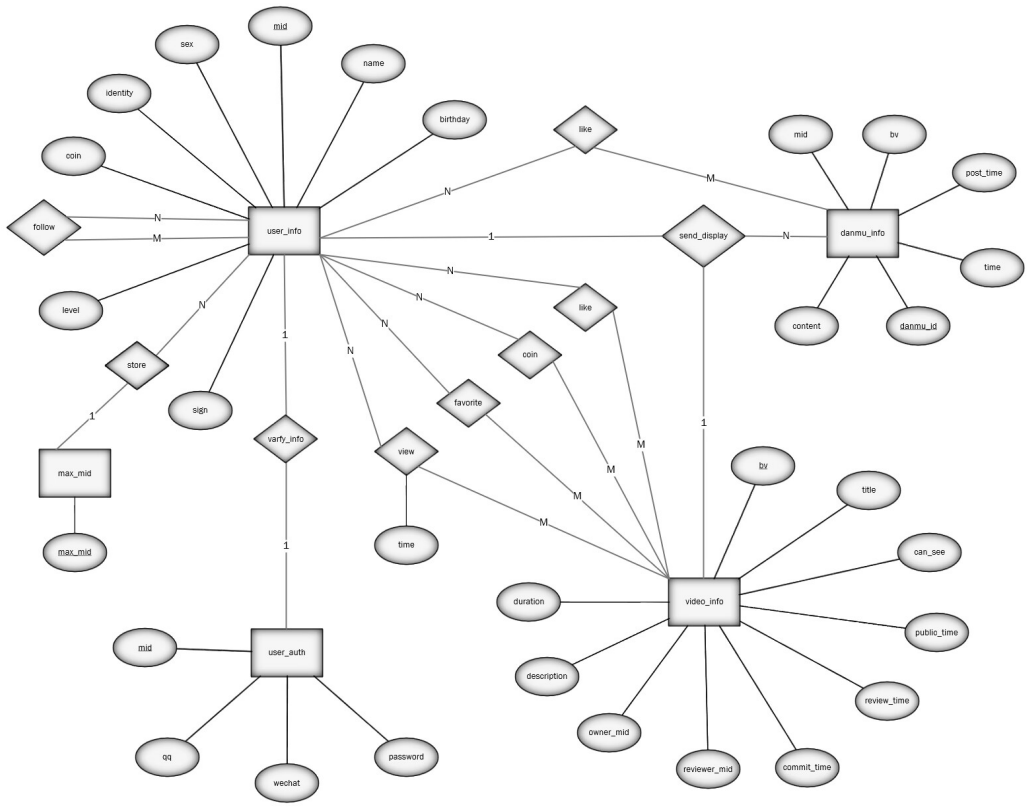
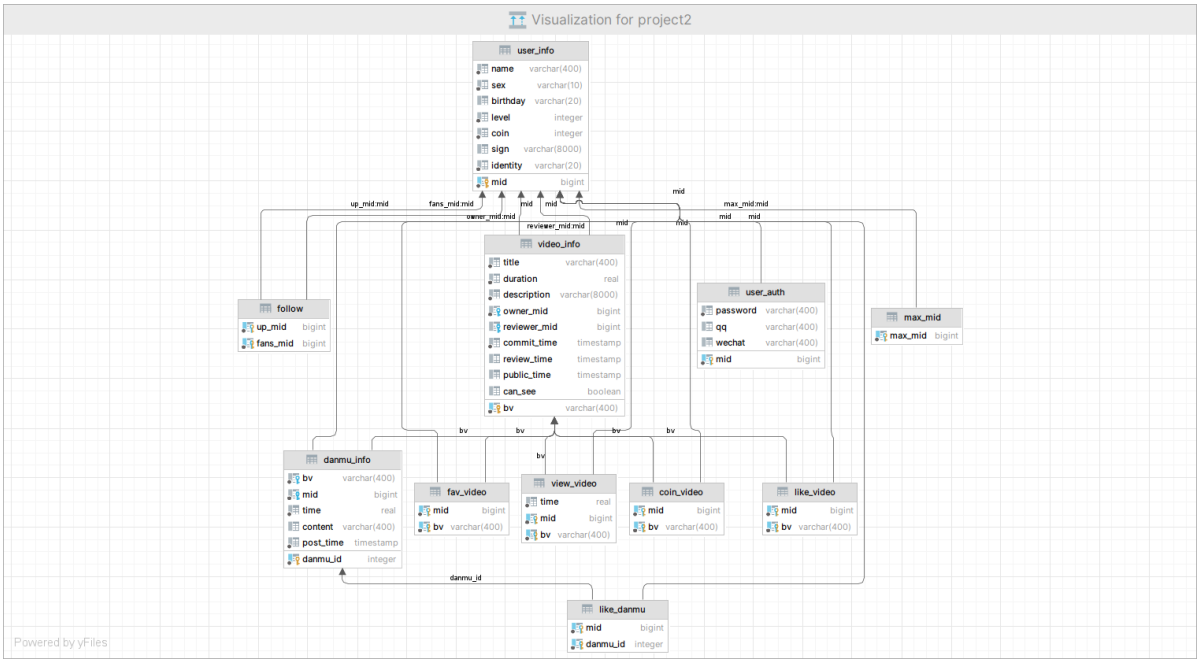
Contribution of work
袁龙: E-R diagram, UserService and DanmuSercive implementation
于斯瑶: RecommenderService and DatabaseSercive implementation, password encryption
赵钊: Database Design, Table Creation, VideoService implementation, BV algorithm

Database Design

1. E-R Diagram



2. Database Diagram by DataGrip



3. Table Design Description

We design **11** tables for this project, **10** of them are basic tables and others are help tables to increase efficiency. A brief description of each table is as follows.

The 10 tables as below are basic tables.

user_info: contains 8 columns of basic information of a user

user_auth: contains 4 columns of authentic information of a user

follow: `up_mid` and `fans_mid` is the mid of follower and followee

video_info: contains 10 basic columns (including `bv`, `title`, `duration`, `description`, `owner_mid`, `reviewer_mid`, `commit_time`, `review_time`, `public_time`) of information of a video

like_video: 2 columns `mid` and `bv` is the mid and bv of the user and the video be liked, also has a constraint `primary key (bv, mid)`

coin_video, **fav_video** and **view_video** is the same as **like_video**, but **view_video** contains an extra column `time`, which records where did the user watch in the video

danmu_info: has a self increasing primary key `danmu_id`, and other 5 columns (including `bv`, `mid`, `time`, `content` and `post_time`) of basic information of a danmu

like_danmu: records a user (with mid `mid`) liked a danmu (with id `danmu_id`)

The 1 table as below are help tables mentioned above.

max_id: records the max value of `mid` exists now, in order to increase the efficiency of register a new user (we only need to use (`max_mid` + 1) to be the new user's mid)

4. Database Privilege

The user has been used in this project is called `manager`, and the database we used in this project is called `project2`. The user `manager` has privilege to access to all tables and do select, insert, update, delete and truncate operations of schema `public` in database `project2`. Here are the sql statement to create user `manager`:

```
create user manager with password '123456';
grant connect on database project2 to manager;
grant usage on schema public to manager;
grant select, insert, update, delete, truncate on all tables in schema public to
manager;
```

Basic API Specification

At first, we create a class called `Authenticaiton` and there exists a static method call `authentication(AuthInfo auth, DataSource datasource)` to verify if the user's authentic information can login or not.

DatabaseServiceImpl.java

There are 3 methods to implement in this interface.

```
public List<Integer> getGroupMembers()
```

This method returns a list contain group members' student ID.

```
public void importData(
    List<DanmuRecord> danmuRecords,
    List<UserRecord> userRecords,
    List<VideoRecord> videoRecords
)
```

This method inserts data through batch processing.

The set value is 1000, and the quantity of each batch can be modified by the variable `public static int BATCH_SIZE`.

In the subsequent report, we optimized this insertion by using multi-threading, and the decision to use faster insertion can be determined by the variable `public static boolean USE_FASTER_IMPORT`.

```
public void truncate()
```

This method truncates all tables.

UserServiceImpl.java

There are 4 methods to implement in this interface.

```
long register(RegisterUserReq req);
```

Firstly, check whether the `RegisterUserReq` is valid. if not, return -1.

If the check is passed, query the max_mid in `max_mid,` and use it add 1 to generate the mid of the new user. Then insert the information into `user_info` and `user_auth` successively. Meanwhile, update the max_mid in `max_mid`.

```
boolean deleteAccount(AuthInfo auth, long mid);
```

First verify if the `AuthInfo` is valid or not. If not, return false.

Then search if there exists the user relating to the mid. If not, return false.

If both the user that initiated the command and the deleted user are the same or the identity of initiator is `superuser` as well as the deleted user is just `user`, it will be deleted successfully.

```
boolean follow(AuthInfo auth, long followeeMid);
```

First verify if the `AuthInfo` is valid or not. If not, return false.

Then search if there exists the user relating to the followeeMid. If not, return false.

If the user has followed the followeemid when performing this operation, it will be deleted from `follow`. On the contrary, it will be inserted.

```
UserInfoResp getUserInfo(long mid);
```

Firstly, search if there exists the user relating to the mid. If not, return null.

Then use sql query statements to obtain the information and return all needed information.

VideoServiceImpl.java

There are 10 methods to implement in this interface.

```
String postVideo(AuthInfo auth, PostVideoReq req);
```

First verify if the `AuthInfo` is valid or not. If not, return null.

Then check whether the `PostVideoReq` is valid. If not, return null.

If the check are passed, then generate a unique bv for the video and insert data into table `video_info` of database `project2`. **We have an efficient algorithm (which is detailed explained in Implement Optimize) to generate bv and we ensure that all bv are unique.**

```
boolean deleteVideo(AuthInfo auth, String bv);
```

First verify if the `AuthInfo` is valid or not. If not, return false.

Then search if there exists the video relating to bv. If not, return false.

If the user is the owner of the video or the user's identity is superuser, then delete the video from table `video_info` of database `project2` and return true.

```
boolean updateVideoInfo(AuthInfo auth, String bv, PostVideoReq req);
```

First verify if the `AuthInfo` and `PostVideoReq` is valid or not. If not, return false.

Then search if there exists the video relating to bv. If not, return false.

If all the check are passed, update the information of video in table `video_info` and return true.

```
List<String> searchVideo(AuthInfo auth, String keywords, int pageSize, int
pageNum);
```

First verify if the `AuthInfo` is valid or not. If not, return null.

Then search if there exists the video relating to bv. If not, return null.

Use two `HashMap` to record the count of matched keywords and count of view of each video. Sort them according to the sorting rule and return the list.

```
double getAverageViewRate(String bv);
```

First search if there exists the video relating to bv. If not, return -1.

Then calculate every view rate of the view and calculate the average of them then return.

```
Set<Integer> getHotspot(String bv);
```

First, check for the corner cases. If happened, return empty set.

Then search each danmu of this video and record which spot it belongs.

At last, get which hotspots has the max number of danmu and return.

```
boolean reviewVideo(AuthInfo auth, String bv);
```

If corner cases happened, false will returned.

If all the check passed, the video will be marked as reviewed through change column `can_see` to true. And the columns `reviewer_mid` and `review_time` will be update.

```
boolean coinVideo(AuthInfo auth, String bv);
boolean likeVideo(AuthInfo auth, String bv);
boolean collectVideo(AuthInfo auth, String bv);
```

These 3 methods are almost same. But `coinVideo(AuthInfo auth, String bv)` need to check and update the number of coin.

If corner cases happened, return false.

If all the checks passed, a new record will be insert into `coin_video` or `like_video` or `fav_video`.

DanmuServiceImpl.java

There are 3 methods to implement in this interface.

```
long sendDanmu(AuthInfo auth, String bv, String content, float time);
```

If any corner cases happened, return -1.

If all the checks passed, insert all the information into `danmu_info` and return the new danmu_id.

```
List<Long> displayDanmu(String bv, float timeStart, float timeEnd, boolean
filter);
```

If any corner cases happened, return null.

If all the checks passed, judge whether it's filter. If not, just display all danmu in this video between the given time. On the contrary, use sql statement to filter out the same danmu while retaining the earliest.

```
boolean likeDanmu(AuthInfo auth, long id);
```

First verify if the `AuthInfo` is valid or not. If not, return false.

Then search whether the id exists and whether the user watched the video where the danmu is. If not, return false.

If the user has liked the danmu when performing this operation, it will be deleted from `like_danmu`. On the contrary, it will be inserted.

RecommenderServiceImpl.java

There are 3 methods to implement in this interface.

```
public List<String> recommendNextVideo(String bv)
```

This method recommends five videos based on the common viewers of the current video and other videos.

First, we check if the input is valid. If the video does not exist in the visible videos, return null.

Then, we use SQL to find videos that have common viewers with it, sort them, and return the top five.

```
public List<String> generalRecommendations(int pageSize, int pageNum)
```

This method recommends videos based on video scores.

First, we check if the input is valid. If not, return null.

Then we use SQL to query the scores of each video, specifically querying the ratio of likes, coins, favorites, bullet comments, and completion. Then we add them together.

It is worth noting that there are many data points where the video has not been watched but has received likes, etc., so we do not consider this part of the data. We only consider the actions performed on videos that have been watched.

Last, we return the required videos' bv as a `list`.

```
public List<String> recommendVideosForUser(AuthInfo auth, int pageSize, int
pageNum)
```

This method is based on interests, specifically the videos watched by friends, to recommend videos.

First, we check if the input is valid. If not, return null.

Next, we use SQL queries to check if the user has any friends. If they don't, we call `generalRecommendations(int pageSize, int pageNum)`.

Then, we use SQL queries to find videos that at least one friend has watched, and then we sort them to return the required videos' bv as a `list`.

```
public List<Long> recommendFriends(AuthInfo auth, int pageSize, int pageNum)
```

This method recommends other users to a specific user based on their mutual following with the user's friends.

First, we check if the input is valid. If not, return null.

Then, we use SQL to find the users who followed same users with this user, but are not followed by this user. The users are then sorted and returned as a `list` of mid.

Implement Optimize

1. Optimization of Import Data

We use multi-thread to improve the efficiency of import data. **Found that the number of follow, like a video, coin a video, collect a video, view a video, like a danmu is very large**, so in the tables related to these, we use multi-thread improve.

Take insert into table `follow` as an example. The method `insertInFollow(List<UserRecord> userRecords)` below is the method deal with it.

```
private void insertInFollow(List<UserRecord> userRecords) {
    int nThread = Math.min((int) Math.sqrt(userRecords.size()), 8);
    ExecutorService executorService = Executors.newFixedThreadPool(nThread);
    try {
        int dealData = 0;
        int ONE_THREAD_DEAL = userRecords.size() / nThread + 1;
        int threads = 0;
        List<UserRecord> users = new ArrayList<>();
        // ---- divide the data into 8 threads ----
        for (int k = 0; k < userRecords.size(); k++) {
```

```
            users.add(userRecords.get(k));
            dealData++;
            if (dealData % ONE_THREAD_DEAL == 0) {
                CThread c = new CThread(users);
                executorService.execute(c);
                users = new ArrayList<>();
            }
        }
        CThread c = new CThread(users);
        executorService.execute(c);
        executorService.shutdown();
        try {
            executorService.awaitTermination(10, TimeUnit.MINUTES);
        } catch (InterruptedException e) {
            e.printStackTrace();
        }
    } catch (Exception e) {
        e.printStackTrace();
        executorService.shutdown();
    }
}
```

Because the provided DataSource with annotation `@Autowired` is HikariDataSource. **Its maximum connection is 8, so we use 8 threads to insert record.** We use ExecutorService to manage our threads instead of manage it manually. The class `CThread` extended `Thread` and its method `run()` controls JDBC to insert data into the tables of database.

After divide data into 8 threads, the thread pool execute and shutdown. In order to block the main thread, we add a method `awaitTermination(10, TimeUnit.MINUTES)`. **If we do not block the main thread, the main thread will continue and other connection will be applied and this will cause exception.**

We test the time cost of import data before optimize and after optimize **each for 5 times**, the result is as follow. **The efficiency is improved about 221%.**

Test No.	1	2	3	4	5	avg
before optimize	14m25s	12m54s	13m8s	13m39s	14m17s	13m41s
after optimize	7m25s	5m18s	6m3s	5m46s	6m15s	6m10s

2. Password Protection

To enhance out system's security, we encryption the password then insert them into database. **If someone intrusion the database and steal all the records, he can directly know everyone's password, which is very dangerous.** So we should encryption the password then insert them into database. Then comes a problem, how should we encryption the password.

At first, we think we can use a one-to-one function (denote as *f*), then we insert *f(password)* into database, and when we want to check `AuthInfo`, we calculate *g(password after encryption)* (*g* is the inverse function of *f*). In cryptography, this is called symmetric cryptography, which means the message sender and receiver share the same secret key for both encryption and decryption. **But**

this is not security enough, because the encryption process can be inverse so if someone know only one side's secret key, the password will be decipher.

Then, there comes an idea. **We can use irreversible encryption.** We assign a hash function and when the password is inserted into database, we call this hash function and insert the result after encipher. When we want to check whether the `AuthInfo` is valid or not, we call this hash function again and compare the result of the password the user gives after encipher to the account's password after encipher in the database. This is much safer than the first method.

In cryptography, the is a concept called **salt**, which means the process of adding salt by inserting a specific string at any fixed position in the password, so that the hash result does not match the hash result using the original password. Usually, when a field is hashed (such as MD5), a hash value is generated, and the hashed value cannot be obtained by a specific algorithm to obtain the original field. **However, in some cases, such as a large rainbow table, searching for the MD5 value in the table may very quickly find the true field content corresponding to the hash value.** The hashed value after salt addition can greatly reduce the risk of password leakage caused by user data theft. Even if the original content corresponding to the hashed value is found through the rainbow table, the characters inserted after salt addition can interfere with the real password, greatly reducing the probability of obtaining the real password.

```
public static final long[] BASE = {1, 257, 66049, 197425, 406721, 718570, 123642,
318804, 143934, 290983, 333948, 890223, 198397, 656525, 955245, 131883, 339595,
244356, 933685, 882401};
public static final long MOD_A = 1048573;
public static final long MOD_B = 2147483647;
public static String hash(String str, long mid) {
    long result = str.charAt(0);
    for (int i = 1; i < str.length(); i++) result = (str.charAt(i) * BASE[i] %
MOD_A + result) % MOD_A;
    return Long.toString(Long.parseLong(result + Long.toString(mid % MOD_A)) %
MOD_B);
}
```

The code show forward is out hash function. In our project, we directly append a decimal number at the end of an account's password. In order to try to make the salt be different and evenly distributed, we choose a mod `MOD_A = 1048573` (a prime number), and the `mid` of the user mod `MOD_A` will be the salt. Because ASCII has 255 chars, so we choose a prime 257 to be the base we encipher password. The array `BASE` is the pretreatment 257 power array mod `MOD_A`.

However, this encryption still has **two sets** of duplicates when importing into the database, indicating that hash collisions have occurred. This reflects the possibility of brute-force attacks on the passwords.

```
public static final long MOD_A = 1048573;
public static final BigInteger MOD_C = new BigInteger("9223372036854775783");
public static String MD5SaltHash(String str, long mid) {
    return new BigInteger(DigestUtils.md5Hex(str) + mid % MOD_A,
16).mod(MOD_C).toString();
}
```

The above code encrypts the string using MD5, then concatenates it with a salt value obtained from the `mid` parameter, and finally applies the modulo operation with a prime number `MOD_C = 9223372036854775783` which close to 2^63 to generate a string that is stored in the database. By querying, **it is known that this method does not have any hash function compared to the first encryption method which had two duplicate passwords.** This further reduces the likelihood of collisions and lowers the risk of password leakage.

3. BV Generating Algorithm

This algorithm is inspired by link1, link2.

We have designed an algorithm to **generate a new video's bv and this can effectively avoiding bv collision**. Every video has a field called av, and this is a **unique** (every video's av are different) long number. And there is a relationship between a video's av and bv (which means for a video, av and bv can mutually transformation), the transformation method is as follow.

```
private static final String key =
"fZodR9XQDSUm21yCkr6zBqiveYah8bt4xsWpHnJE7jL5VG3guMTKNPAwcF";
private static final int[] pos = {11, 10, 3, 8, 4, 6};
private static final long xorNum = 177451812;
private static final long minusNum = 8728348608L;

private static long bv2av(String bv) {
    long num = 0;
    for (int i = 0; i < pos.length; i++)
        num = (long) (num + key.indexOf(bv.charAt(pos[i])) * Math.pow(58, i));
    return (num - minusNum) ^ xorNum;
}

private static String av2bv(long av) {
    av = (av ^ xorNum) + minusNum;
    String[] tmp = "BV1  4 1 7  ".split("");
    for (int i = 0; i < pos.length; i++)
        tmp[pos[i]] = key.split("")[(int) (av / Math.pow(58, i) % 58)];
    return String.join("", tmp);
}
```

When we want to create a new bv, we get all the exist videos' bv and trasform them into av. Then find the maximum of existed av, the new video's av would be max_av + 1, **this promise the uniqueness of av**. Next convert the new video's av to bv and the new video's bv has been generated.

Then we explain our transformation algorithm. Choose transform bv to av as an example (the transformation of av to bv is just a reverse process). The bv of a video must be "BV" at beginning and another 10 digits after. Assuming the highest bit is the 0th bit and the lowest bit is the 9th bit, then the 0th bit must be 1, the 3rd bit must be 4, the 5th bit must be 1, and the 7th bit must be 7. Namely, **bv's last 10 digits must be "1xx4x1x7xx"**, these known digits did not participate in the calculation of av number. **f, Z, o, d, R, 9, X, Q, D, S, U, m, 2,1, y, C, k, r, 6, z, B, q, i, v, e, Y, a, h, 8, b, t, 4, x, s, W, p, H, n, J, E, 7, j, L, 5, V, G, 3, g, u, M, T, K, N, P, A, w, c, F represent the 58 base expressed in the range of 0 to 57, respectively.** This is called a confusion table, the table is as follow.

1	2	3	4	5	6	7	8	9
13	12	46	31	43	18	40	28	5
A	B	C	D	E	F	G	H	I
54	20	15	8	39	57	45	36	/
J	K	L	M	N	O	P	Q	R
38	51	42	49	52	/	53	7	4
S	T	U	V	W	X	Y	Z	
9	50	10	44	34	6	25	1	
a	b	c	d	e	f	g	h	i
26	29	56	3	24	0	47	27	22
j	k	l	m	n	o	p	q	r
41	16	/	11	37	2	35	21	17
s	t	u	v	w	x	y	z	
33	30	48	23	55	32	14	19	

Then replace each number in the bv number with a decimal representation of the number. The only truly useful ones are positions 1, 2, 4, 6, 8, and 9. Then calculate a 10 base number s use the following formula.

$$(s)_{10} = (\overline{bv[4], bv[2], bv[6], bv[1], bv[8], bv[9]})_{58}$$

Finally, subtract the constant 8728348608 from s, and the result obtained is XOR with 77451812. The result is represented as a decimal number, which is the av.