

# 作业三

## 一、实验目的

通过使用 Java API，实现hadoop、hbase的常见操作，包括在**Hadoop**分布式文件管理系统上创建文件、删除文件、上传文件、读取文件内容，在**Hbase**分布式数据库上创建表、列族、插入删除数据等，从而加深对分布式计算框架和分布式数据库的理解和应用能力。

## 二、实验环境

- 操作系统: Ubuntu 22.04 LTS
- 虚拟机: UTM
- 集群节点: 1 个 master 节点, 2 个 slave 节点 (slave1, slave2)
- 网络配置: 静态 IP 地址
- 软件版本:
  - Hadoop: 2.7.1
  - Hbase: 1.2.1
  - zookeeper: 3.4.10
  - jdk: 1.8.0\_151

## 三、hdfs和hbase任务

### 3.1 使用Java API操作hdfs

所有操作都统一在一个源文件中 `Hdfsop.java` 中实现后编译，并打包成jar包，运行方法为：

```
java -cp $(hadoop classpath):. Hdfsop <命令> <参数1> [参数2]
```

例如: `java -cp $(hadoop classpath):. Hdfsop create /user/lfl/java/create.txt "hello hdfs"`

```
lfl@master:~/JavaAPI$ javac -cp $(hadoop classpath) Hdfsop.java
```

```
lfl@master:~/JavaAPI$ ls
```

```
Hdfsop.class Hdfsop.java
```

```
hello hdfs lfl@master:~$ jar cfe Hdfsop.jar Hdfsop Hdfsop.class
```

```
lfl@master:~/JavaAPI$ ls
```

```
Hdfsop.class Hdfsop.jar Hdfsop.java
```

#### 3.1.1 在hdfs上创建文件

```

1 // 创建文件          Hadoop文件系统      文件路径      文件内容
2 public static void createFile(FileSystem fs, String hdfsPath, String content) throws
Exception {
3     // 将字符串路径包装成 Hadoop 的 Path 对象
4     Path path = new Path(hdfsPath);
5
6     // 使用 try-with-resources 确保流会被自动关闭
7     try (OutputStream out = fs.create(path)) {
8         out.write(content.getBytes());
9         System.out.println("文件已创建: " + hdfsPath);
10    }
11 }

```

运行结果：

```

lfl@master:~/JavaAPI$ java -cp $(hadoop classpath):: Hdfsop create /user/lfl/java/create.txt "hello hdfs"
25/09/11 15:47:45 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using builtin-
java classes where applicable
文件已创建: /user/lfl/java/create.txt
lfl@master:~/JavaAPI$ hdfs dfs -cat /user/lfl/java/create.txt
hello hdfs
lfl@master:~/JavaAPI$ 

```

## Browse Directory

/user/lfl/java								Go!
Permission	Owner	Group	Size	Last Modified	Replication	Block Size	Name	
-rw-r--r--	lfl	supergroup	10 B	2025/9/11 15:47:51	2	128 MB	create.txt	

### 3.1.2 删除hdfs上的文件

```

1 // 删除文件
2 public static void deleteFile(FileSystem fs, String hdfsPath) throws Exception {
3     Path path = new Path(hdfsPath);
4     if (fs.exists(path)) {
5         fs.delete(path, true);
6         System.out.println("文件已删除: " + hdfsPath);
7     } else {
8         System.out.println("文件不存在: " + hdfsPath);
9     }
10 }

```

运行结果：

```

lfl@master:~/JavaAPI$ hadoop jar Hdfsop.jar delete /user/lfl/java/create.txt
文件已删除: /user/lfl/java/create.txt
lfl@master:~/JavaAPI$ hdfs dfs -ls /user/lfl/java
lfl@master:~/JavaAPI$ 

```

## Browse Directory

/user/lfl/java

Go!

Permission	Owner	Group	Size	Last Modified	Replication	Block Size	Name
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### 3.1.3 上传文件至hdfs

```
1 // 上传本地文件
2 public static void uploadFile(FileSystem fs, String localPath, String hdfsPath) throws
Exception {
3     Path src = new Path(localPath);
4     Path dst = new Path(hdfsPath);
5     fs.copyFromLocalFile(src, dst);
6     System.out.println("文件已上传: " + localPath + " -> " + hdfsPath);
7 }
```

在本地上创建文件 upload.txt

```
lfl@master:~/JavaAPI$ vi upload.txt
lfl@master:~/JavaAPI$ ls
Hdfsop.class  Hdfsop.jar  Hdfsop.java  upload.txt
```

运行结果：

```
lfl@master:~/JavaAPI$ hadoop jar Hdfsop.jar upload upload.txt /user/lfl/java/upload.txt
文件已上传: upload.txt -> /user/lfl/java/upload.txt
lfl@master:~/JavaAPI$ hdfs dfs -cat /user/lfl/java/upload.txt
Upload success!

lfl@master:~/JavaAPI$
```

### 3.1.4 读取文件内容

```
1 // 读取 HDFS 文件
2 public static void readFile(FileSystem fs, String hdfsPath) throws Exception {
3     Path path = new Path(hdfsPath);
4     if (!fs.exists(path)) {
5         System.out.println("文件不存在: " + hdfsPath);
6         return;
7     }
8     try (BufferedReader br = new BufferedReader(new InputStreamReader(fs.open(path)))) {
9         System.out.println("文件内容:");
10        String line;
11        while ((line = br.readLine()) != null) {
12            System.out.println(line);
13        }
14    }
15 }
```

运行结果：

```
lfl@master:~/JavaAPI$ hadoop jar Hdfsop.jar read /user/lfl/java/upload.txt
文件内容：
Upload success!
```

```
lfl@master:~/JavaAPI$
```

### 3.1.5 完整代码

```
1 import org.apache.hadoop.conf.Configuration;
2 import org.apache.hadoop.fs.FileSystem;
3 import org.apache.hadoop.fs.Path;
4 import java.io.*;
5
6 public class Hdfsop {
7
8     // 创建文件
9     public static void createFile(FileSystem fs, String hdfsPath, String content)
10    throws Exception {
11         Path path = new Path(hdfsPath);
12         try (OutputStream out = fs.create(path)) {
13             out.write(content.getBytes());
14             System.out.println("文件已创建: " + hdfsPath);
15         }
16     }
17
18     // 删除文件
19     public static void deleteFile(FileSystem fs, String hdfsPath) throws Exception {
20         Path path = new Path(hdfsPath);
21         if (fs.exists(path)) {
22             fs.delete(path, true);
23             System.out.println("文件已删除: " + hdfsPath);
24         } else {
25             System.out.println("文件不存在: " + hdfsPath);
26         }
27     }
28
29     // 上传本地文件
30     public static void uploadFile(FileSystem fs, String localPath, String hdfsPath)
31    throws Exception {
32         Path src = new Path(localPath);
33         Path dst = new Path(hdfsPath);
34         fs.copyFromLocalFile(src, dst);
35         System.out.println("文件已上传: " + localPath + " -> " + hdfsPath);
36     }
37
38     // 读取 HDFS 文件
39     public static void readFile(FileSystem fs, String hdfsPath) throws Exception {
40         Path path = new Path(hdfsPath);
41         if (!fs.exists(path)) {
```

```
40             System.out.println("文件不存在: " + hdfsPath);
41         }
42     }
43     try (BufferedReader br = new BufferedReader(new
44 InputStreamReader(fs.open(path)))) {
45         System.out.println("文件内容:");
46         String line;
47         while ((line = br.readLine()) != null) {
48             System.out.println(line);
49         }
50     }
51
52     public static void main(String[] args) throws Exception {
53         if (args.length < 1) {
54             System.out.println("用法: java Hdfsop <command> [args...]");
55             System.out.println("命令列表:");
56             System.out.println("  create <hdfsPath> <content>");
57             System.out.println("  delete <hdfsPath>");
58             System.out.println("  upload <localPath> <hdfsPath>");
59             System.out.println("  read <hdfsPath>");
60             System.exit(1);
61     }
62
63     Configuration conf = new Configuration();
64     conf.set("fs.defaultFS", "hdfs://master:9000");
65     FileSystem fs = FileSystem.get(conf);
66
67     String command = args[0];
68     switch (command) {
69         case "create":
70             if (args.length != 3) {
71                 System.out.println("用法: create <hdfsPath> <content>");
72                 return;
73             }
74             createFile(fs, args[1], args[2]);
75             break;
76
77         case "delete":
78             if (args.length != 2) {
79                 System.out.println("用法: delete <hdfsPath>");
80                 return;
81             }
82             deleteFile(fs, args[1]);
83             break;
84
85         case "upload":
86             if (args.length != 3) {
87                 System.out.println("用法: upload <localPath> <hdfsPath>");
88                 return;
89             }
90             uploadFile(fs, args[1], args[2]);
```

```

91             break;
92
93         case "read":
94             if (args.length != 2) {
95                 System.out.println("用法: read <hdfsPath>");
96                 return;
97             }
98             readFile(fs, args[1]);
99             break;
100
101     default:
102         System.out.println("未知命令: " + command);
103     }
104
105     fs.close();
106 }
107 }
108

```

## 3.2 使用Java API操作hbase

所有操作都统一在一个源文件中 `HBBaseop.java` 中实现后编译，并打包成jar包，运行方法为：

```
java -cp "$(hbase classpath):$(hadoop classpath):HBBaseop.jar" HBBaseop <命令> <参数1> [参数2]
```

例如：`java -cp "$(hbase classpath):$(hadoop classpath):HBBaseop.jar" HBBaseop createTable student info score`

```

lfl@master:~/JavaAPI$ ls
HBBaseop.java Hdfsop.class Hdfsop.jar Hdfsop.java upload.txt
lfl@master:~/JavaAPI$ javac -cp "$(hbase classpath):$(hadoop classpath)" HBBaseop.java
lfl@master:~/JavaAPI$ sudo vi MANIFEST.MF
lfl@master:~/JavaAPI$ jar cfm HBBaseop.jar MANIFEST.MF HBBaseop.class
lfl@master:~/JavaAPI$ ls
HBBaseop.class HBBaseop.jar HBBaseop.java Hdfsop.class Hdfsop.jar Hdfsop.java MANIFEST.MF upload.txt
lfl@master:~/JavaAPI$ 

```

### 3.2.1 创建表、列族

```

1  public static void createTable(Admin admin, String tableName, String... familyNames)
2  throws Exception {
3
4     TableName tName = TableName.valueOf(tableName);
5
6     if (admin.tableExists(tName)) {
7         System.out.println("表已存在: " + tableName);
8         return;
9     }
10
11    HTableDescriptor tableDescriptor = new HTableDescriptor(tName);
12
13    for (String family : familyNames) {
14        HColumnDescriptor columnDescriptor = new HColumnDescriptor(family);
15
16        tableDescriptor.addFamily(columnDescriptor);
17    }
18
19    admin.createTable(tableDescriptor);
20
21    System.out.println("表 " + tableName + " 创建成功");
22
23 }
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```

```

13     tableDescriptor.addFamily(columnDescriptor);
14 }
15
16 admin.createTable(tableDescriptor);
17 System.out.println("表已创建: " + tableName + ", 列族: " + String.join(",",
18 familyNames));
}

```

运行结果：

```
lfl@master:~/JavaAPI$ java -cp "$(hbase classpath):$(hadoop classpath):HBaseop.jar" HBaseop createTable student info score
表已创建: student, 列族: info,score
```

```
lfl@master:~/JavaAPI$ java -cp "$(hbase classpath):$(hadoop classpath):HBaseop.jar" HBaseop createTable course info
表已创建: course, 列族: info
```

访问<http://master:16010>查看创建的表信息：

The screenshot shows the HBase web interface with the following details:

- Header:** R P A C H E HBASE Home Table Details Local Logs Log Level Debug Dump Metrics Dump HBase Configuration
- User Tables:**

Table	Description
course	'course', {NAME => 'info', BLOOMFILTER => 'ROW', VERSIONS => '1', IN_MEMORY => 'false', KEEP_DELETED_CELLS => 'FALSE', DATA_BLOCK_ENCODING => 'NONE', TTL => 'FOREVER', COMPRESSION => 'NONE', MIN_VERSIONS => '0', BLOCKCACHE => 'true', BLOCKSIZE => '65536', REPLICATION_SCOPE => '0'}
student	'student', {NAME => 'info', BLOOMFILTER => 'ROW', VERSIONS => '1', IN_MEMORY => 'false', KEEP_DELETED_CELLS => 'FALSE', DATA_BLOCK_ENCODING => 'NONE', TTL => 'FOREVER', COMPRESSION => 'NONE', MIN_VERSIONS => '0', BLOCKCACHE => 'true', BLOCKSIZE => '65536', REPLICATION_SCOPE => '0'}, {NAME => 'score', BLOOMFILTER => 'ROW', VERSIONS => '1', IN_MEMORY => 'false', KEEP_DELETED_CELLS => 'FALSE', DATA_BLOCK_ENCODING => 'NONE', TTL => 'FOREVER', COMPRESSION => 'NONE', MIN_VERSIONS => '0', BLOCKCACHE => 'true', BLOCKSIZE => '65536', REPLICATION_SCOPE => '0'}

使用 `habse shell` 命令查看：

```
hbase(main):017:0> list
TABLE
course
student
2 row(s) in 0.2050 seconds

=> ["course", "student"]
hbase(main):018:0>
```

### 3.2.2 插入数据

```
1 public static void insertData(Connection connection, String tableName, String rowKey,
2                               String family, String column, String value) throws
Exception {
3     try (Table table = connection.getTable(TableName.valueOf(tableName))) {
4         Put put = new Put(Bytes.toBytes(rowKey));
5         put.addColumn(Bytes.toBytes(family), Bytes.toBytes(column), Bytes.toBytes(value));
6         table.put(put);
7         System.out.println("插入成功: " + rowKey + " -> " + family + ":" + column + "=" +
value);
8     }
9 }
```

运行结果：

在 student 表的列族 info 插入列 name，值为 Alice，键值为 1：

```
lfl@master:~/JavaAPI$ java -cp "$(hbase classpath):$(hadoop classpath):HBaseop.jar" HBaseop put student 1 info name Alice
```

插入成功: 1 -> info:name=Alice

在 student 表的列族 score 插入列 math , 值为 95 , 键值为 2 :

```
lfl@master:~/JavaAPI$ java -cp "$(hbase classpath):$(hadoop classpath):HBaseop.jar" HBaseop put student 1 info Age 18  
插入成功: 1 -> info:Age=18
```

同样插入多条数据后,使用 `hbase shell` 命令扫描全表:

```
hbase(main):018:0> scan 'student'
ROW                                              COLUMN+CELL
1                                                column=info:Age, timestamp=1758287688324, value=18
1                                                column=info:name, timestamp=1758287546003, value=Alice
1                                                column=score:math, timestamp=1758287981723, value=95
2                                                column=info:Age, timestamp=1758287894315, value=22
2                                                column=info:name, timestamp=1758287731320, value=Bob
2                                                column=score:math, timestamp=1758287988509, value=90
2 row(s) in 1.2550 seconds
```

## 查询数据

```
1 public static void getData(Connection connection, String tableName, String rowKey)
2     throws Exception {
3     try (Table table = connection.getTable(TableName.valueOf(tableName))) {
4         Get get = new Get(Bytes.toBytes(rowKey));
5         Result result = table.get(get);
6         if (result.isEmpty()) {
7             System.out.println("未找到数据: " + rowKey);
8         } else {
9             result.listCells().forEach(cell -> {
10                 String family = Bytes.toString(cell.getFamilyArray(), cell.getFamilyOffset(),
11                     cell.getFamilyLength());
12                 String qualifier = Bytes.toString(cell.getQualifierArray(),
13                     cell.getQualifierOffset(), cell.getQualifierLength());
14                 String value = Bytes.toString(cell.getValueArray(), cell.getValueOffset(),
15                     cell.getValueLength());
16                 System.out.println("row=" + rowKey + ", family=" + family + ", column=" +
17                     qualifier + ", value=" + value);
18             }
19         }
20     }
21 }
```

```
13     });
14 }
15 }
16 }
```

运行结果：

在 student 表查询键值为 1 行：

```
lfl@master:~/JavaAPI$ java -cp "$(hbase classpath):$(hadoop classpath):HBaseop.jar" HBaseop get student 1
2025-09-19 21:20:23,772 INFO  [main-SendThread(master:2181)] zookeeper.ClientCnxn: Session establishment complete
on server master/10.211.55.22:2181, sessionid = 0x19961f36dc90019, negotiated timeout = 40000
row=1, family=info, column=Age, value=18
row=1, family=info, column=name, value=Alice
row=1, family=score, column=math, value=95
```

在 student 表查询键值为 2 的行：

```
lfl@master:~/JavaAPI$ java -cp "$(hbase classpath):$(hadoop classpath):HBaseop.jar" HBaseop get student 2
2025-09-19 21:20:40,286 INFO  [main-SendThread(master:2181)] zookeeper.ClientCnxn: Session establishment comple
t
e on server master/10.211.55.22:2181, sessionid = 0x19961f36dc9001a, negotiated timeout = 40000
row=2, family=info, column=Age, value=22
row=2, family=info, column=name, value=Bob
row=2, family=score, column=math, value=90
```

### 3.2.5 删除数据

```
1 public static void deleteData(Connection connection, String tableName, String rowKey)
2     throws Exception {
3     try (Table table = connection.getTable(TableName.valueOf(tableName))) {
4         Delete delete = new Delete(Bytes.toBytes(rowKey));
5         table.delete(delete);
6         System.out.println("已删除: " + rowKey + " from " + tableName);
7     }
}
```

运行结果：

在 student 表删除键值为 2 的行：

```
lfl@master:~/JavaAPI$ java -cp "$(hbase classpath):$(hadoop classpath):HBaseop.jar" HBaseop get student 2
lfl@master:~/JavaAPI$ java -cp "$(hbase classpath):$(hadoop classpath):HBaseop.jar" HBaseop delete student 2
已删除: 2 from student
```

在 hbase shell 中再次扫描全表

```
hbase(main):022:0> scan 'student'
ROW
1
1
1
1 row(s) in 0.5110 seconds
COLUMN+CELL
column=info:Age, timestamp=1758287688324, value=18
column=info:name, timestamp=1758287546003, value=Alice
column=score:math, timestamp=1758287981723, value=95
```

### 完整代码

```
1 import org.apache.hadoop.conf.Configuration;
```

```
2 import org.apache.hadoop.hbase.HBaseConfiguration;
3 import org.apache.hadoop.hbase.HColumnDescriptor;
4 import org.apache.hadoop.hbase.HTableDescriptor;
5 import org.apache.hadoop.hbase.TableName;
6 import org.apache.hadoop.hbase.client.*;
7 import org.apache.hadoop.hbase.util.Bytes;
8
9 public class HBaseop {
10
11     public static void main(String[] args) throws Exception {
12         if (args.length < 1) {
13             System.out.println("用法: java HBaseDemo <command> [args...]");
14             System.out.println("命令列表:");
15             System.out.println("  createTable <tableName> <familyName>");
16             System.out.println("  put <tableName> <rowKey> <family> <column> <value>");
17             System.out.println("  get <tableName> <rowKey>");
18             System.out.println("  delete <tableName> <rowKey>");
19             System.exit(1);
20     }
21
22     String command = args[0];
23     Configuration conf = HBaseConfiguration.create();
24
25     conf.set("hbase.zookeeper.quorum", "master");
26     conf.set("hbase.zookeeper.property.clientPort", "2181");
27
28     try (Connection connection = ConnectionFactory.createConnection(conf);
29          Admin admin = connection.getAdmin()) {
30
31         switch (command) {
32             case "createTable":
33                 if (args.length < 3) {
34                     System.out.println("用法: createTable <tableName> <family1> <family2> <family3> ...");
35                     return;
36                 }
37                 String tableName = args[1];
38                 String[] families = new String[args.length - 2];
39                 System.arraycopy(args, 2, families, 0, families.length);
40                 createTable(admin, tableName, families);
41                 break;
42
43             case "put":
44                 if (args.length != 6) {
45                     System.out.println("用法: put <tableName> <rowKey> <family> <column> <value>");
46                     return;
47                 }
48                 insertData(connection, args[1], args[2], args[3], args[4],
49                 args[5]);
49                     break;
```

```
50
51         case "get":
52             if (args.length != 3) {
53                 System.out.println("用法: get <tableName> <rowKey>");
54                 return;
55             }
56             getData(connection, args[1], args[2]);
57             break;
58
59         case "delete":
60             if (args.length != 3) {
61                 System.out.println("用法: delete <tableName> <rowKey>");
62                 return;
63             }
64             deleteData(connection, args[1], args[2]);
65             break;
66
67         default:
68             System.out.println("未知命令: " + command);
69         }
70     }
71 }
72
73 // 1. 创建表, 支持多个列族
74 public static void createTable(Admin admin, String tableName, String...
75 familyNames) throws Exception {
76     TableName tName = TableName.valueOf(tableName);
77
78     if (admin.tableExists(tName)) {
79         System.out.println("表已存在: " + tableName);
80         return;
81     }
82
83     HTableDescriptor tableDescriptor = new HTableDescriptor(tName);
84
85     for (String family : familyNames) {
86         HColumnDescriptor columnDescriptor = new HColumnDescriptor(family);
87         tableDescriptor.addFamily(columnDescriptor);
88     }
89
90     admin.createTable(tableDescriptor);
91     System.out.println("表已创建: " + tableName + ", 列族: " + String.join(",",
92 familyNames));
93 }
94
95 // 2. 插入数据
96 public static void insertData(Connection connection, String tableName, String
97 rowKey,
98                                 String family, String column, String value) throws
99 Exception {
100     try (Table table = connection.getTable(TableName.valueOf(tableName))) {
101         Put put = new Put(Bytes.toBytes(rowKey));
```

```

98         put.addColumn(Bytes.toBytes(family), Bytes.toBytes(column),
99         Bytes.toBytes(value));
100        table.put(put);
101        System.out.println("插入成功: " + rowKey + " -> " + family + ":" + column
102        + "=" + value);
103    }
104
105    // 3. 查询数据
106    public static void getData(Connection connection, String tableName, String
107    rowKey) throws Exception {
108        try (Table table = connection.getTable(Table.Name.valueOf(tableName))) {
109            Get get = new Get(Bytes.toBytes(rowKey));
110            Result result = table.get(get);
111            if (result.isEmpty()) {
112                System.out.println("未找到数据: " + rowKey);
113            } else {
114                result.listCells().forEach(cell -> {
115                    String family = Bytes.toString(cell.getFamilyArray(),
116                    cell.getFamilyOffset(), cell.getFamilyLength());
117                    String qualifier = Bytes.toString(cell.getQualifierArray(),
118                    cell.getQualifierOffset(), cell.getQualifierLength());
119                    String value = Bytes.toString(cell.getValueArray(),
120                    cell.getValueOffset(), cell.getValueLength());
121                    System.out.println("row=" + rowKey + ", family=" + family + ", "
122                    + "column=" + qualifier + ", value=" + value);
123                });
124            }
125        }
126
127        // 4. 删除数据
128        public static void deleteData(Connection connection, String tableName, String
129        rowKey) throws Exception {
130            try (Table table = connection.getTable(Table.Name.valueOf(tableName))) {
131                Delete delete = new Delete(Bytes.toBytes(rowKey));
132                table.delete(delete);
133                System.out.println("已删除: " + rowKey + " from " + tableName);
134            }
135        }
136    }

```

## 四、实验总结

本次实验中，我成功使用 Java API 实现了对hdfs和hbase的各种操作，例如创建文件、删除文件、上传文件、读取文件内容等常见hdfs处理操作，以及在hbase中创建表和列族、插入数据、查询数据、删除数据等操作。

通过本次实验，我的分布式系统开发能力得到了显著提升，不仅掌握了 Java 提供的对hdfs和hbase的API，还学会了如何在集群环境中部署和调试应用程序。同时，也对分布式计算的优势和挑战有了更深入的理解，为今后进一步学习和应用大数据技术奠定了坚实的基础。在未来的学习和工作中，我将继续探索更多大数据处理技术和框架，不断提升自己的专业技能。