

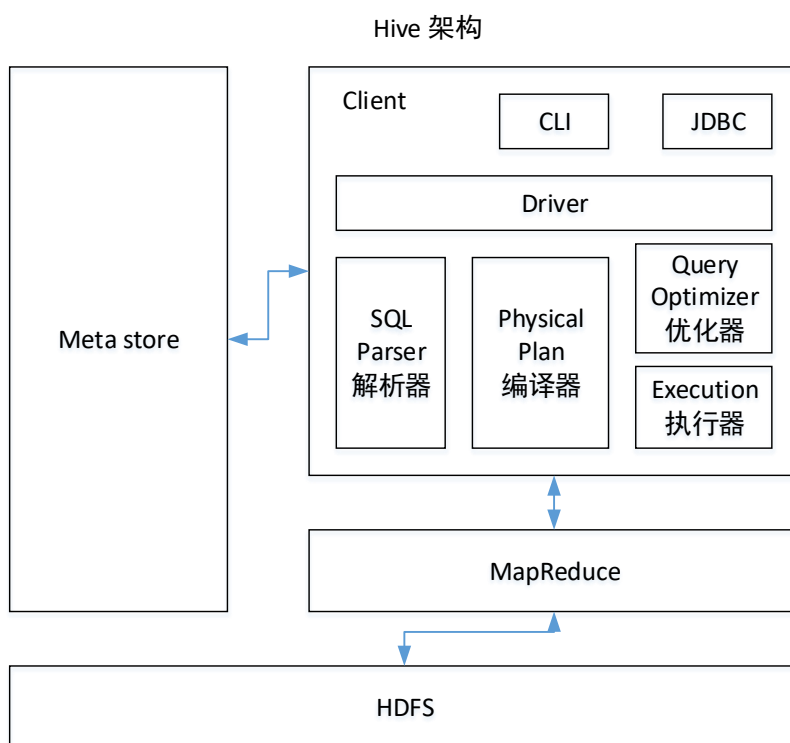
# 尚硅谷大数据技术之 Hive 源码

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版本 2.0

## 第 1 章 HQL 是如何转换为 MR 任务的

### 1.1 Hive 的核心组成介绍



#### 1) 用户接口：Client

CLI（command-line interface）、JDBC/ODBC(jdbc 访问 hive)、WEBUI（浏览器访问 hive）

#### 2) 元数据：Metastore

元数据包括：表名、表所属的数据库（默认是 default）、表的拥有者、列/分区字段、表的类型（是否是外部表）、表的数据所在目录等；

默认存储在自带的 derby 数据库中，推荐使用 MySQL 存储 Metastore

#### 3) Hadoop

使用 HDFS 进行存储，使用 MapReduce 进行计算。

#### 4) 驱动器: Driver

#### 5) 解析器 (SQL Parser)

将 SQL 字符串转换成抽象语法树 AST, 这一步一般都用第三方工具库完成, 比如 antlr; 对 AST 进行语法分析, 比如表是否存在、字段是否存在、SQL 语义是否有误。

#### 6) 编译器 (Physical Plan)

将 AST 编译生成逻辑执行计划。

#### 7) 优化器 (Query Optimizer)

对逻辑执行计划进行优化。

#### 8) 执行器 (Execution)

把逻辑执行计划转换成可以运行的物理计划。对于 Hive 来说, 就是 MR/Spark。

## 1.2 HQL 转换为 MR 任务流程说明



### HQL编译为MR任务流程介绍

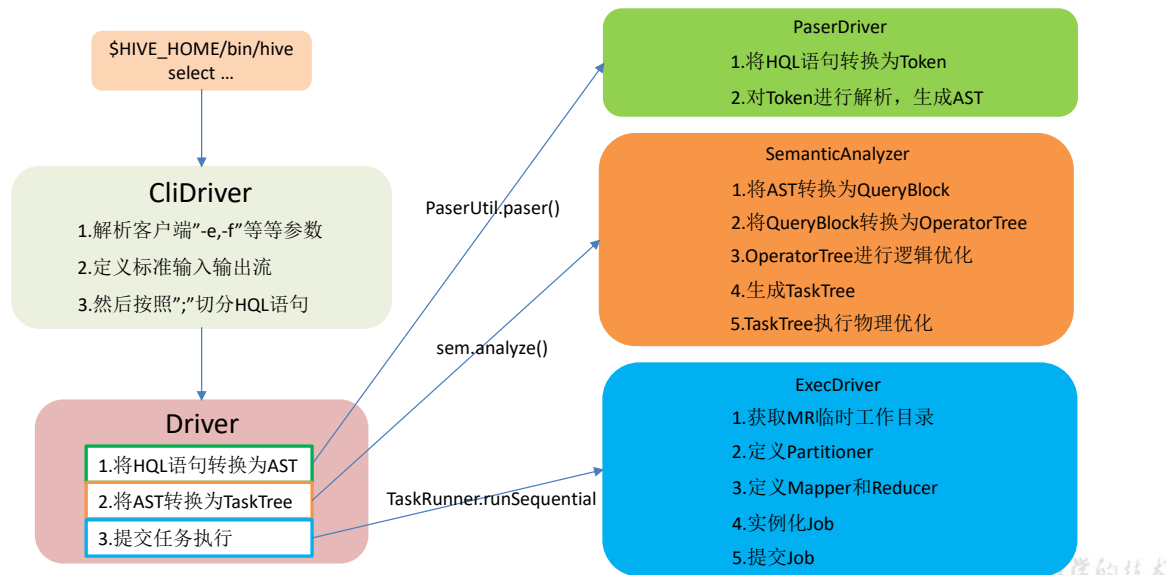


1. 进入程序, 利用Antlr框架定义HQL的语法规则, 对HQL完成词法语法解析, 将HQL转换为AST (抽象语法树);
2. 遍历AST, 抽象出查询的基本组成单元QueryBlock (查询块), 可以理解为最小的查询执行单元;
3. 遍历QueryBlock, 将其转换为OperatorTree (操作树, 也就是逻辑执行计划), 可以理解为不可拆分的一个逻辑执行单元;
4. 使用逻辑优化器对OperatorTree (操作树) 进行逻辑优化。例如合并不必要的ReduceSinkOperator, 减少Shuffle数据量;
5. 遍历OperatorTree, 转换为TaskTree。也就是翻译为MR任务的流程, 将逻辑执行计划转换为物理执行计划;
6. 使用物理优化器对TaskTree进行物理优化;
7. 生成最终的执行计划, 提交任务到Hadoop集群运行。

让天下没有难学的技术

## 第 2 章 HQL 转换为 MR 源码详细解读

### 2.1 HQL 转换为 MR 源码整体流程介绍



## 2.2 程序入口 — CliDriver

众所周知，我们执行一个 HQL 语句通常有以下几种方式：

- 1) \$HIVE\_HOME/bin/hive 进入客户端，然后执行 HQL；
- 2) \$HIVE\_HOME/bin/hive -e “hql”；
- 3) \$HIVE\_HOME/bin/hive -f hive.sql；
- 4) 先开启 hiveServer2 服务端，然后通过 JDBC 方式连接远程提交 HQL。

可以知道我们执行 HQL 主要依赖于 \$HIVE\_HOME/bin/hive 和 \$HIVE\_HOME/bin/hiveServer2 两种脚本来实现提交 HQL，而在这两个脚本中，最终启动的 JAVA 程序的主类为“org.apache.hadoop.hive.cli.CliDriver”，所以其实 Hive 程序的入口就是“CliDriver”这个类。

## 2.3 HQL 的读取与参数解析

### 2.3.1 找到“CliDriver”这个类的“main”方法

```
public static void main(String[] args) throws Exception {
    int ret = new CliDriver().run(args);
    System.exit(ret);
}
```

### 2.3.2 主类的 run 方法

```
public int run(String[] args) throws Exception {

    OptionsProcessor oproc = new OptionsProcessor();

    //解析系统参数
```

```
if (!oproc.process_stage1(args)) {
    return 1;
}

... ..

CliSessionState ss = new CliSessionState(new
HiveConf(SessionState.class));

//标准输入输出以及错误输出流的定义,后续需要输入 HQL 以及打印控制台信息
ss.in = System.in;
try {
    ss.out = new PrintStream(System.out, true, "UTF-8");
    ss.info = new PrintStream(System.err, true, "UTF-8");
    ss.err = new CachingPrintStream(System.err, true, "UTF-8");
} catch (UnsupportedEncodingException e) {
    return 3;
}

//解析用户参数,包含"-e -f -v -database"等等
if (!oproc.process_stage2(ss)) {
    return 2;
}

... ..

// execute cli driver work
try {
    return executeDriver(ss, conf, oproc);
} finally {
    ss.resetThreadName();
    ss.close();
}
}
```

### 2.3.3 executeDriver 方法

```
private int executeDriver(CliSessionState ss, HiveConf conf,
OptionsProcessor oproc)
    throws Exception {

    CliDriver cli = new CliDriver();
    cli.setHiveVariables(oproc.getHiveVariables());

    // use the specified database if specified
    cli.processSelectDatabase(ss);

    // Execute -i init files (always in silent mode)
    cli.processInitFiles(ss);

    if (ss.execString != null) {
        int cmdProcessStatus = cli.processLine(ss.execString);
        return cmdProcessStatus;
    }

    ... ..

    setupConsoleReader();
}
```

```
String line;
int ret = 0;
String prefix = "";
String curDB = getFormattedDb(conf, ss);
String curPrompt = prompt + curDB;
String dbSpaces = spacesForString(curDB);

//读取客户端的输入 HQL
while ((line = reader.readLine(curPrompt + "> ")) != null) {
    if (!prefix.equals("")) {
        prefix += '\n';
    }
    if (line.trim().startsWith("--")) {
        continue;
    }
    //以按照“;”分割的方式解析
    if (line.trim().endsWith(";") && !line.trim().endsWith("\\;")) {
        line = prefix + line;
        ret = cli.processLine(line, true);
        prefix = "";
        curDB = getFormattedDb(conf, ss);
        curPrompt = prompt + curDB;
        dbSpaces = dbSpaces.length() == curDB.length() ? dbSpaces :
spacesForString(curDB);
    } else {
        prefix = prefix + line;
        curPrompt = prompt2 + dbSpaces;
        continue;
    }
}

return ret;
}
```

### 2.3.4 processLine 方法

```
public int processLine(String line, boolean allowInterrupting) {
    SignalHandler oldSignal = null;
    Signal interruptSignal = null;

    ... ..

    try {
        int lastRet = 0, ret = 0;

        // we can not use "split" function directly as ";" may be quoted
        List<String> commands = splitSemiColon(line);

        String command = "";
        for (String oneCmd : commands) {

            if (StringUtils.endsWith(oneCmd, "\\;")) {
                command += StringUtils.chop(oneCmd) + ";";
                continue;
            } else {
                command += oneCmd;
            }
            if (StringUtils.isBlank(command)) {
                continue;
            }
        }
    }
}
```

```
    }

    //解析单行 HQL
    ret = processCmd(command);
    command = "";
    lastRet = ret;
    boolean ignoreErrors = HiveConf.getBoolVar(conf,
HiveConf.ConfVars.CLIIGNOREERRORS);
    if (ret != 0 && !ignoreErrors) {
        return ret;
    }
}
return lastRet;
} finally {
    // Once we are done processing the line, restore the old handler
    if (oldSignal != null && interruptSignal != null) {
        Signal.handle(interruptSignal, oldSignal);
    }
}
}
```

### 2.3.5 processCmd 方法

```
public int processCmd(String cmd) {
    CliSessionState ss = (CliSessionState) SessionState.get();

    ... ..

    //1.如果命令为"quit"或者"exit",则退出
    if (cmd_trimmed.toLowerCase().equals("quit") ||
cmd_trimmed.toLowerCase().equals("exit")) {

        // if we have come this far - either the previous commands
        // are all successful or this is command line. in either case
        // this counts as a successful run
        ss.close();
        System.exit(0);

        //2.如果命令为"source"开头,则表示执行 HQL 文件,继续读取文件并解析
    } else if (tokens[0].equalsIgnoreCase("source")) {
        String cmd_1 = getFirstCmd(cmd_trimmed, tokens[0].length());
        cmd_1 = new VariableSubstitution(new HiveVariableSource() {
            @Override
            public Map<String, String> getHiveVariable() {
                return SessionState.get().getHiveVariables();
            }
        }).substitute(ss.getConf(), cmd_1);

        File sourceFile = new File(cmd_1);
        if (!sourceFile.isFile()){
            console.printError("File: " + cmd_1 + " is not a file.");
            ret = 1;
        } else {
            try {
                ret = processFile(cmd_1);
            } catch (IOException e) {
                console.printError("Failed processing file " + cmd_1 + " "+
e.getMessage(),
                stringifyException(e));
            }
        }
    }
}
```

```
        ret = 1;
    }
}

//3.如果命令以"!"开头,则表示用户需要执行 Linux 命令
} else if (cmd_trimmed.startsWith("!")) {
    // for shell commands, use unstripped command
    String shell_cmd = cmd.trim().substring(1);
    shell_cmd = new VariableSubstitution(new HiveVariableSource() {
        @Override
        public Map<String, String> getHiveVariable() {
            return SessionState.get().getHiveVariables();
        }
    }).substitute(ss.getConf(), shell_cmd);

    // shell_cmd = "/bin/bash -c \"" + shell_cmd + "\"";
    try {
        ShellCmdExecutor executor = new ShellCmdExecutor(shell_cmd,
ss.out, ss.err);
        ret = executor.execute();
        if (ret != 0) {
            console.printError("Command failed with exit code = " + ret);
        }
    } catch (Exception e) {
        console.printError("Exception raised from Shell command " +
e.getLocalizedMessage(),
            stringifyException(e));
        ret = 1;
    }

    //4.以上三者都不是,则认为用户输入的为"select ..."正常的增删改查 HQL 语句,则进
    行 HQL 解析
    } else {
        try {

            try (CommandProcessor proc = CommandProcessorFactory.get(tokens,
(HiveConf) conf)) {
                if (proc instanceof IDriver) {
                    // Let Driver strip comments using sql parser
                    ret = processLocalCmd(cmd, proc, ss);
                } else {
                    ret = processLocalCmd(cmd_trimmed, proc, ss);
                }
            }
        } catch (SQLException e) {
            console.printError("Failed processing command " + tokens[0] + " "
+ e.getLocalizedMessage(),
                org.apache.hadoop.util.StringUtils.stringifyException(e));
            ret = 1;
        }
        catch (Exception e) {
            throw new RuntimeException(e);
        }
    }

    ss.resetThreadName();
    return ret;
}
```

### 2.3.6 processLocalCmd 方法

```
int processLocalCmd(String cmd, CommandProcessor proc, CliSessionState ss) {
    boolean escapeCRLF = HiveConf.getBoolVar(conf,
        HiveConf.ConfVars.HIVE_CLI_PRINT_ESCAPE_CRLF);
    int ret = 0;

    if (proc != null) {
        if (proc instanceof IDriver) {
            IDriver qp = (IDriver) proc;
            PrintStream out = ss.out;

            // 获取系统时间作为开始时间,以便后续计算 HQL 执行时长
            long start = System.currentTimeMillis();
            if (ss.getIsVerbose()) {
                out.println(cmd);
            }

            // HQL 执行的核心方法
            ret = qp.run(cmd).getResponseCode();
            if (ret != 0) {
                qp.close();
                return ret;
            }

            // query has run capture the time
            // 获取系统时间作为结束时间,以便后续计算 HQL 执行时长
            long end = System.currentTimeMillis();
            double timeTaken = (end - start) / 1000.0;

            ArrayList<String> res = new ArrayList<String>();

            // 打印头信息
            printHeader(qp, out);

            // print the results, 包含结果集并获取抓取到数据的条数
            int counter = 0;
            try {
                if (out instanceof FetchConverter) {
                    ((FetchConverter) out).fetchStarted();
                }
                while (qp.getResults(res)) {
                    for (String r : res) {
                        if (escapeCRLF) {
                            r = EscapeCRLFHelper.escapeCRLF(r);
                        }
                        out.println(r);
                    }
                    counter += res.size();
                    res.clear();
                    if (out.checkError()) {
                        break;
                    }
                }
            } catch (IOException e) {
                console.printError("Failed with exception " +
                    e.getClass().getName() + ":" + e.getMessage(),
```



```
        "\n" +
        org.apache.hadoop.util.StringUtils.stringifyException(e));
        ret = 1;
    }

    qp.close();

    if (out instanceof FetchConverter) {
        ((FetchConverter) out).fetchFinished();
    }

    //打印 HQL 执行时间以及抓取数据的条数（经常使用 Hive 的同学是否觉得这句很熟悉
    呢，其实就是执行完一个 HQL 最后打印的那句话）
    console.printlnInfo(
        "Time taken: " + timeTaken + " seconds" + (counter == 0 ? "" :
        ", Fetched: " + counter + " row(s)");
    } else {
        String firstToken = tokenizeCmd(cmd.trim())[0];
        String cmd_1 = getFirstCmd(cmd.trim(), firstToken.length());

        if (ss.getIsVerbose()) {
            ss.out.println(firstToken + " " + cmd_1);
        }
        CommandProcessorResponse res = proc.run(cmd_1);
        if (res.getResponseCode() != 0) {
            ss.out
                .println("Query returned non-zero code: " +
                res.getResponseCode() + ", cause: " + res.getErrorMessage());
        }
        if (res.getConsoleMessages() != null) {
            for (String consoleMsg : res.getConsoleMessages()) {
                console.println(consoleMsg);
            }
        }
        ret = res.getResponseCode();
    }
}

return ret;
}
```

### 2.3.7 qp.run(cmd)方法

点击进入“run”方法，该方法为 IDriver 接口的抽象方法，此处实际调用的是“org.apache.hadoop.hive.ql.Driver”类中的“run”方法，找到“Driver”类中的“run”方法。

```
public CommandProcessorResponse run(String command) {
    return run(command, false);
}

public CommandProcessorResponse run(String command, boolean
alreadyCompiled) {

    try {
        runInternal(command, alreadyCompiled);
        return createProcessorResponse(0);
    } catch (CommandProcessorResponse cpr) {
        ... ..
    }
}
```

```
}  
  
}
```

### 2.3.8 runInternal 方法

```
private void runInternal(String command, boolean alreadyCompiled)  
throws CommandProcessorResponse {  
    errorMessage = null;  
    SQLState = null;  
    downstreamError = null;  
    LockedDriverState.setLockedDriverState(lDrvState);  
  
    lDrvState.stateLock.lock();  
  
    ... ..  
  
    PerfLogger perfLogger = null;  
  
    if (!alreadyCompiled) {  
        // compile internal will automatically reset the perf logger  
  
        //1.编译 HQL 语句  
        compileInternal(command, true);  
        // then we continue to use this perf logger  
        perfLogger = SessionState.getPerfLogger();  
    }  
  
    ... ..  
  
    try {  
  
        //2.执行  
        execute();  
    } catch (CommandProcessorResponse cpr) {  
        rollback(cpr);  
        throw cpr;  
    }  
  
    isFinishedWithError = false;  
}  
}
```

## 2.4 HQL 生成 AST（抽象语法树）

### 2.4.1 compileInternal 方法

```
private void compileInternal(String command, boolean deferClose) throws  
CommandProcessorResponse {  
    Metrics metrics = MetricsFactory.getInstance();  
    if (metrics != null) {  
        metrics.incrementCounter(MetricsConstant.WAITING_COMPILE_OPS, 1);  
    }  
  
    ... ..  
  
    if (compileLock == null) {  
        throw  
createProcessorResponse(ErrorMsg.COMPILE_LOCK_TIMED_OUT.getErrorCode());  
    }  
}
```

```
    }

    try {
        compile(command, true, deferClose);
    } catch (CommandProcessorResponse cpr) {
        try {
            releaseLocksAndCommitOrRollback(false);
        } catch (LockException e) {
            LOG.warn("Exception in releasing locks. " +
org.apache.hadoop.util.StringUtils.stringifyException(e));
        }
        throw cpr;
    }
}
```

### 2.4.2 compile 方法

```
private void compile(String command, boolean resetTaskIds, boolean
deferClose) throws CommandProcessorResponse {
    PerfLogger perfLogger = SessionState.getPerfLogger(true);
    perfLogger.PerfLogBegin(CLASS_NAME, PerfLogger.DRIVER_RUN);
    perfLogger.PerfLogBegin(CLASS_NAME, PerfLogger.COMPILE);
    lDrvState.stateLock.lock();

    ... ..

    //HQL 生成 AST
    ASTNode tree;
    try {
        tree = ParseUtils.parse(command, ctx);
    } catch (ParseException e) {
        parseError = true;
        throw e;
    } finally {
        hookRunner.runAfterParseHook(command, parseError);
    }
}
```

### 2.4.3 parse 方法

```
/** Parses the Hive query. */
public static ASTNode parse(String command, Context ctx) throws
ParseException {
    return parse(command, ctx, null);
}
```

```
public static ASTNode parse(
    String command, Context ctx, String viewFullyQualifiedName) throws
ParseException {
    ParseDriver pd = new ParseDriver();
    ASTNode tree = pd.parse(command, ctx, viewFullyQualifiedName);
    tree = findRootNonNullToken(tree);
    handleSetColRefs(tree);
    return tree;
}
```

```
public ASTNode parse(String command, Context ctx, String
viewFullyQualifiedName)
    throws ParseException {
    if (LOG.isDebugEnabled()) {
        LOG.debug("Parsing command: " + command);
    }

    //1.构建词法解析器
    HiveLexerX lexer = new HiveLexerX(new
ANTLRNoCaseStringStream(command));

    //2.将 HQL 中的关键词替换为 Token
    TokenRewriteStream tokens = new TokenRewriteStream(lexer);
    if (ctx != null) {
        if (viewFullyQualifiedName == null) {
            // Top level query
            ctx.setTokenRewriteStream(tokens);
        } else {
            // It is a view
            ctx.addViewTokenRewriteStream(viewFullyQualifiedName, tokens);
        }
        lexer.setHiveConf(ctx.getConf());
    }
}
```

**说明：Antlr 框架。**Hive 使用 Antlr 实现 SQL 的词法和语法解析。Antlr 是一种语言识别的工具，可以用来构造领域语言。这里不详细介绍 Antlr，只需要了解使用 Antlr 构造特定的语言只需要编写一个语法文件，定义词法和语法替换规则即可，Antlr 完成了词法分析、语法分析、语义分析、中间代码生成的过程。

Hive 中语法规则的定义文件在 0.10 版本以前是 Hive.g 一个文件，随着语法规则越来越复杂，由语法规则生成的 Java 解析类可能超过 Java 类文件的最大上限，0.11 版本将 Hive.g 拆成了 5 个文件，词法规则 HiveLexer.g 和语法规则的 4 个文件 SelectClauseParser.g，FromClauseParser.g，IdentifiersParser.g，HiveParser.g。

```
HiveParser parser = new HiveParser(tokens);
if (ctx != null) {
    parser.setHiveConf(ctx.getConf());
}
parser.setTreeAdaptor(adaptor);
HiveParser.statement_return r = null;
try {
    //3.进行语法解析，生成最终的 AST
    r = parser.statement();
} catch (RecognitionException e) {
    e.printStackTrace();
    throw new ParseException(parser.errors);
}

if (lexer.getErrors().size() == 0 && parser.errors.size() == 0) {
    LOG.debug("Parse Completed");
} else if (lexer.getErrors().size() != 0) {
    throw new ParseException(lexer.getErrors());
} else {
```

```

        throw new ParseException(parser.errors);
    }

    ASTNode tree = (ASTNode) r.getTree();
    tree.setUnknownTokenBoundaries();
    return tree;
}

```

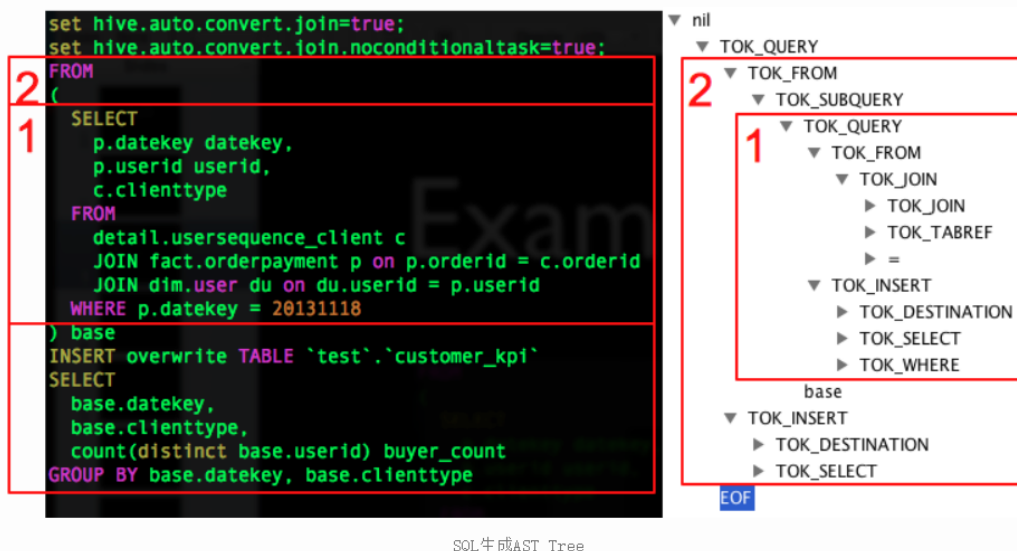
说明：例如 HQL 语句为：

```

FROM
(
  SELECT
    p.datekey datekey,
    p.userid userid,
    c.clienttype
  FROM
    detail.usersequence_client c
    JOIN fact.orderpayment p ON p.orderid = c.orderid
    JOIN default.user du ON du.userid = p.userid
  WHERE p.datekey = 20131118
) base
INSERT OVERWRITE TABLE `test`.`customer_kpi`
SELECT
  base.datekey,
  base.clienttype,
  count(distinct base.userid) buyer_count
GROUP BY base.datekey, base.clienttype

```

生成对应的 AST（抽象语法树）为：



## 2.5 对 AST 进一步解析

接下来的步骤包括：

- 1) 将 AST 转换为 QueryBlock 进一步转换为 OperatorTree;
- 2) 对 OperatorTree 进行逻辑优化 (LogicalOptimizer);

- 3) 将 OperatorTree 转换为 TaskTree (任务树);
- 4) 对 TaskTree 进行物理优化 (PhysicalOptimizer)。

之所以将这 4 个步骤写在一起, 是因为这几个步骤在源码中存在于一个方法中。

### 2.5.1 compile 方法 (接 2.4.2 节 compile 方法继续往下)

```
private void compile(String command, boolean resetTaskIds, boolean
deferClose) throws CommandProcessorResponse {
    PerfLogger perfLogger = SessionState.getPerfLogger(true);
    perfLogger.PerfLogBegin(CLASS_NAME, PerfLogger.DRIVER_RUN);
    perfLogger.PerfLogBegin(CLASS_NAME, PerfLogger.COMPILE);
    lDrvState.stateLock.lock();

    ... ..

    //HQL 生成 AST
    ASTNode tree;
    try {
        tree = ParseUtils.parse(command, ctx);
    } catch (ParseException e) {
        parseError = true;
        throw e;
    } finally {
        hookRunner.runAfterParseHook(command, parseError);
    }

    // Do semantic analysis and plan generation
    BaseSemanticAnalyzer sem = SemanticAnalyzerFactory.get(queryState,
tree);

    if (!retrial) {
        openTransaction();
        generateValidTxnList();
    }

    //进一步解析抽象语法树
    sem.analyze(tree, ctx);
}
```

### 2.5.2 analyze 方法

```
public void analyze(ASTNode ast, Context ctx) throws
SemanticException {
    initCtx(ctx);
    init(true);
    analyzeInternal(ast);
}
```

### 2.5.3 analyzeInternal 方法

```
public abstract void analyzeInternal(ASTNode ast) throws
SemanticException;
```

此方法为“org.apache.hadoop.hive.ql.parse.BaseSemanticAnalyzer”抽象类的抽象方法, 我们进入实现类“org.apache.hadoop.hive.ql.parse.SemanticAnalyzer”的 analyzeInternal 方法。

```
public void analyzeInternal(ASTNode ast) throws SemanticException {
```

```
analyzeInternal(ast, new PlannerContextFactory() {  
    @Override  
    public PlannerContext create() {  
        return new PlannerContext();  
    }  
});  
}
```

## 2.5.4 继续调用重载的 analyzeInternal 方法

**注意：**该段源码中出现的“1,2,3,4...11”均为源码所定义步骤，该方法代码虽然很长，但是由于存在官方提供的步骤注释，其实读懂并不难。

```
void analyzeInternal(ASTNode ast, PlannerContextFactory pcf) throws  
SemanticException {  
    LOG.info("Starting Semantic Analysis");  
    // 1. Generate Resolved Parse tree from syntax tree  
    boolean needsTransform = needsTransform();  
    //change the location of position alias process here  
    processPositionAlias(ast);  
    PlannerContext plannerCtx = pcf.create();  
    //处理 AST, 转换为 QueryBlock  
    if (!genResolvedParseTree(ast, plannerCtx)) {  
        return;  
    }  
  
    ... ..  
  
    // 2. Gen OP Tree from resolved Parse Tree  
    Operator sinkOp = genOPTree(ast, plannerCtx);  
  
    // 3. Deduce Resultset Schema:定义输出数据的 Schema  
    ... ..  
  
    // 4. Generate Parse Context for Optimizer & Physical compiler  
    copyInfoToQueryProperties(queryProperties);  
    ParseContext pCtx = new ParseContext(queryState, opToPartPruner,  
    opToPartList, topOps,  
        new HashSet<JoinOperator>(joinContext.keySet()),  
        new HashSet<SMBMapJoinOperator>(smbMapJoinContext.keySet()),  
        loadTableWork, loadFileWork, columnStatsAutoGatherContexts, ctx,  
        idToTableNameMap, destTableId, uCtx,  
        listMapJoinOpsNoReducer, prunedPartitions, tabNameToTabObject,  
        opToSamplePruner,  
        globalLimitCtx, nameToSplitSample, inputs, rootTasks,  
        opToPartToSkewedPruner,  
        viewAliasToInput,  
        reduceSinkOperatorsAddedByEnforceBucketingSorting,  
        analyzeRewrite, tableDesc, createVwDesc,  
        materializedViewUpdateDesc,  
        queryProperties, viewProjectToTableSchema, acidFileSinks);  
  
    ... ..  
  
    // 5. Take care of view creation: 处理视图相关  
  
    ... ..
```

```
// 6. Generate table access stats if required
if (HiveConf.getBoolVar(this.conf,
HiveConf.ConfVars.HIVE_STATS_COLLECT_TABLEKEYS)) {
    TableAccessAnalyzer tableAccessAnalyzer = new
TableAccessAnalyzer(pCtx);
    setTableAccessInfo(tableAccessAnalyzer.analyzeTableAccess());
}

// 7. Perform Logical optimization: 对操作树执行逻辑优化
if (LOG.isDebugEnabled()) {
    LOG.debug("Before logical optimization\n" +
Operator.toString(pCtx.getTopOps().values()));
}

//创建优化器
Optimizer optm = new Optimizer();
optm.setPctx(pCtx);
optm.initialize(conf);
//执行优化
pCtx = optm.optimize();
if (pCtx.getColumnAccessInfo() != null) {
    // set ColumnAccessInfo for view column authorization
    setColumnAccessInfo(pCtx.getColumnAccessInfo());
}
if (LOG.isDebugEnabled()) {
    LOG.debug("After logical optimization\n" +
Operator.toString(pCtx.getTopOps().values()));
}

// 8. Generate column access stats if required - wait until column
pruning
// takes place during optimization
boolean isColumnInfoNeedForAuth =
SessionState.get().isAuthorizationModeV2()
    && HiveConf.getBoolVar(conf,
HiveConf.ConfVars.HIVE_AUTHORIZATION_ENABLED);
if (isColumnInfoNeedForAuth
    || HiveConf.getBoolVar(this.conf,
HiveConf.ConfVars.HIVE_STATS_COLLECT_SCANCOLS)) {
    ColumnAccessAnalyzer columnAccessAnalyzer = new
ColumnAccessAnalyzer(pCtx);
    // view column access info is carried by
this.getColumnAccessInfo().

setColumnAccessInfo(columnAccessAnalyzer.analyzeColumnAccess(this.getColu
mnAccessInfo()));
}

// 9. Optimize Physical op tree & Translate to target execution
engine (MR,
// TEZ..): 执行物理优化
if (!ctx.getExplainLogical()) {
    TaskCompiler compiler = TaskCompilerFactory.getCompiler(conf,
pCtx);
    compiler.init(queryState, console, db);
    //compile 为抽象方法, 对应的实现类分别为 MapReduceCompiler、TezCompiler 和
SparkCompiler
    compiler.compile(pCtx, rootTasks, inputs, outputs);
}
```



```
        fetchTask = pCtx.getFetchTask();
    }
    //find all Acid FileSinkOperators
    QueryPlanPostProcessor qp = new QueryPlanPostProcessor(rootTasks,
        acidFileSinks, ctx.getExecutionId());

    // 10. Attach CTAS/Insert-Commit-hooks for Storage Handlers

    ... ..

    LOG.info("Completed plan generation");

    // 11. put accessed columns to readEntity
    if (HiveConf.getBoolVar(this.conf,
        HiveConf.ConfVars.HIVE_STATS_COLLECT_SCANCOLS)) {
        putAccessedColumnsToReadEntity(inputs, columnAccessInfo);
    }

    if (isCacheEnabled && lookupInfo != null) {
        if (queryCanBeCached()) {
            QueryResultsCache.QueryInfo queryInfo =
                createCacheQueryInfoForQuery(lookupInfo);

            // Specify that the results of this query can be cached.
            setCacheUsage(new CacheUsage(
                CacheUsage.CacheStatus.CAN_CACHE_QUERY_RESULTS, queryInfo));
        }
    }
}
```

## 2.5.5 提交任务并执行（接 2.3.8 节 runInternal 方法继续往下）

此处接 2.3.8 节中的第二步：

```
//2.执行
execute();
```

## 2.5.6 execute 方法

```
private void execute() throws CommandProcessorResponse {
    PerfLogger perfLogger = SessionState.getPerfLogger();
    perfLogger.PerfLogBegin(CLASS_NAME, PerfLogger.DRIVER_EXECUTE);

    ... ..

    //1.构建任务：根据任务树构建 MrJob
    setQueryDisplays(plan.getRootTasks());
    int mrJobs = Utilities.getMRTasks(plan.getRootTasks()).size();
    int jobs = mrJobs +
        Utilities.getTezTasks(plan.getRootTasks()).size()
        + Utilities.getSparkTasks(plan.getRootTasks()).size();
    if (jobs > 0) {
        logMrWarning(mrJobs);
        console.println("Query ID = " + queryId);
        console.println("Total jobs = " + jobs);
    }

    perfLogger.PerfLogBegin(CLASS_NAME, PerfLogger.RUN_TASKS);
```

```
// Loop while you either have tasks running, or tasks queued up
while (driverCxt.isRunning()) {
    // Launch upto maxthreads tasks
    Task<? extends Serializable> task;
    while ((task = driverCxt.getRunnable(maxthreads)) != null) {

        //2.启动任务
        TaskRunner runner = launchTask(task, queryId, noName, jobname,
jobs, driverCxt);
        if (!runner.isRunning()) {
            break;
        }
    }

    ... ..

    //打印结果中最后的 OK
    if (console != null) {
        console.println("OK");
    }
}
```

### 2.5.7 launchTask 方法

```
private TaskRunner launchTask(Task<? extends Serializable> tsk, String
queryId, boolean noName,
    String jobname, int jobs, DriverContext cxt) throws HiveException {
    if (SessionState.get() != null) {
        SessionState.get().getHiveHistory().startTask(queryId, tsk,
tsk.getClass().getName());
    }
    if (tsk.isMapRedTask() && !(tsk instanceof ConditionalTask)) {
        if (noName) {
            conf.set(MRJobConfig.JOB_NAME, jobname + " (" + tsk.getId() +
")");
        }
        conf.set(DagUtils.MAPREDUCE_WORKFLOW_NODE_NAME, tsk.getId());
        Utilities.setWorkflowAdjacencies(conf, plan);
        cxt.incCurJobNo(1);
        console.println("Launching Job " + cxt.getCurJobNo() + " out of "
+ jobs);
    }
    tsk.initialize(queryState, plan, cxt, ctx.getOpContext());
    TaskRunner tskRun = new TaskRunner(tsk);

    //添加启动任务
    cxt.launching(tskRun);

    // Launch Task: 根据是否可以并行来决定是否并行启动 Task
    if (HiveConf.getBoolVar(conf, HiveConf.ConfVars.EXECPARALLEL) &&
tsk.canExecuteInParallel()) {
        // Launch it in the parallel mode, as a separate thread only for MR
tasks
        if (LOG.isInfoEnabled()){
            LOG.info("Starting task [" + tsk + "] in parallel");
        }
        //可并行任务启动,实际上还是执行 tskRun.runSequential();
        tskRun.start();
    } else {
```

```
if (LOG.isInfoEnabled()) {
    LOG.info("Starting task [" + tsk + "] in serial mode");
}
//不可并行任务,则按照序列顺序执行任务
tskRun.runSequential();
}
return tskRun;
}
```

## 2.5.8 runSequential 方法

```
public void runSequential() {
    int exitVal = -101;
    try {
        exitVal = tsk.executeTask(ss == null ? null : ss.getHiveHistory());
    } catch (Throwable t) {
        if (tsk.getException() == null) {
            tsk.setException(t);
        }
        LOG.error("Error in executeTask", t);
    }
    result.setExitVal(exitVal);
    if (tsk.getException() != null) {
        result.setTaskError(tsk.getException());
    }
}
```

## 2.5.9 executeTask 方法

```
public int executeTask(HiveHistory hiveHistory) {
    try {
        this.setStarted();
        if (hiveHistory != null) {
            hiveHistory.logPlanProgress(queryPlan);
        }
        int retval = execute(driverContext);
        this.setDone();
        if (hiveHistory != null) {
            hiveHistory.logPlanProgress(queryPlan);
        }
        return retval;
    } catch (IOException e) {
        throw new RuntimeException("Unexpected error: " + e.getMessage(),
e);
    }
}
```

## 2.5.10 execute 方法

```
protected abstract int execute(DriverContext driverContext);
```

此时我们进入了一个抽象“org.apache.hadoop.hive.ql.exec.Task”的“execute”方法，我们则需要找到一个实现类的“execute”方法，此处我选择“org.apache.hadoop.hive.ql.exec.mr.MapRedTask”这个类。

```
public int execute(DriverContext driverContext) {

    Context ctx = driverContext.getCtx();
    boolean ctxCreated = false;
```

```
try {
    ... ..

    if (!runningViaChild) {
        // since we are running the mapred task in the same jvm, we should
        update the job conf
        // in ExecDriver as well to have proper local properties.
        if (this.isLocalMode()) {
            // save the original job tracker

ctx.setOriginalTracker(ShimLoader.getHadoopShims().getJobLauncherRpcAddress(job));
            // change it to local
            ShimLoader.getHadoopShims().setJobLauncherRpcAddress(job,
"local");
        }
        // we are not running this mapred task via child jvm
        // so directly invoke ExecDriver

        //设置MR任务的 InputFormat、OutputFormat 等等这些 MRJob 的执行类
        int ret = super.execute(driverContext);

        // restore the previous properties for framework name, RM address
        etc.
        if (this.isLocalMode()) {
            // restore the local job tracker back to original
            ctx.restoreOriginalTracker();
        }
        return ret;
    }

    ... ..

    //构建执行MR任务的命令
    String isSilent = "true".equalsIgnoreCase(System
        .getProperty("test.silent")) ? "-nolog" : "";

    String jarCmd = hiveJar + " " + ExecDriver.class.getName() +
libJarsOption;

    String cmdLine = hadoopExec + " jar " + jarCmd + " -plan "
        + planPath.toString() + " " + isSilent + " " + hiveConfArgs;

    ... ..

    // Run ExecDriver in another JVM
    executor = Runtime.getRuntime().exec(cmdLine, env, new
File(workDir));
}
```

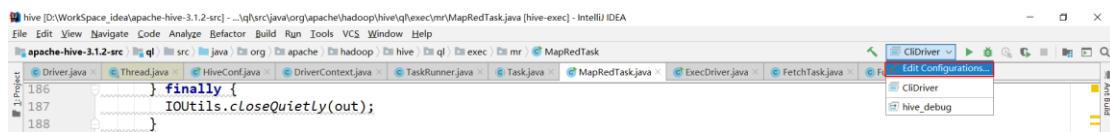
## 第 3 章 Hive 源码 Debug 介绍

### 3.1 Debug 环境准备

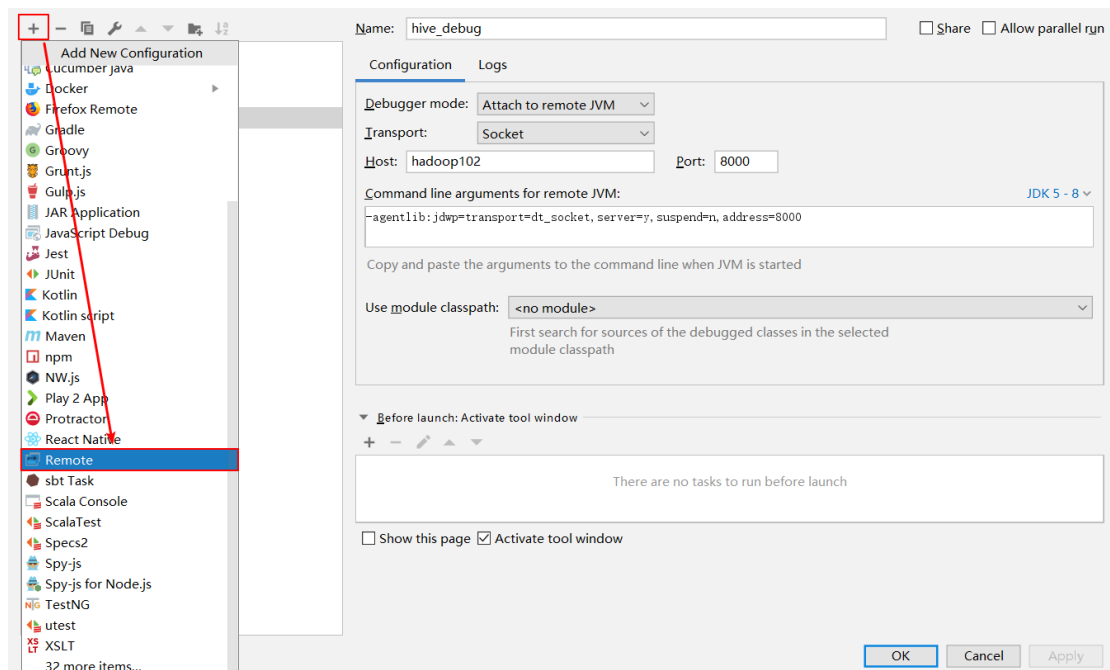
#### 3.1.1 下载源码包

下载 Hive 源码包，自行编译一下，建议在 Linux 环境下编译，然后将整个编译好的包全部拷贝到 IDEA 工作目录中并使用 IDEA 打开。该文档是以 Hive3.1.2 版本作为讲解的。在资料包中提供了已经编译好的 Hive 源码包。

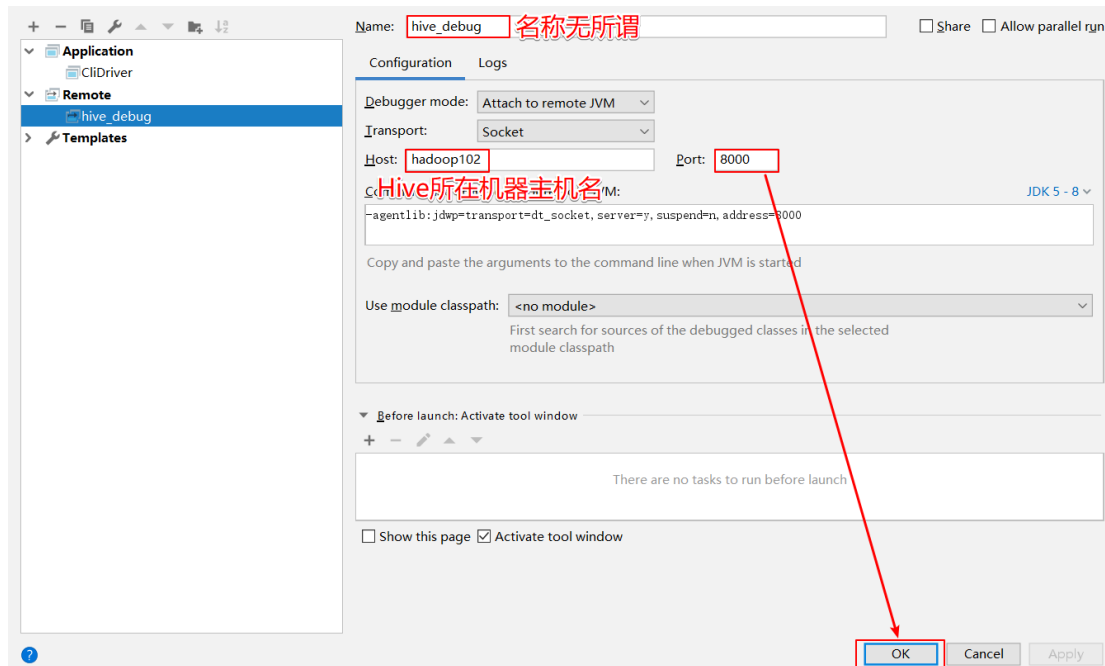
#### 3.1.2 打开项目配置项



#### 3.1.3 添加远程连接配置组

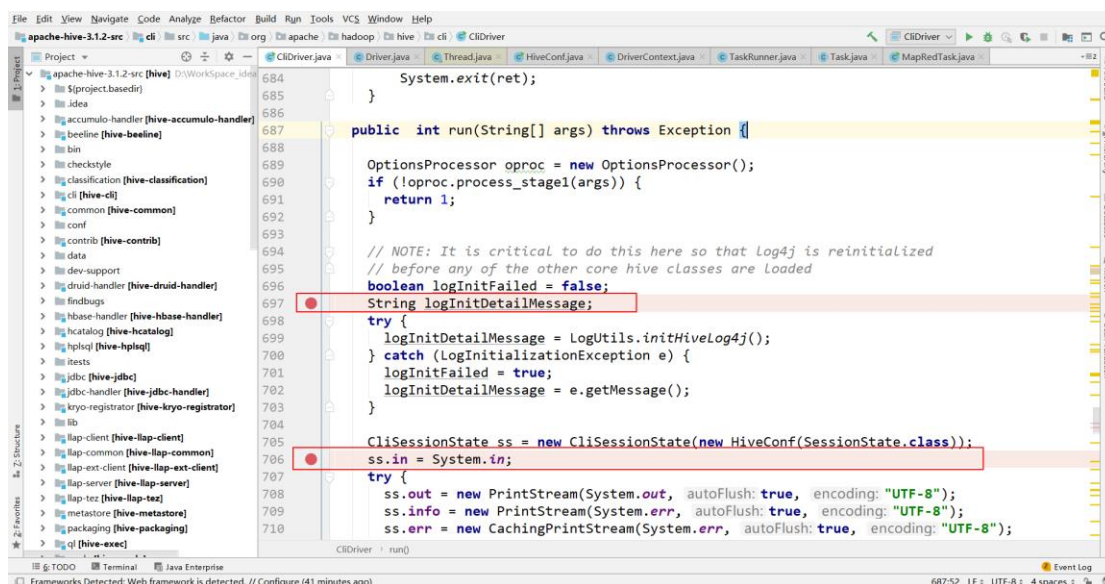


### 3.1.4 添加配置信息



## 3.2 测试

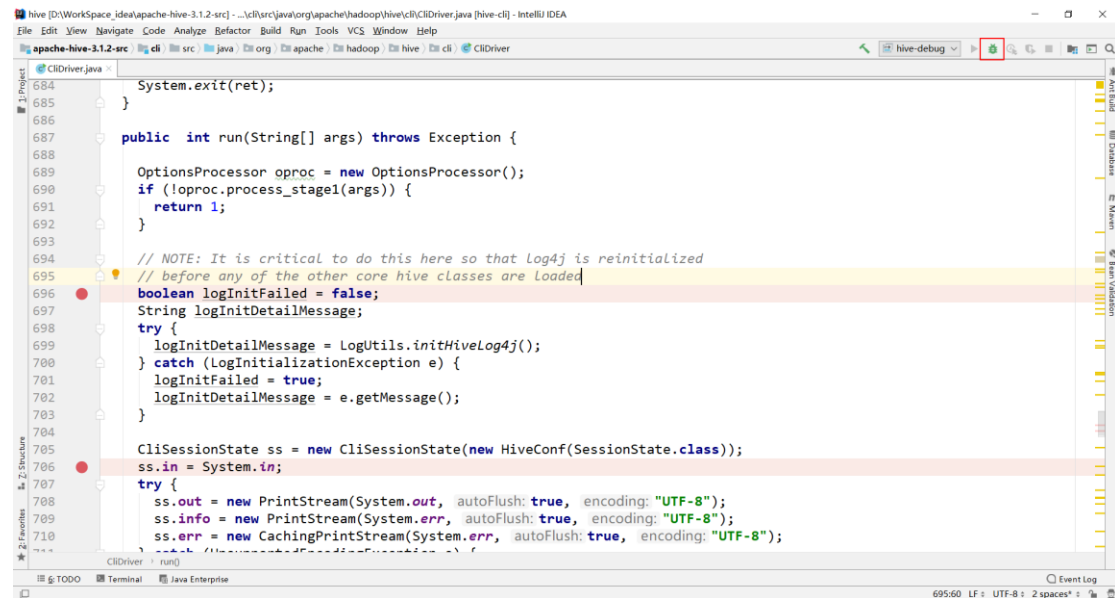
### 3.2.1 在 CliDriver 类的 run 方法中随意打上断点



### 3.2.2 开启 Hive 客户端 Debug 模式

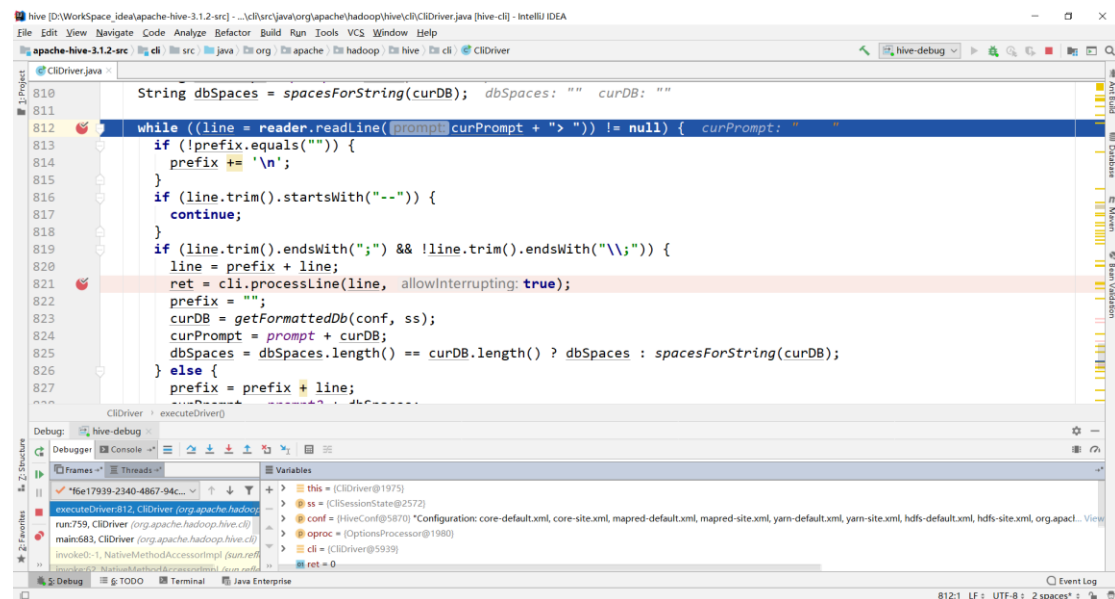
```
$HIVE_HOME/bin/hive -debug
```

### 3.2.3 使用 debug 模式启动本地项目



### 3.2.4 在 Hive 客户端中执行 HQL，切换到 IDEA 中查看

1) 在 IDEA 中查看断点



2) 在 Hive Debug 模式客户端查看



```
hadoop102 - atguigu@hadoop102:/opt/module/hive - Xshell 5 (Free for Home/School)
[atguigu@hadoop102 hive]$ bin/hive --debug
which: no hbase in (/usr/local/bin:/usr/bin:/usr/sbin:/opt/module/jdk1.8.0_144/bin:/opt/module/hadoop-3.1.2/bin:/opt/module/hadoop-3.1.2/sbin:/opt/module/jdk1.8.0_144/bin:/opt/module/hadoop-3.1.2/bin:/opt/module/hadoop-3.1.2/sbin:/home/atguigu/.local/bin:/home/atguigu/bin)
Listening for transport dt_socket at address: 8000

Hive Session ID = f6e17939-2340-4867-94c3-80410f292914

Logging initialized using configuration in jar:file:/opt/module/hive/lib/hive-common-3.1.2.jar!/hive-log4j2.properties Async: true
Hive-on-MR is deprecated in Hive 2 and may not be available in the future versions. Consider using a different execution engine (i.e. spark, tez) or using Hive 1.X releases.
Hive Session ID = 251f39a9-alda-4b48-9963-0e166d968c83
hive>
```

说明：此文档部分图片来自于美团帖子

链接：<https://tech.meituan.com/2014/02/12/hive-sql-to-mapreduce.html>