大数据集群部署与运维技术文档

项目概述

本项目为"电商用户行为全链路分析平台综合实践项目"，执行周期为2周（10个工作日）。项目成功完成了从基础环境搭建到大数据平台完整部署的全流程实施，构建了基于3节点高可用架构的大数据处理平台。

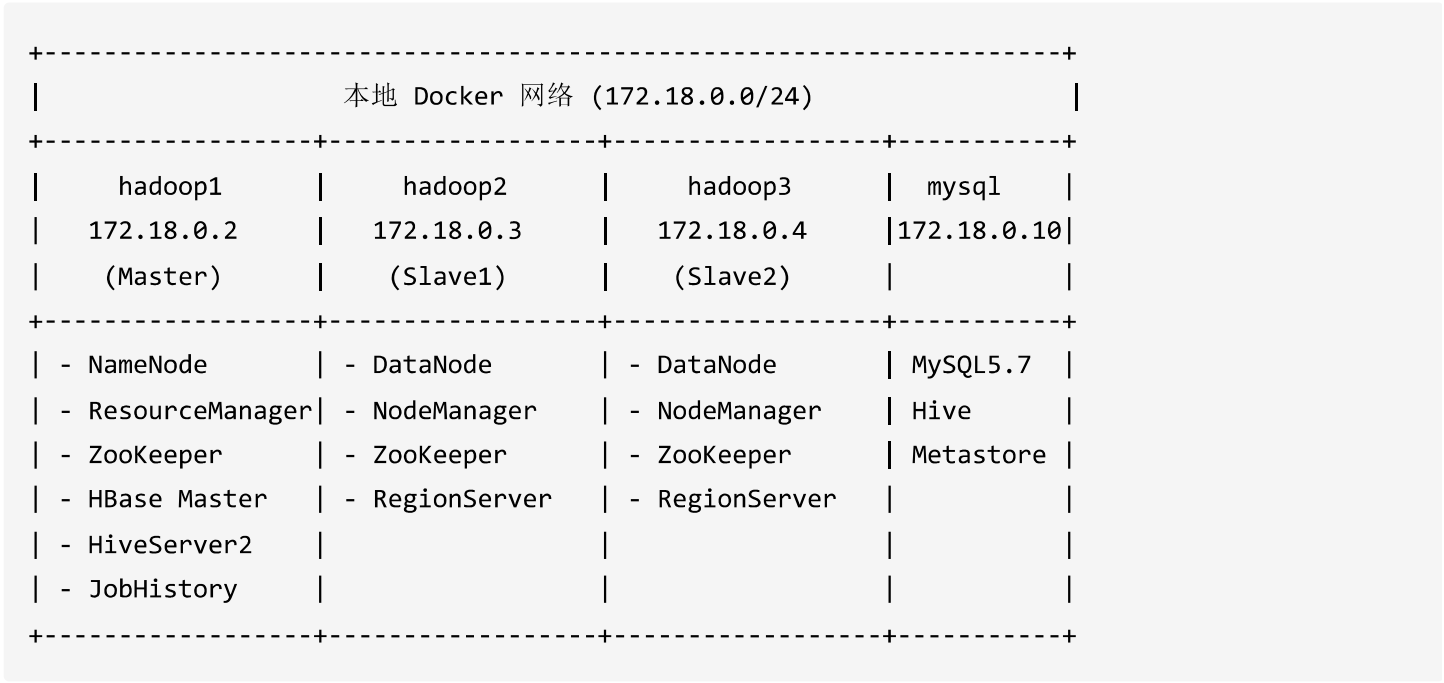
技术成果总结：

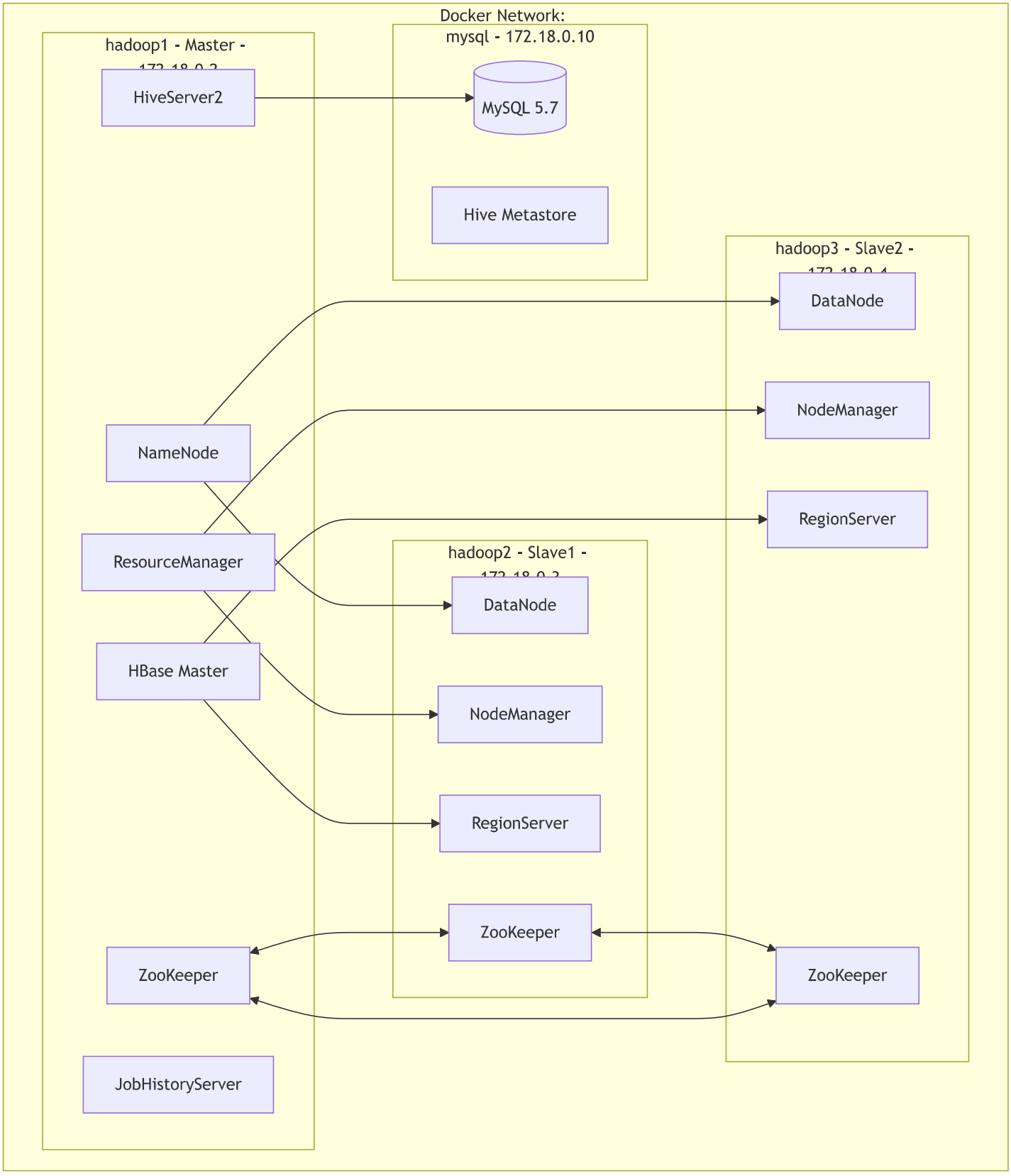
- 成功部署ZooKeeper集群并验证选举机制
- 搭建Hadoop HA集群（HDFS+YARN）并完成故障转移测试
- 部署HBase分布式数据库集群并设计用户行为数据表结构
- 集成Hive数据仓库并实现跨组件数据流转
- 建立基础监控体系并完成故障模拟处理

实现细节及步骤

1. 集群架构设计

1.1 整体架构图





1.2 节点角色分配表

节点名称	IP地址	角色	部署组件
hadoop1	172.18.0.2	Master	NameNode, ResourceManager, ZooKeeper, HBase Master, HiveServer2, JobHistoryServer

节点名称	IP地址	角色	部署组件
hadoop2	172.18.0.3	Slave	DataNode, NodeManager, ZooKeeper, HBase RegionServer
hadoop3	172.18.0.4	Slave	DataNode, NodeManager, ZooKeeper, HBase RegionServer
mysql	172.18.0.10	数据库	MySQL 5.7 (Hive Metastore)

1.3 端口规划表

服务	端口	用途
HDFS NameNode	9870	Web UI
HDFS NameNode	9000	RPC通信
YARN ResourceManager	8088	Web UI
ZooKeeper	2181	客户端连接
ZooKeeper	2888	Follower通信
ZooKeeper	3888	Leader选举
HBase Master	16010	Web UI
HBase RegionServer	16030	Web UI
HiveServer2	10000	JDBC连接
JobHistoryServer	19888	Web UI
MySQL	3306	数据库连接

[截图占位符-1: 集群架构图]

> 提示: 可使用draw.io或Visio绘制架构图，保存为PNG格式插入此处

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2. 环境准备

2.1 基础环境配置

本项目采用Docker容器化部署，基于Ubuntu 22.04镜像构建。

2.1.1 软件版本信息

软件	版本	说明
Docker Desktop	latest	容器运行环境
OpenJDK	8	Java运行环境
Hadoop	3.3.6	分布式计算框架
ZooKeeper	3.8.4	分布式协调服务
HBase	2.5.7	列式数据库
Hive	3.1.3	数据仓库
MySQL	5.7	元数据存储

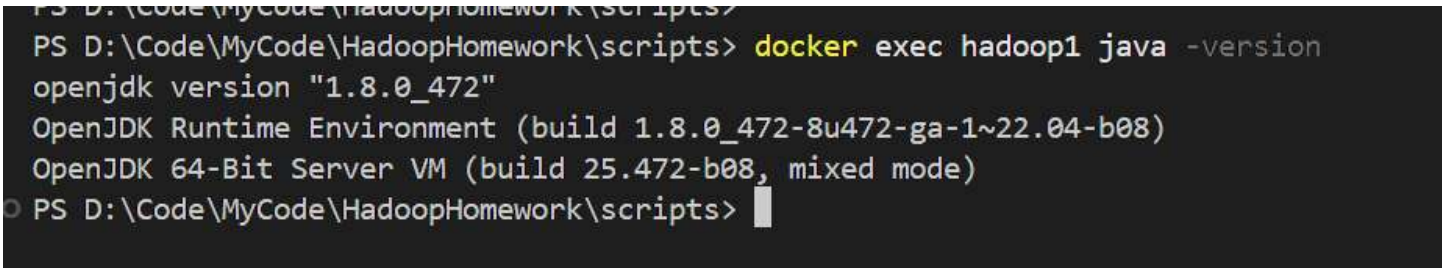
2.1.2 JDK环境配置

JDK安装路径: `/usr/lib/jvm/java-8-openjdk-amd64`

环境变量配置 (`/etc/profile`):

```
export JAVA_HOME=/usr/lib/jvm/java-8-openjdk-amd64
export PATH=$PATH:$JAVA_HOME/bin
```

验证命令:
在 hadoop1 中输入 `java -version`



2.2 网络配置

2.2.1 Docker网络配置

网络名称: `compose_hadoop-net`
网络类型: bridge
子网范围: 172.18.0.0/24

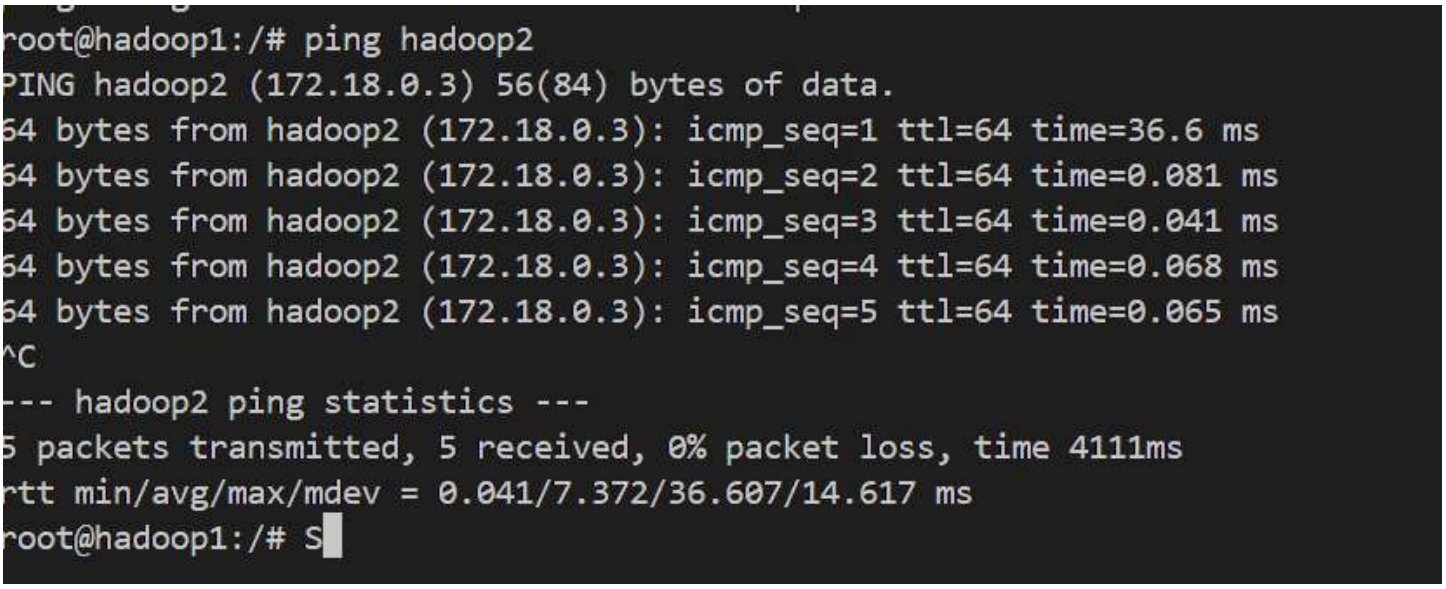
2.2.2 主机名解析配置

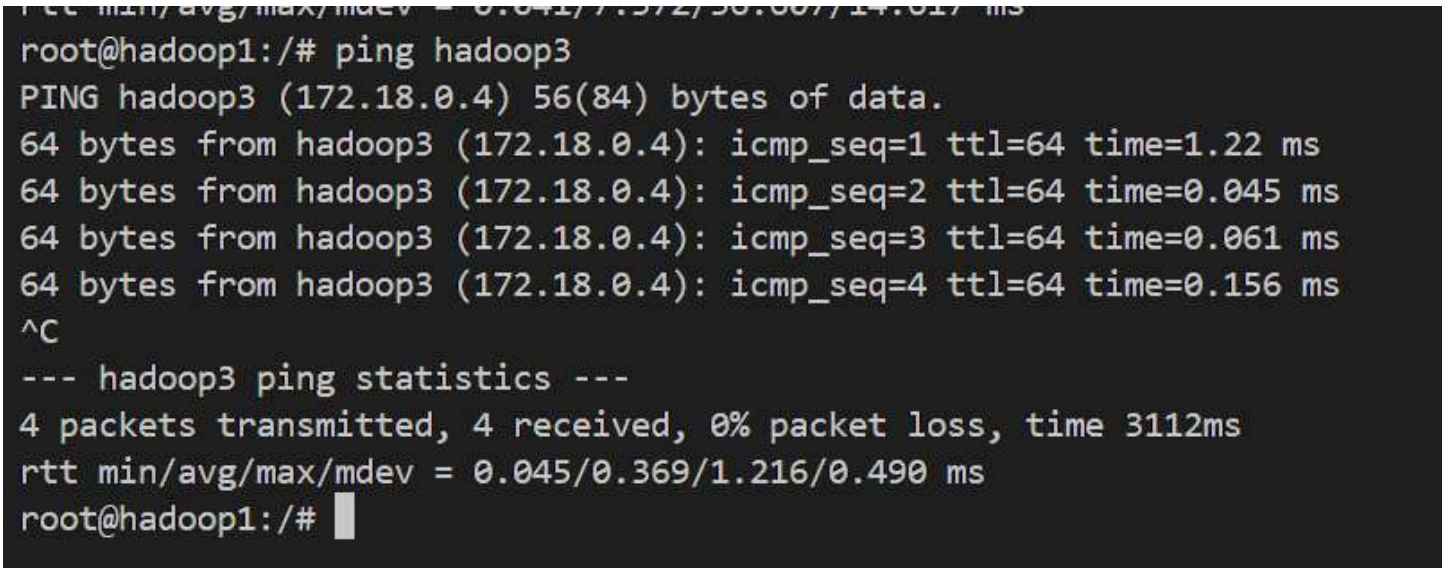
各节点 `/etc/hosts` 配置:

```
172.18.0.2  hadoop1
172.18.0.3  hadoop2
172.18.0.4  hadoop3
172.18.0.10 mysql
```

验证网络连通性:

```
# 在hadoop1上测试
ping hadoop2
ping hadoop3
```





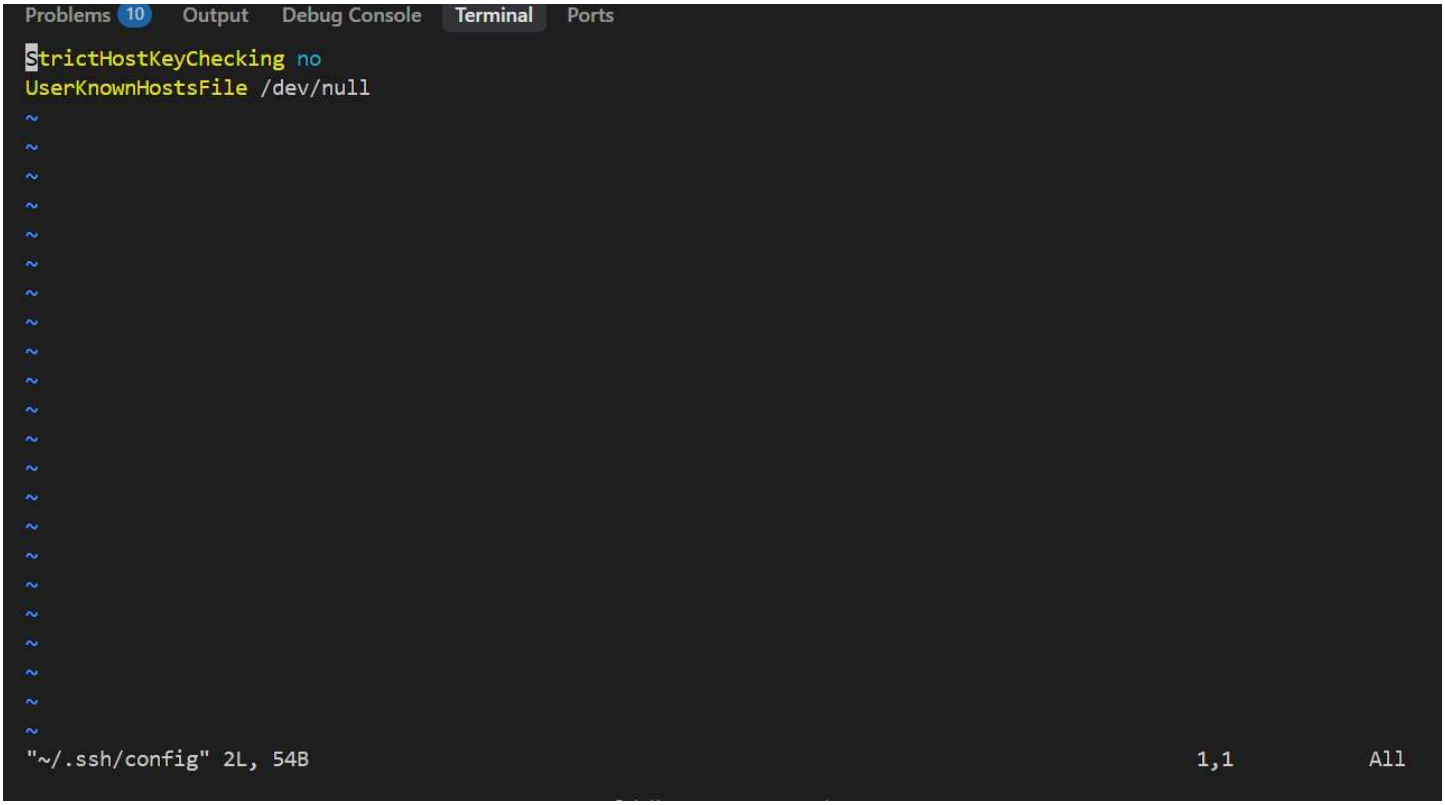
2.3 SSH免密登录配置

2.3.1 配置步骤

1. 生成SSH密钥对
2. 分发公钥到各节点
3. 配置SSH客户端

SSH配置文件 (`~/.ssh/config`):

```
StrictHostKeyChecking no
UserKnownHostsFile /dev/null
```



3. ZooKeeper集群部署

3.1 ZooKeeper配置

安装路径: `/usr/local/zookeeper`

3.1.1 核心配置文件 (zoo.cfg)

```
tickTime=2000
initLimit=10
syncLimit=5
dataDir=/data/zookeeper/data
dataLogDir=/data/zookeeper/logs
clientPort=2181
server.1=hadoop1:2888:3888
server.2=hadoop2:2888:3888
server.3=hadoop3:2888:3888
```

3.1.2 配置参数说明

参数	值	说明
tickTime	2000	心跳时间间隔(毫秒)
initLimit	10	初始化连接超时(tickTime倍数)
syncLimit	5	同步超时(tickTime倍数)
dataDir	/data/zookeeper/data	数据存储目录
clientPort	2181	客户端连接端口

3.1.3 myid配置

各节点myid文件内容:

节点	myid内容
hadoop1	1
hadoop2	2
hadoop3	3

3.2 ZooKeeper集群验证

3.2.1 服务状态检查

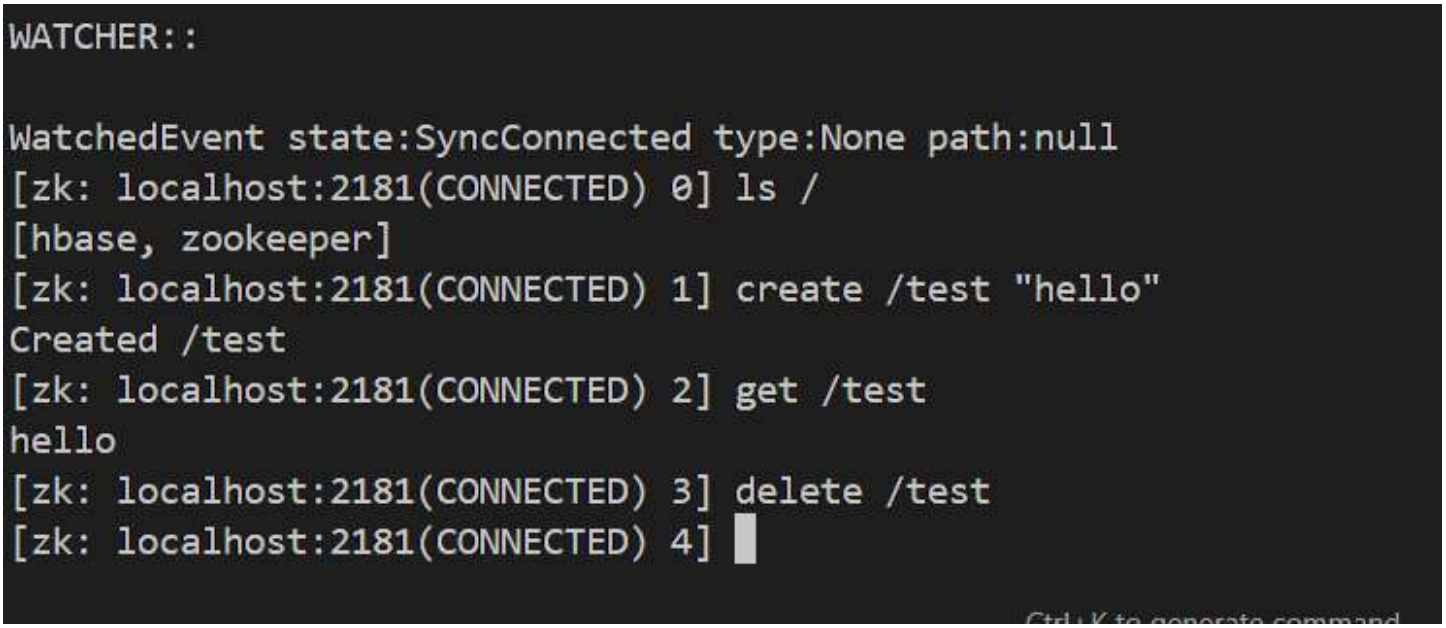
在各节点执行 `zkServer.sh status`

- 一个节点显示 `Mode: leader`
- 两个节点显示 `Mode: follower`

```
root@hadoop1:/#
PS D:\Code\MyCode\HadoopHomework\scripts> docker exec hadoop1 zkServer.sh status
ZooKeeper JMX enabled by default
Using config: /usr/local/zookeeper/bin/../conf/zoo.cfg
Client port found: 2181. Client address: localhost. Client SSL: false.
Mode: follower
PS D:\Code\MyCode\HadoopHomework\scripts> docker exec hadoop2 zkServer.sh status
ZooKeeper JMX enabled by default
Using config: /usr/local/zookeeper/bin/../conf/zoo.cfg
Client port found: 2181. Client address: localhost. Client SSL: false.
Mode: follower
PS D:\Code\MyCode\HadoopHomework\scripts> docker exec hadoop3 zkServer.sh status
ZooKeeper JMX enabled by default
Using config: /usr/local/zookeeper/bin/../conf/zoo.cfg
Client port found: 2181. Client address: localhost. Client SSL: false.
Mode: leader
PS D:\Code\MyCode\HadoopHomework\scripts>
```

3.2.2 集群选举验证

```
# 连接ZooKeeper客户端
zkCli.sh -server hadoop1:2181

# 执行命令
ls /
create /test "hello"
get /test
delete /test
```



4. Hadoop集群部署

4.1 HDFS配置

安装路径: `/usr/local/hadoop`

4.1.1 core-site.xml 配置

```
<configuration>
    <property>
        <name>fs.defaultFS</name>
        <value>hdfs://hadoop1:9000</value>
    </property>
    <property>
        <name>hadoop.tmp.dir</name>
        <value>/data/hadoop/tmp</value>
    </property>
</configuration>
```

4.1.2 hdfs-site.xml 配置

```
<configuration>
    <property>
        <name>dfs.replication</name>
        <value>2</value>
    </property>
    <property>
        <name>dfs.namenode.name.dir</name>
        <value>/data/hadoop/name</value>
    </property>
    <property>
        <name>dfs.datanode.data.dir</name>
        <value>/data/hadoop/data</value>
    </property>
    <property>
        <name>dfs.webhdfs.enabled</name>
        <value>true</value>
    </property>
</configuration>
```

4.1.3 workers 配置

```
hadoop1
hadoop2
hadoop3
```

4.2 YARN配置

4.2.1 yarn-site.xml 配置

```
<configuration>
    <property>
        <name>yarn.resourcemanager.hostname</name>
        <value>hadoop1</value>
    </property>
    <property>
        <name>yarn.nodemanager.aux-services</name>
        <value>mapreduce_shuffle</value>
    </property>
    <property>
        <name>yarn.nodemanager.resource.memory-mb</name>
        <value>4096</value>
    </property>
</configuration>
```

4.2.2 mapred-site.xml 配置

```
<configuration>
    <property>
        <name>mapreduce.framework.name</name>
        <value>yarn</value>
    </property>
    <property>
        <name>mapreduce.jobhistory.address</name>
        <value>hadoop1:10020</value>
    </property>
</configuration>
```

4.3 Hadoop集群验证

4.3.1 HDFS状态检查

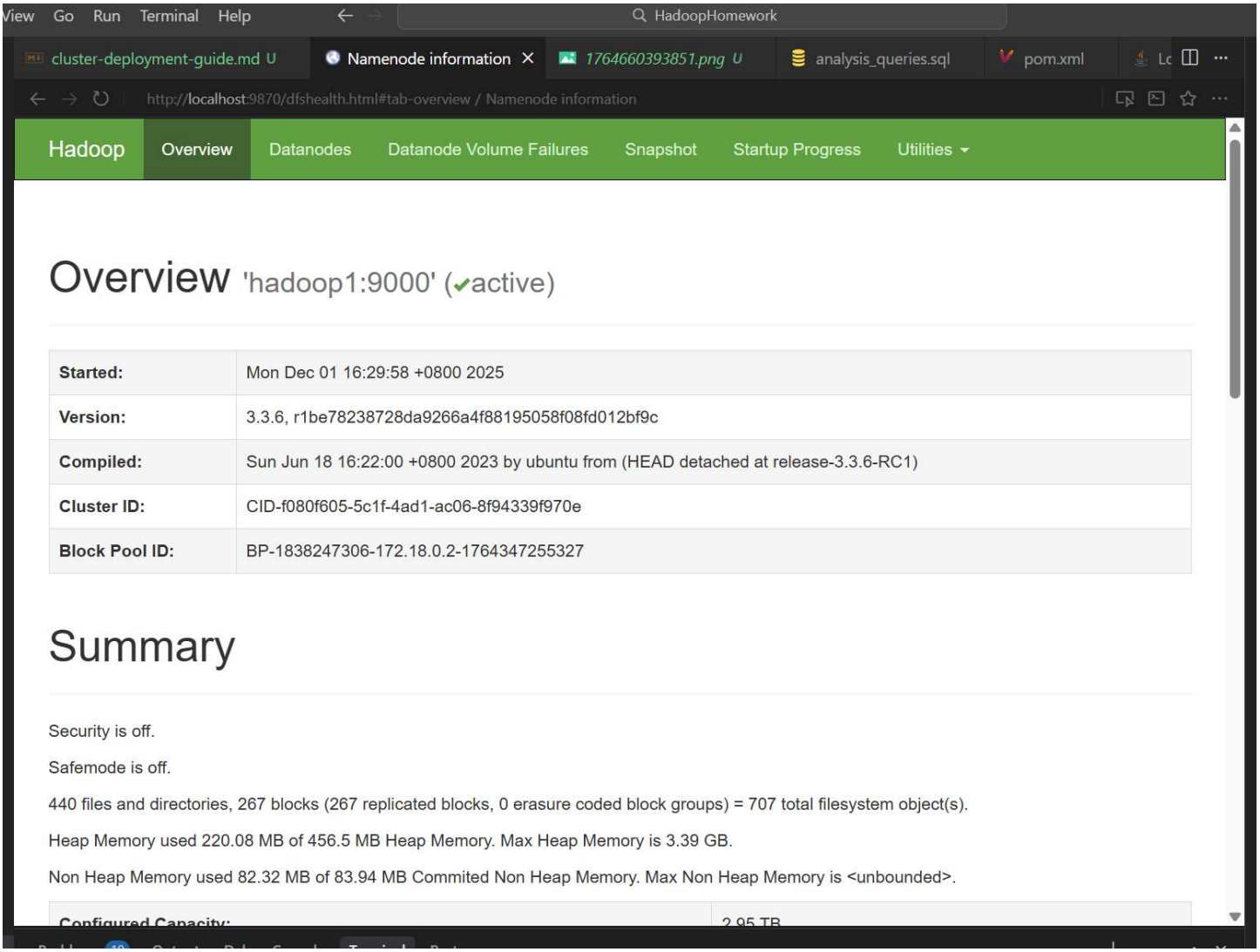
```
# 查看HDFS报告
hdfs dfsadmin -report
```

```
PS D:\Code\MyCode\HadoopHomework\scripts> docker exec hadoop1 hdfs dfsadmin -report
WARNING: log4j.properties is not found. HADOOP_CONF_DIR may be incomplete.
Configured Capacity: 3243303530496 (2.95 TB)
Present Capacity: 3015451485672 (2.74 TB)
DFS Remaining: 3015443133096 (2.74 TB)
DFS Used: 8352576 (7.97 MB)
DFS Used%: 0.00%
Replicated Blocks:
        Under replicated blocks: 0
        Blocks with corrupt replicas: 0
        Missing blocks: 0
        Missing blocks (with replication factor 1): 0
        Low redundancy blocks with highest priority to recover: 0
        Pending deletion blocks: 0
Erasure Coded Block Groups:
        Low redundancy block groups: 0
        Block groups with corrupt internal blocks: 0
        Missing block groups: 0
        Low redundancy blocks with highest priority to recover: 0
        Pending deletion blocks: 0

-------------------------------------------------
Live datanodes (3):

Name: 172.18.0.2:9866 (hadoop1)
Hostname: hadoop1
Decommission Status : Normal
Configured Capacity: 1081101176832 (1006.85 GB)
DFS Used: 4038968 (3.85 MB)
Non DFS Used: 20241243848 (18.85 GB)
DFS Remaining: 1004789797204 (935.78 GB)
DFS Used%: 0.00%
DFS Remaining%: 92.94%
Configured Cache Capacity: 0 (0 B)
Cache Used: 0 (0 B)
Cache Remaining: 0 (0 B)
Cache Used%: 100.00%
Cache Remaining%: 0.00%
Xceivers: 8
Last contact: Tue Dec 02 07:46:24 GMT 2025
Last Block Report: Mon Dec 01 10:27:50 GMT 2025
Num of Blocks: 257


Name: 172.18.0.3:9866 (hadoop2)
Hostname: hadoop2
```

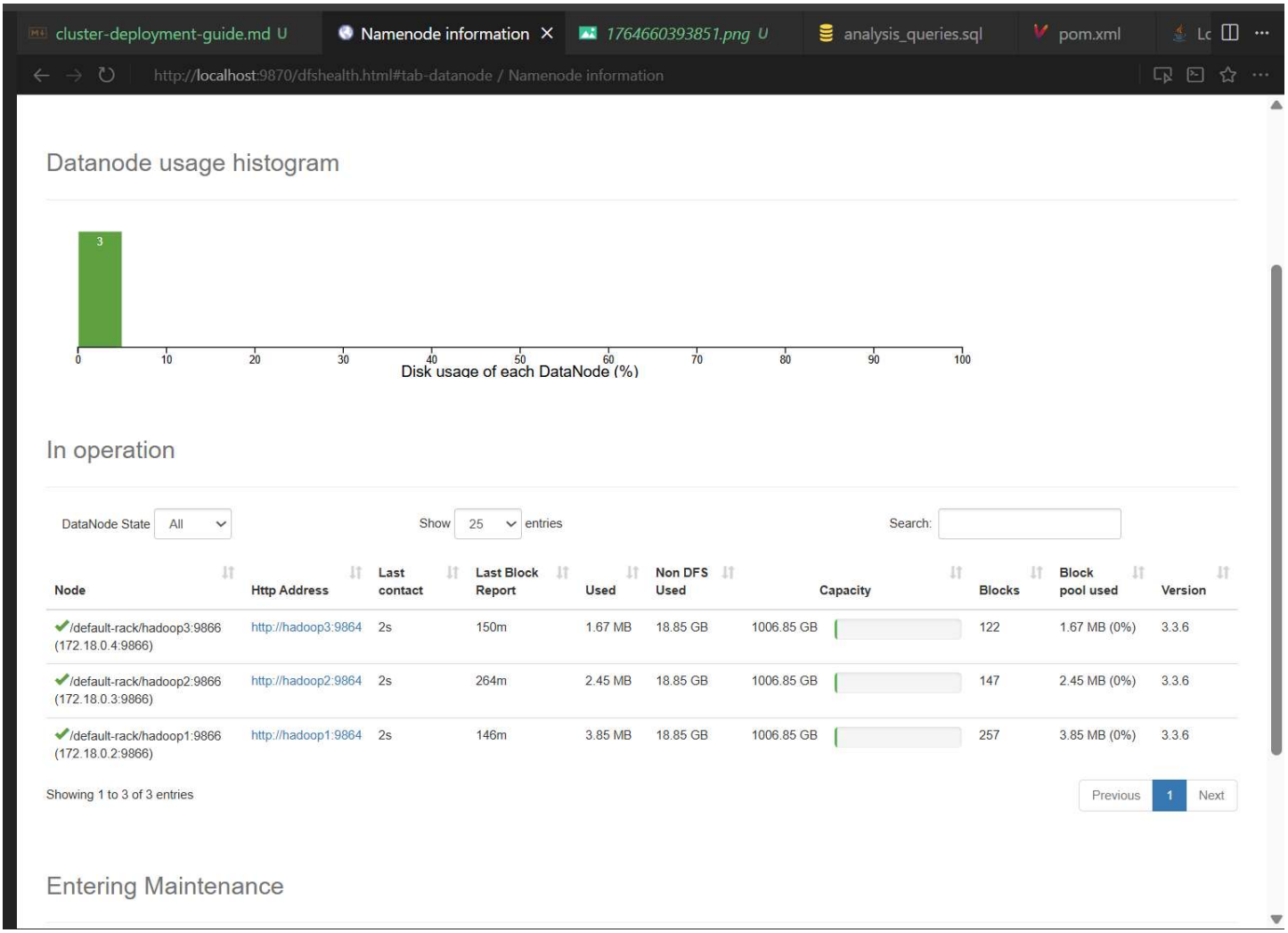
```
Decommission Status : Normal
Configured Capacity: 1081101176832 (1006.85 GB)
DFS Used: 2564408 (2.45 MB)
Non DFS Used: 20242718408 (18.85 GB)
DFS Remaining: 1005326667946 (936.28 GB)
DFS Used%: 0.00%
DFS Remaining%: 92.99%
Configured Cache Capacity: 0 (0 B)
Cache Used: 0 (0 B)
Cache Remaining: 0 (0 B)
Cache Used%: 100.00%
Cache Remaining%: 0.00%
Xceivers: 4
Last contact: Tue Dec 02 07:46:24 GMT 2025
Last Block Report: Mon Dec 01 08:30:02 GMT 2025
Num of Blocks: 147


Name: 172.18.0.4:9866 (hadoop3)
Hostname: hadoop3
Decommission Status : Normal
Configured Capacity: 1081101176832 (1006.85 GB)
DFS Used: 1749200 (1.67 MB)
Non DFS Used: 20243533616 (18.85 GB)
DFS Remaining: 1005326667946 (936.28 GB)
DFS Used%: 0.00%
DFS Remaining%: 92.99%
Configured Cache Capacity: 0 (0 B)
Cache Used: 0 (0 B)
Cache Remaining: 0 (0 B)
Cache Used%: 100.00%
Cache Remaining%: 0.00%
Xceivers: 4
Last contact: Tue Dec 02 07:46:24 GMT 2025
Last Block Report: Mon Dec 01 10:23:38 GMT 2025
Num of Blocks: 122
```

4.3.2 HDFS Web UI

访问地址: http://localhost:9870



HDFS DataNodes列表:



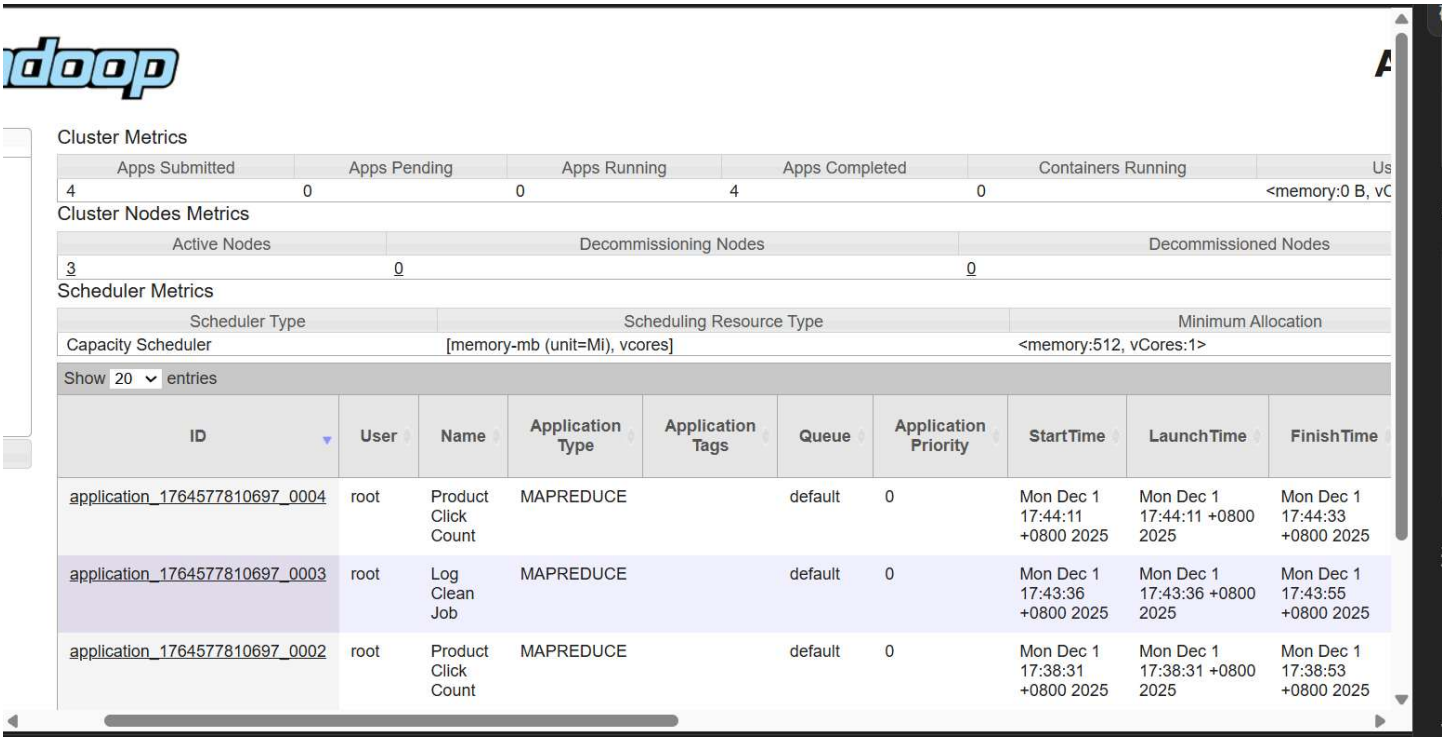
4.3.3 YARN状态检查

```
# 查看节点列表
yarn node -list
```

```
PS D:\Code\MyCode\HadoopHomework\scripts> docker exec hadoop1 yarn node -list
WARNING: log4j.properties is not found. HADOOP_CONF_DIR may be incomplete.
2025-12-02 07:49:09,187 INFO  [main] client.DefaultNoHARMFailoverProxyProvider (DefaultNoHARMFailoverProxyProvide
r.java:init(64)) - Connecting to ResourceManager at hadoop1/172.18.0.2:8032
Total Nodes:3
         Node-Id             Node-State Node-Http-Address       Number-of-Running-Containers
   hadoop1:36919                RUNNING      hadoop1:8042                                  0
   hadoop3:39447                RUNNING      hadoop3:8042                                  0
   hadoop2:42473                RUNNING      hadoop2:8042                                  0
```

4.3.4 YARN Web UI

访问地址: http://localhost:8088



Cluster Metrics

Apps Submitted	Apps Pending	Apps Running	Apps Completed	Containers Running	Us
4	0	0	4	0	<memory:0 B, vC

Cluster Nodes Metrics

Active Nodes	Decommissioning Nodes	Decommissioned Nodes
3	0	0

Scheduler Metrics

Scheduler Type	Scheduling Resource Type	Minimum Allocation
Capacity Scheduler	[memory-mb (unit=Mi), vcores]	<memory:512, vCores:1>

Show 20 entries

ID	User	Name	Application Type	Application Tags	Queue	Application Priority	StartTime	LaunchTime	FinishTime
application_1764577810697_0004	root	Product Click Count	MAPREDUCE		default	0	Mon Dec 1 17:44:11 +0800 2025	Mon Dec 1 17:44:11 +0800 2025	Mon Dec 1 17:44:33 +0800 2025
application_1764577810697_0003	root	Log Clean Job	MAPREDUCE		default	0	Mon Dec 1 17:43:36 +0800 2025	Mon Dec 1 17:43:36 +0800 2025	Mon Dec 1 17:43:55 +0800 2025
application_1764577810697_0002	root	Product Click Count	MAPREDUCE		default	0	Mon Dec 1 17:38:31 +0800 2025	Mon Dec 1 17:38:31 +0800 2025	Mon Dec 1 17:38:53 +0800 2025

5. HBase集群部署

5.1 HBase配置

安装路径: `/usr/local/hbase`

5.1.1 hbase-site.xml 配置

```
<configuration>
    <property>
        <name>hbase.cluster.distributed</name>
        <value>true</value>
    </property>
    <property>
        <name>hbase.rootdir</name>
        <value>hdfs://hadoop1:9000/hbase</value>
    </property>
    <property>
        <name>hbase.zookeeper.quorum</name>
        <value>hadoop1,hadoop2,hadoop3</value>
    </property>
</configuration>
```

5.1.2 regionservers 配置

```
hadoop2
hadoop3
```

5.1.3 hbase-env.sh 配置

```
export JAVA_HOME=/usr/lib/jvm/java-8-openjdk-amd64
export HBASE_MANAGES_ZK=false
```

5.2 HBase集群验证

5.2.1 HBase进程检查

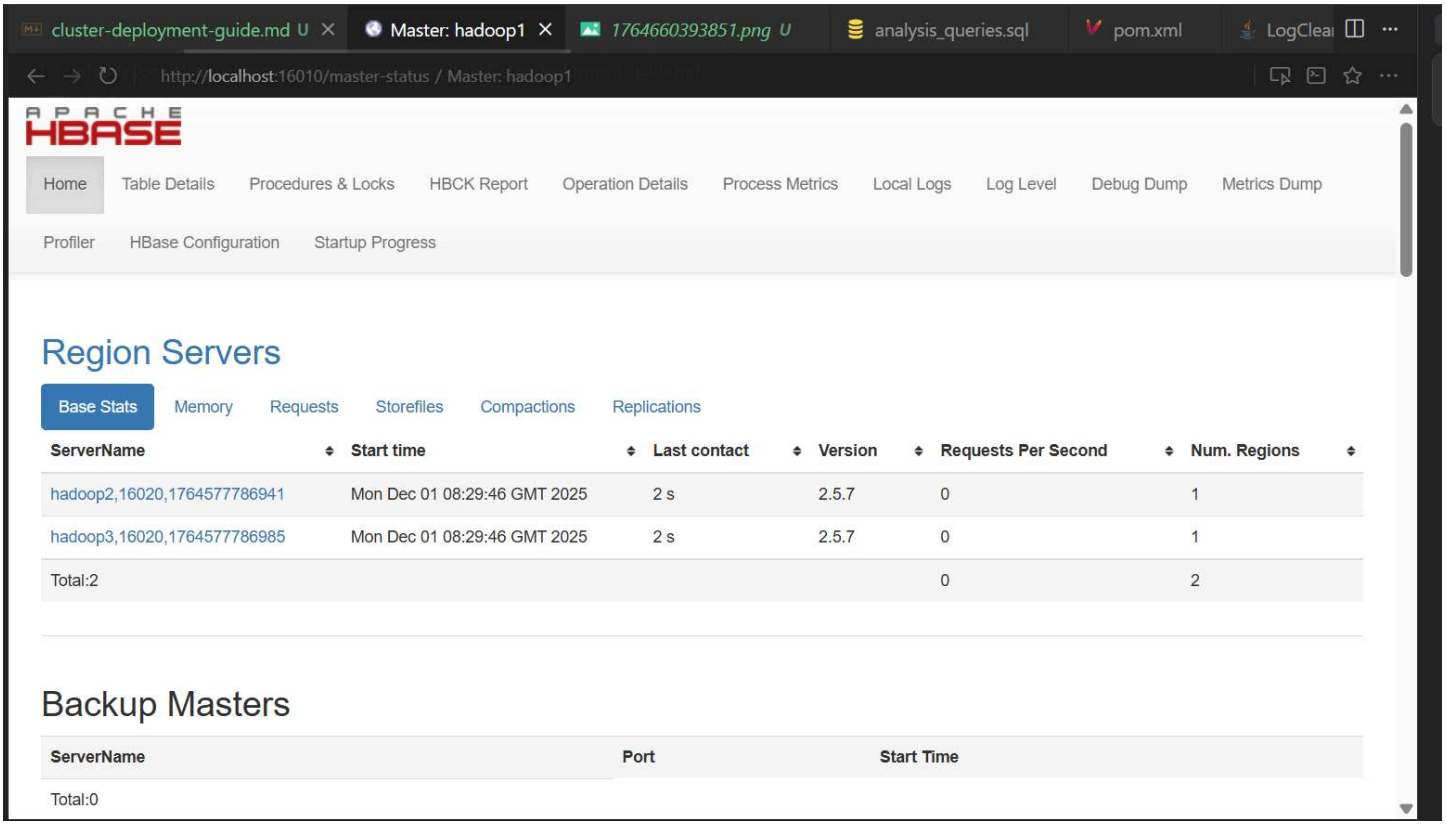
```
# 在各节点执行jps
jps
```

```
PS D:\Code\MyCode\HadoopHomework\scripts> docker exec hadoop1 jps
1056 NodeManager
2096 HMaster
11472 ZooKeeperMain
11904 Jps
2705 RunJar
242 NameNode
916 ResourceManager
11542 ZooKeeperMain
634 SecondaryNameNode
381 DataNode
29 QuorumPeerMain
1486 JobHistoryServer
```

```
PS D:\Code\MyCode\HadoopHomework\scripts> docker exec hadoop2 jps
2083 Jps
531 DataNode
663 NodeManager
119 HRegionServer
28 QuorumPeerMain
PS D:\Code\MyCode\HadoopHomework\scripts> docker exec hadoop3 jps
538 DataNode
123 HRegionServer
28 QuorumPeerMain
2335 Jps
671 NodeManager
```

5.2.2 HBase Web UI

访问地址: http://localhost:16010



6. Hive数据仓库部署

6.1 Hive配置

安装路径: `/usr/local/hive`

6.1.1 hive-site.xml 配置

```
<configuration>
    <property>
        <name>javax.jdo.option.ConnectionURL</name>
        <value>jdbc:mysql://mysql:3306/hive_metastore?createDatabaseIfNotExist=true</value>
    </property>
    <property>
        <name>javax.jdo.option.ConnectionDriverName</name>
        <value>com.mysql.cj.jdbc.Driver</value>
    </property>
    <property>
        <name>javax.jdo.option.ConnectionUserName</name>
        <value>hive</value>
    </property>
    <property>
        <name>javax.jdo.option.ConnectionPassword</name>
        <value>hive123</value>
    </property>
    <property>
        <name>hive.metastore.warehouse.dir</name>
        <value>/user/hive/warehouse</value>
    </property>
</configuration>
```

6.2 MySQL元数据库配置

6.2.1 数据库信息

项目	值
数据库主机	mysql (172.18.0.10)
数据库端口	3306
数据库名称	hive_metastore
用户名	hive
密码	hive123

6.3 Hive功能验证

6.3.1 HiveServer2服务检查

```
# 检查HiveServer2进程
jps | grep RunJar

# 检查端口监听
netstat -tlnp | grep 10000
```

```
PS D:\Code\MyCode\HadoopHomework\scripts> docker exec hadoop1 bash -c "jps | grep RunJar && netstat -tlnp | grep
10000"
2705 RunJar
tcp6       0      0 :::10000                :::*                    LISTEN      2705/java
PS D:\Code\MyCode\HadoopHomework\scripts>
```

6.3.2 Hive CLI操作验证

```
# 进入Hive CLI
hive
```

所有数据库：

```
hive (default)> show databases;
OK
database_name
default
ecommerce
test_db
Time taken: 0.181 seconds, Fetched: 3 row(s)
```

所有表格：

```
hive (default)> show tables
              > ;
OK
tab_name
raw_user_behavior
Time taken: 0.037 seconds, Fetched: 1 row(s)
hive (default)>
```

执行hive结果：

```
hive (default)> select * from raw_user_behavior;
OK
raw_user_behavior.user_id       raw_user_behavior.product_id    raw_user_behavior.action_type   raw_user_behavior
.duration       raw_user_behavior.event_time
1001    P001    click   5       2024-12-01 10:00:01
1001    P001    browse  120     2024-12-01 10:00:10
1001    P001    cart    2       2024-12-01 10:02:15
1002    P002    click   3       2024-12-01 10:05:00
1002    P002    browse  60      2024-12-01 10:05:05
1003    P001    click   8       2024-12-01 10:10:00
1003    P001    browse  180     2024-12-01 10:10:10
1003    P001    cart    1       2024-12-01 10:13:30
1003    P001    order   5       2024-12-01 10:14:00
1001    P002    click   4       2024-12-01 10:20:00
1001    P003    click   6       2024-12-01 10:25:00
1001    P003    browse  90      2024-12-01 10:25:10
1004    P002    click   2       2024-12-01 10:30:00
1004    P002    browse  45      2024-12-01 10:30:05
1004    P002    cart    3       2024-12-01 10:31:00
1004    P002    order   8       2024-12-01 10:32:00
1005    P004    click   5       2024-12-01 10:35:00
1005    P004    browse  200     2024-12-01 10:35:10
1002    P003    click   7       2024-12-01 10:40:00
1002    P003    browse  150     2024-12-01 10:40:10
1002    P003    cart    2       2024-12-01 10:43:00
1006    P001    click   4       2024-12-01 10:45:00
1006    P001    browse  80      2024-12-01 10:45:05
```

6.3.3 Beeline连接测试

```
beeline -u jdbc:hive2://localhost:10000 -n root
```

```
root@hadoop1:/# beeline -u jdbc:hive2://localhost:10000 -n root
WARNING: log4j.properties is not found. HADOOP_CONF_DIR may be incomplete.
SLF4J: Class path contains multiple SLF4J bindings.
SLF4J: Found binding in [jar:file:/usr/local/hive/lib/log4j-slf4j-impl-2.17.1.jar!/org/slf4j/impl/StaticLoggerBi
der.class]
SLF4J: Found binding in [jar:file:/usr/local/hadoop/share/hadoop/common/lib/slf4j-reload4j-1.7.36.jar!/org/slf4j
impl/StaticLoggerBinder.class]
SLF4J: See http://www.slf4j.org/codes.html#multiple_bindings for an explanation.
SLF4J: Actual binding is of type [org.apache.logging.slf4j.Log4jLoggerFactory]
Connecting to jdbc:hive2://localhost:10000
Connected to: Apache Hive (version 3.1.3)
Driver: Hive JDBC (version 3.1.3)
Transaction isolation: TRANSACTION_REPEATABLE_READ
Beeline version 3.1.3 by Apache Hive
0: jdbc:hive2://localhost:10000>
0: jdbc:hive2://localhost:10000>
0: jdbc:hive2://localhost:10000>
0: jdbc:hive2://localhost:10000>
```

7. 集群功能验证

7.1 跨组件数据流转测试

本节验证数据在各组件间的流转: HDFS -> MapReduce -> Hive

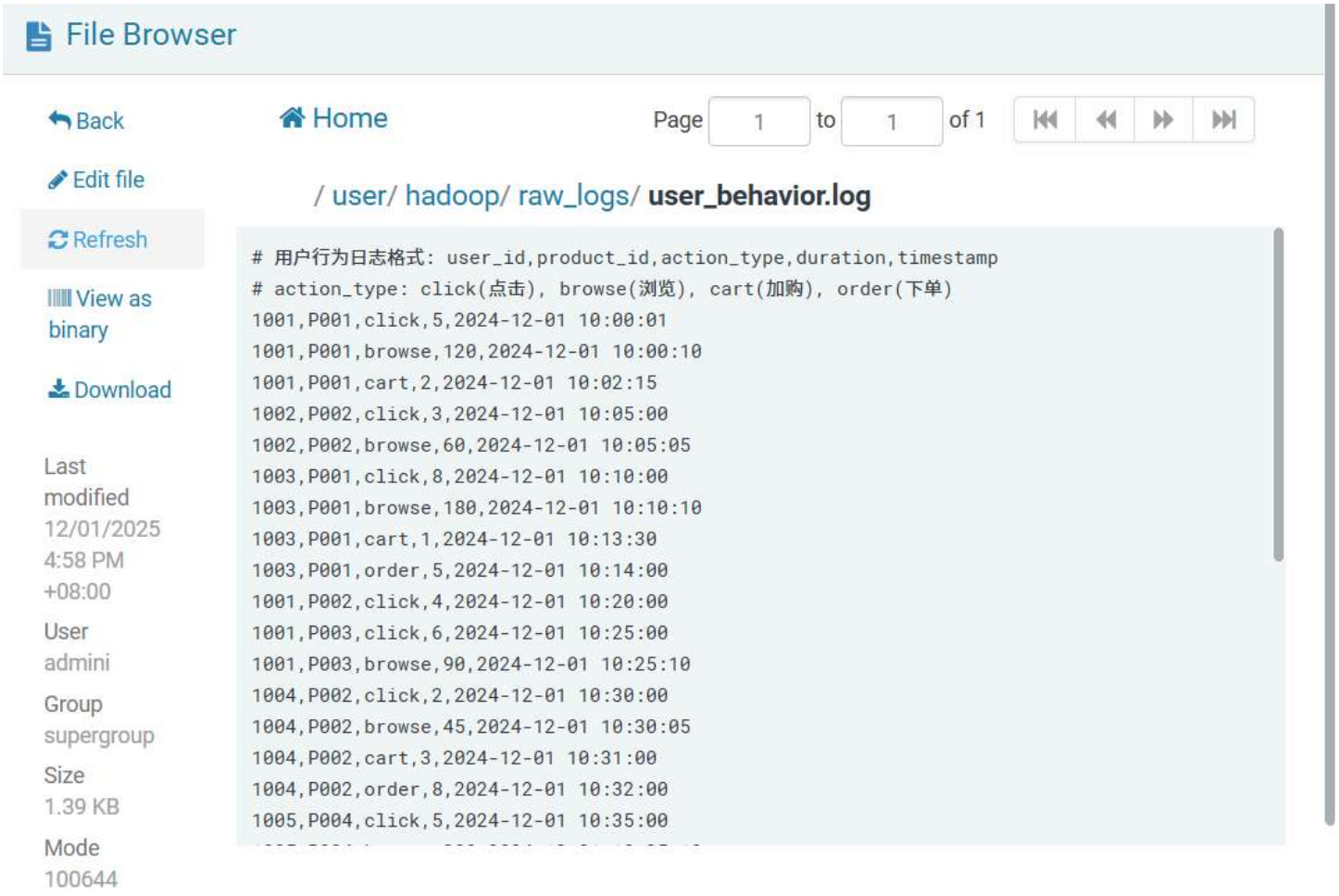
7.1.1 测试数据准备

测试数据文件: `user_behavior.log`

```
1001,P001,click,5,2024-12-01 10:00:01
1001,P001,browse,120,2024-12-01 10:00:10
1002,P002,click,3,2024-12-01 10:05:00
...
```

7.1.2 数据上传到HDFS

```
hdfs dfs -mkdir -p /user/hadoop/raw_logs
hdfs dfs -put user_behavior.log /user/hadoop/raw_logs/
hdfs dfs -ls /user/hadoop/raw_logs/
```



7.1.3 MapReduce数据处理

a. 运行数据清洗任务

```
hadoop jar /opt/mapreduce/target/ecommerce-analysis-1.0-SNAPSHOT.jar \
    com.ecommerce.clean.LogCleanDriver \
    /user/hadoop/raw_logs \
    /user/hadoop/cleaned_data
```

```
810697_0005
2025-12-02 08:09:04,422 INFO  [main] mapreduce.Job (Job.java:monitorAndPrintJob(1748)) - Job job_1764577810697_00
05 running in uber mode : false
2025-12-02 08:09:04,424 INFO  [main] mapreduce.Job (Job.java:monitorAndPrintJob(1755)) -  map 0% reduce 0%
2025-12-02 08:09:09,479 INFO  [main] mapreduce.Job (Job.java:monitorAndPrintJob(1755)) -  map 100% reduce 0%
2025-12-02 08:09:09,488 INFO  [main] mapreduce.Job (Job.java:monitorAndPrintJob(1766)) - Job job_1764577810697_00
05 completed successfully
2025-12-02 08:09:09,584 INFO  [main] mapreduce.Job (Job.java:monitorAndPrintJob(1773)) - Counters: 34
        File System Counters
                FILE: Number of bytes read=0
                FILE: Number of bytes written=277171
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=1549
                HDFS: Number of bytes written=1238
                HDFS: Number of read operations=7
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=2
                HDFS: Number of bytes read erasure-coded=0
        Job Counters
                Launched map tasks=1
                Data-local map tasks=1
                Total time spent by all maps in occupied slots (ms)=5012
                Total time spent by all reduces in occupied slots (ms)=0
                Total time spent by all map tasks (ms)=2506
                Total vcore-milliseconds taken by all map tasks=2506
                Total megabyte-milliseconds taken by all map tasks=2566144
        Map-Reduce Framework
```

```
root@hadoop1:~# hadoop jar /opt/mapreduce/target/ecommerce-analysis-1.0-SNAPSHOT.jar \
    com.ecommerce.clean.LogCleanDriver \
    /user/hadoop/raw_logs \
    /user/hadoop/cleaned_data
WARNING: log4j.properties is not found. HADOOP_CONF_DIR may be incomplete.
Output directory exists, deleting: /user/hadoop/cleaned_data
2025-12-02 08:08:57,210 INFO  [main] client.DefaultNoHARMFailoverProxyProvider (DefaultNoHARMFa
2025-12-02 08:08:57,546 INFO  [main] mapreduce.JobResourceUploader (JobResourceUploader.java:di
2025-12-02 08:08:57,849 INFO  [main] input.FileInputFormat (FileInputFormat.java:listStatus(306
2025-12-02 08:08:57,922 INFO  [main] mapreduce.JobSubmitter (JobSubmitter.java:submitJobInterna
2025-12-02 08:08:58,046 INFO  [main] mapreduce.JobSubmitter (JobSubmitter.java:printTokens(298)
2025-12-02 08:08:58,046 INFO  [main] mapreduce.JobSubmitter (JobSubmitter.java:printTokens(299)
2025-12-02 08:08:58,216 INFO  [main] conf.Configuration (Configuration.java:getConfResourceAsIn
2025-12-02 08:08:58,216 INFO  [main] resource.ResourceUtils (ResourceUtils.java:addResourcesFil
2025-12-02 08:08:58,294 INFO  [main] impl.YarnClientImpl (YarnClientImpl.java:submitApplicatior
2025-12-02 08:08:58,330 INFO  [main] mapreduce.Job (Job.java:submit(1682)) - The url to track t
2025-12-02 08:08:58,331 INFO  [main] mapreduce.Job (Job.java:monitorAndPrintJob(1727)) - Runnin
2025-12-02 08:09:04,422 INFO  [main] mapreduce.Job (Job.java:monitorAndPrintJob(1748)) - Job jo
2025-12-02 08:09:04,424 INFO  [main] mapreduce.Job (Job.java:monitorAndPrintJob(1755)) -  map 0
2025-12-02 08:09:09,479 INFO  [main] mapreduce.Job (Job.java:monitorAndPrintJob(1755)) -  map 1
2025-12-02 08:09:09,488 INFO  [main] mapreduce.Job (Job.java:monitorAndPrintJob(1766)) - Job jo
2025-12-02 08:09:09,584 INFO  [main] mapreduce.Job (Job.java:monitorAndPrintJob(1773)) - Counte
        File System Counters
                FILE: Number of bytes read=0
                FILE: Number of bytes written=277171
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=1549
                HDFS: Number of bytes written=1238
                HDFS: Number of read operations=7
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=2
                HDFS: Number of bytes read erasure-coded=0
        Job Counters
                Launched map tasks=1
                Data-local map tasks=1
                Total time spent by all maps in occupied slots (ms)=5012
                Total time spent by all reduces in occupied slots (ms)=0
                Total time spent by all map tasks (ms)=2506
                Total vcore-milliseconds taken by all map tasks=2506
                Total megabyte-milliseconds taken by all map tasks=2566144
        Map-Reduce Framework
                Map input records=35
                Map output records=32
                Input split bytes=123
```

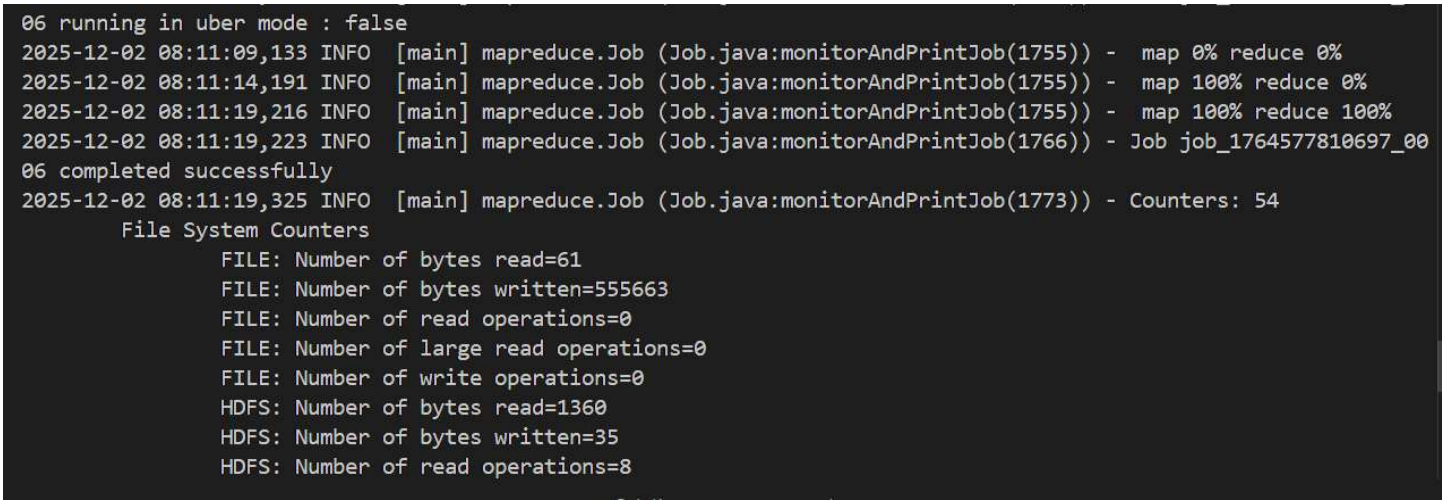
```
                Input split bytes=123
                Spilled Records=0
                Failed Shuffles=0
                Merged Map outputs=0
                GC time elapsed (ms)=30
                CPU time spent (ms)=320
                Physical memory (bytes) snapshot=212844544
                Virtual memory (bytes) snapshot=2594578432
                Total committed heap usage (bytes)=212860928
                Peak Map Physical memory (bytes)=212844544
                Peak Map Virtual memory (bytes)=2594578432
        CleanStats
                ValidRecords=32
        File Input Format Counters
                Bytes Read=1426
        File Output Format Counters
                Bytes Written=1238
root@hadoop1:~#




                Input split bytes=123
                Spilled Records=0
                Failed Shuffles=0
                Merged Map outputs=0
                GC time elapsed (ms)=30
                CPU time spent (ms)=320
                Physical memory (bytes) snapshot=212844544
                Virtual memory (bytes) snapshot=2594578432
                Total committed heap usage (bytes)=212860928
                Peak Map Physical memory (bytes)=212844544
                Peak Map Virtual memory (bytes)=2594578432
        CleanStats
                ValidRecords=32
        File Input Format Counters
                Bytes Read=1426
        File Output Format Counters
                Bytes Written=1238
root@hadoop1:~#

                Input split bytes=123
                Spilled Records=0
                Failed Shuffles=0
                Merged Map outputs=0
                GC time elapsed (ms)=30
```

```
		CPU time spent (ms)=320
		Physical memory (bytes) snapshot=212844544
		Virtual memory (bytes) snapshot=2594578432
		Total committed heap usage (bytes)=212860928
		Peak Map Physical memory (bytes)=212844544
		Peak Map Virtual memory (bytes)=2594578432
	CleanStats
		ValidRecords=32
	File Input Format Counters
		Input split bytes=123
		Spilled Records=0
		Failed Shuffles=0
		Merged Map outputs=0
		GC time elapsed (ms)=30
		CPU time spent (ms)=320
		Physical memory (bytes) snapshot=212844544
		Virtual memory (bytes) snapshot=2594578432
		Input split bytes=123
		Spilled Records=0
		Failed Shuffles=0
		Merged Map outputs=0
		GC time elapsed (ms)=30
		CPU time spent (ms)=320
		Input split bytes=123
		Spilled Records=0
		Failed Shuffles=0
		Merged Map outputs=0
		Spilled Records=0
		Failed Shuffles=0
		Merged Map outputs=0
		GC time elapsed (ms)=30
		Failed Shuffles=0
		Merged Map outputs=0
		GC time elapsed (ms)=30
		Merged Map outputs=0
		GC time elapsed (ms)=30
		GC time elapsed (ms)=30
		CPU time spent (ms)=320
		Physical memory (bytes) snapshot=212844544
		Virtual memory (bytes) snapshot=2594578432
		Total committed heap usage (bytes)=212860928
		Peak Map Physical memory (bytes)=212844544
		Peak Map Virtual memory (bytes)=2594578432
	CleanStats
		ValidRecords=32
	File Input Format Counters
```

```
                Bytes Read=1426
        File Output Format Counters
                Bytes Written=1238
```

b. 运行统计任务

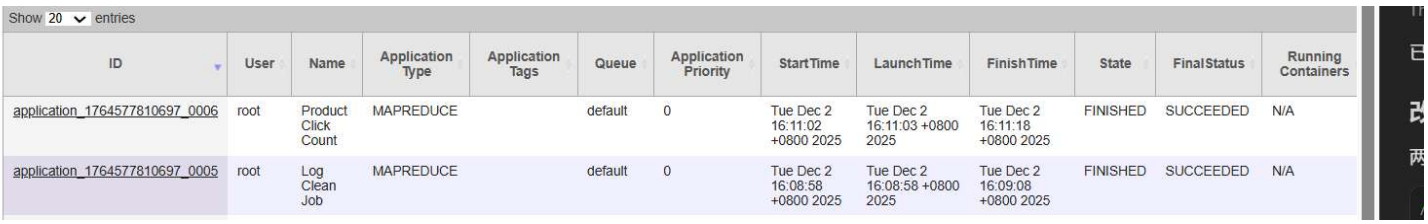
```
hadoop jar /opt/mapreduce/target/ecommerce-analysis-1.0-SNAPSHOT.jar \
    com.ecommerce.stats.ProductClickCount \
    /user/hadoop/cleaned_data \
    /user/hadoop/output/product_clicks
```



```
root@hadoop1:~# hadoop jar /opt/mapreduce/target/ecommerce-analysis-1.0-SNAPSHOT.jar \
    com.ecommerce.stats.ProductClickCount \
    /user/hadoop/cleaned_data \
    /user/hadoop/output/product_clicks
WARNING: log4j.properties is not found. HADOOP_CONF_DIR may be incomplete.
Output directory exists, deleting: /user/hadoop/output/product_clicks
2025-12-02 08:11:02,066 INFO  [main] client.DefaultNoHARMFailoverProxyProvider (DefaultNoHARMFa
2025-12-02 08:11:02,339 INFO  [main] mapreduce.JobResourceUploader (JobResourceUploader.java:di
2025-12-02 08:11:02,632 INFO  [main] input.FileInputFormat (FileInputFormat.java:listStatus(306
2025-12-02 08:11:02,699 INFO  [main] mapreduce.JobSubmitter (JobSubmitter.java:submitJobInterna
2025-12-02 08:11:02,788 INFO  [main] mapreduce.JobSubmitter (JobSubmitter.java:printTokens(298)
2025-12-02 08:11:02,788 INFO  [main] mapreduce.JobSubmitter (JobSubmitter.java:printTokens(299)
2025-12-02 08:11:02,951 INFO  [main] conf.Configuration (Configuration.java:getConfResourceAsIn
2025-12-02 08:11:02,951 INFO  [main] resource.ResourceUtils (ResourceUtils.java:addResourcesFil
2025-12-02 08:11:03,014 INFO  [main] impl.YarnClientImpl (YarnClientImpl.java:submitApplicatior
2025-12-02 08:11:03,050 INFO  [main] mapreduce.Job (Job.java:submit(1682)) - The url to track t
2025-12-02 08:11:03,051 INFO  [main] mapreduce.Job (Job.java:monitorAndPrintJob(1727)) - Runnin
2025-12-02 08:11:09,132 INFO  [main] mapreduce.Job (Job.java:monitorAndPrintJob(1748)) - Job jo
2025-12-02 08:11:09,133 INFO  [main] mapreduce.Job (Job.java:monitorAndPrintJob(1755)) -  map 0
2025-12-02 08:11:14,191 INFO  [main] mapreduce.Job (Job.java:monitorAndPrintJob(1755)) -  map 1
2025-12-02 08:11:19,216 INFO  [main] mapreduce.Job (Job.java:monitorAndPrintJob(1755)) -  map 1
2025-12-02 08:11:19,223 INFO  [main] mapreduce.Job (Job.java:monitorAndPrintJob(1766)) - Job jo
2025-12-02 08:11:19,325 INFO  [main] mapreduce.Job (Job.java:monitorAndPrintJob(1773)) - Counte
        File System Counters
                FILE: Number of bytes read=61
                FILE: Number of bytes written=555663
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=1360
                HDFS: Number of bytes written=35
                HDFS: Number of read operations=8
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=2
                HDFS: Number of bytes read erasure-coded=0
        Job Counters
                Launched map tasks=1
                Launched reduce tasks=1
                Data-local map tasks=1
                Total time spent by all maps in occupied slots (ms)=4854
                Total time spent by all reduces in occupied slots (ms)=5408
                Total time spent by all map tasks (ms)=2427
                Total time spent by all reduce tasks (ms)=2704
                Total vcore-milliseconds taken by all map tasks=2427
                Total vcore-milliseconds taken by all reduce tasks=2704
                Total megabyte-milliseconds taken by all map tasks=2485248
```

```
                Total megabyte-milliseconds taken by all reduce tasks=2768896
        Map-Reduce Framework
                Map input records=32
                Map output records=13
                Map output bytes=117
                Map output materialized bytes=61
                Input split bytes=122
                Combine input records=13
                Combine output records=5
                Reduce input groups=5
                Reduce shuffle bytes=61
                Reduce input records=5
                Reduce output records=5
                Spilled Records=10
                Shuffled Maps =1
                Failed Shuffles=0
                Merged Map outputs=1
                GC time elapsed (ms)=65
                CPU time spent (ms)=800
                Physical memory (bytes) snapshot=546078720
                Virtual memory (bytes) snapshot=5187530752
                Total committed heap usage (bytes)=531103744
                Peak Map Physical memory (bytes)=318783488
                Peak Map Virtual memory (bytes)=2589093888
                Peak Reduce Physical memory (bytes)=227295232
                Peak Reduce Virtual memory (bytes)=2598436864
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=1238
        File Output Format Counters
                Bytes Written=35
```

c. yarn 截图



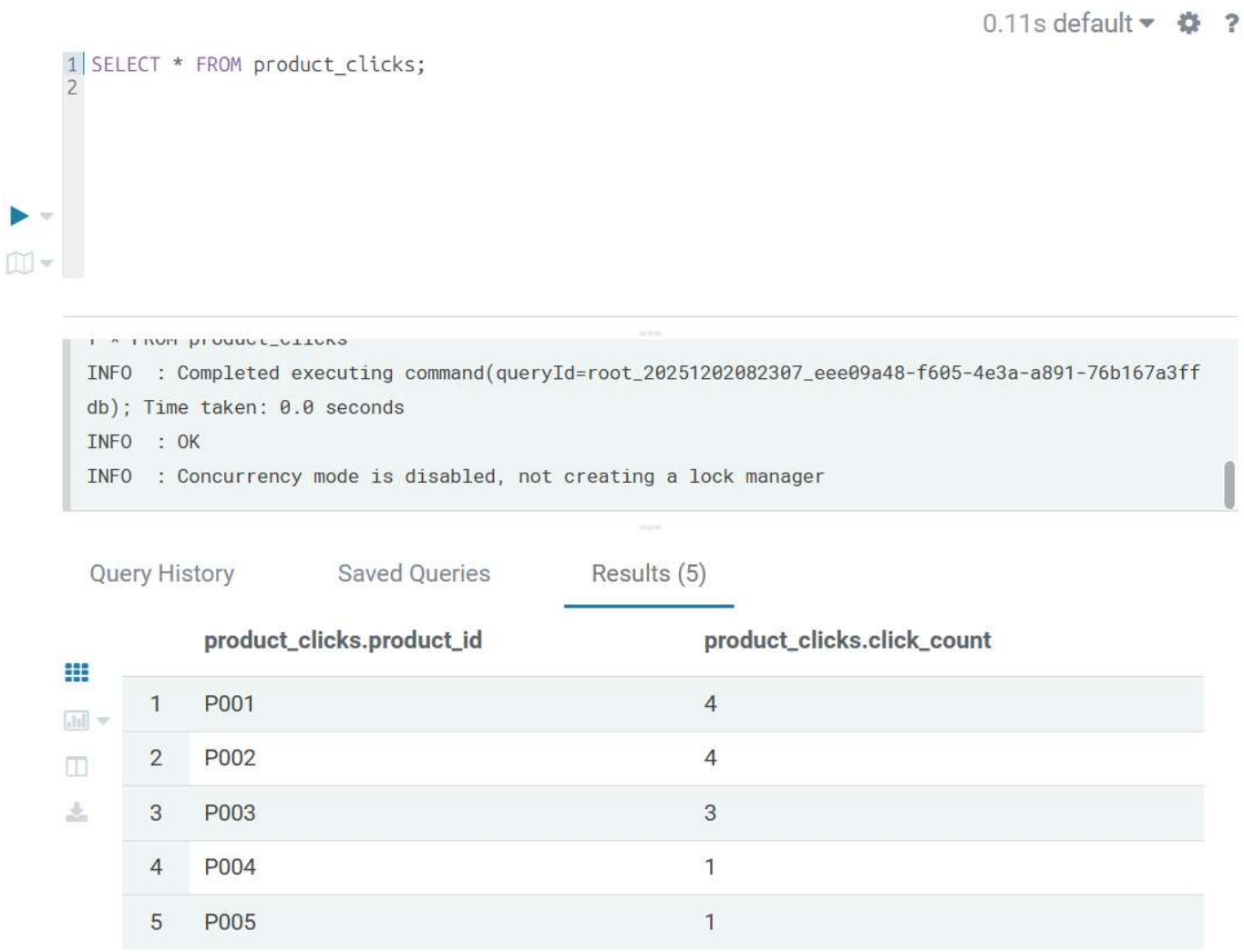
Show 20 entries

ID	User	Name	Application Type	Application Tags	Queue	Application Priority	StartTime	LaunchTime	FinishTime	State	FinalStatus	Running Containers
application_1764577810697_0006	root	Product Click Count	MAPREDUCE		default	0	Tue Dec 2 16:11:02 +0800 2025	Tue Dec 2 16:11:03 +0800 2025	Tue Dec 2 16:11:18 +0800 2025	FINISHED	SUCCEEDED	N/A
application_1764577810697_0005	root	Log Clean Job	MAPREDUCE		default	0	Tue Dec 2 16:08:58 +0800 2025	Tue Dec 2 16:08:58 +0800 2025	Tue Dec 2 16:09:08 +0800 2025	FINISHED	SUCCEEDED	N/A

7.1.4 Hive数据分析

```
USE ecommerce;

CREATE EXTERNAL TABLE IF NOT EXISTS product_clicks (
    product_id STRING,
    click_count INT
)
ROW FORMAT DELIMITED
FIELDS TERMINATED BY '\t'
LOCATION '/user/hadoop/output/product_clicks';

SHOW TABLES;

SELECT * FROM product_clicks;
```

```
tab_name
product_clicks
Time taken: 0.126 seconds, Fetched: 1 row(s)
OK
product_clicks.product_id       product_clicks.click_count
P001    4
P002    4
P003    3
P004    1
P005    1
Time taken: 0.915 seconds, Fetched: 5 row(s)
WARN: The method class org.apache.commons.logging.impl.SLF4JLogFactory#release() was invoked.
WARN: Please see http://www.slf4j.org/codes.html#release for an explanation.
```



7.2 数据流转验证结果

阶段	输入	输出	状态
数据上传	本地文件	HDFS /user/hadoop/raw_logs	成功
数据清洗	原始日志	HDFS /user/hadoop/cleaned_data	成功
指标统计	清洗数据	HDFS /user/hadoop/output/product_clicks	成功
Hive分析	HDFS数据	SQL查询结果	成功

8. 运维监控

8.1 监控指标体系

8.1.1 HDFS监控指标

指标	检查命令	正常范围
DataNode存活数	`hdfs dfsadmin -report`	等于配置节点数
磁盘使用率	`hdfs dfs -df -h`	< 80%
副本缺失数	`hdfs fsck / -files`	0

8.1.2 YARN监控指标

指标	检查命令	正常范围
NodeManager存活数	`yarn node -list`	等于配置节点数
可用内存	Web UI	> 20%
任务队列	`yarn application -list`	无长时间PENDING

8.1.3 ZooKeeper监控指标

指标	检查命令	正常值
集群状态	`zkServer.sh status`	1 leader + 2 followers
连接数	`echo stat | nc localhost 2181`	< maxClientCnxns

8.2 日志分析

8.2.1 日志文件位置

组件	日志路径
Hadoop	$HADOOP_HOME/logs/
ZooKeeper	/data/zookeeper/logs/
HBase	$HBASE_HOME/logs/
Hive	/data/hadoop/logs/hiveserver2.log

8.2.2 常用日志分析命令

```
# 查看最近错误
grep -i error $HADOOP_HOME/logs/*.log | tail -20

# 查看NameNode日志
tail -100 $HADOOP_HOME/logs/hadoop-root-namenode-*.log

# 查看HBase Master日志
tail -100 $HBASE_HOME/logs/hbase-root-master-*.log
```

8.3 健康检查脚本

```
#!/bin/bash
echo "=== 集群健康检查 ==="

echo "[HDFS] DataNode数量:"
hdfs dfsadmin -report | grep "Live datanodes"

echo "[YARN] NodeManager数量:"
yarn node -list 2>/dev/null | grep "Total Nodes"

echo "[ZooKeeper] 集群状态:"
zkServer.sh status 2>&1 | grep "Mode"

echo "[HBase] RegionServer数量:"
echo "status" | hbase shell -n 2>/dev/null | grep "servers"

echo "[Hive] HiveServer2状态:"
jps | grep -c "RunJar"
```

```
=== 集群健康检查 ===
[HDFS] DataNode数量:
WARNING: log4j.properties is not found. HADOOP_CONF_DIR may be incomplete.
Live datanodes (3):
[YARN] NodeManager数量:
Total Nodes:3
[ZooKeeper] 集群状态:
Mode: follower
[HBase] RegionServer数量:
1 active master, 0 backup masters, 2 servers, 0 dead, 1.0000 average load
[Hive] HiveServer2状态:
3
```

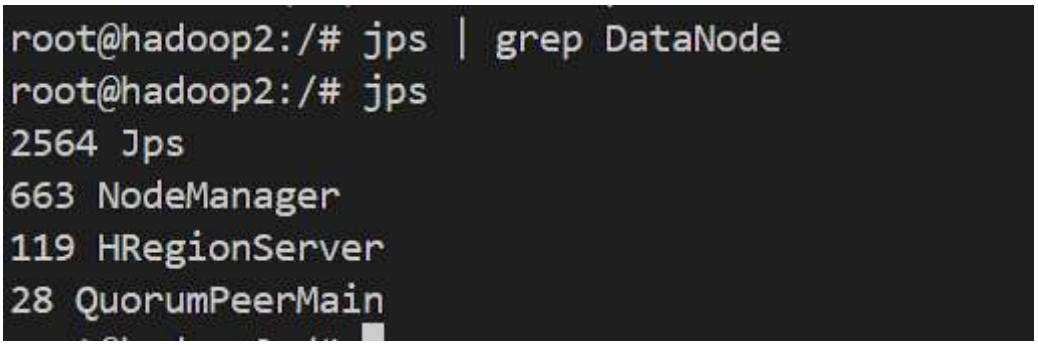
9. 故障处理与恢复

本章模拟各组件常见故障场景，演示诊断方法和恢复操作。

9.1 DataNode故障模拟与恢复

9.1.1 故障模拟

```
# 在hadoop2上停止DataNode服务
docker exec hadoop2 bash -c "jps | grep DataNode | awk '{print \$1}' | xargs kill -9"
```



9.1.2 故障现象

等待一段时间之后，Live datanodes数量减少

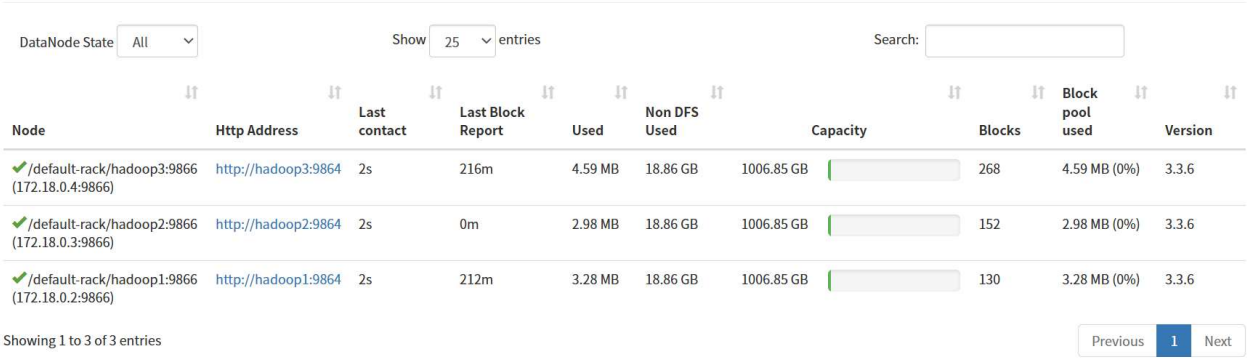
Node	Http Address	Last contact	Last Block Report	Used	Non DFS Used	Capacity	Blocks	Block pool used	Version
/default-rack/hadoop3:9866 (172.18.0.4:9866)	http://hadoop3:9864	2s	213m	2.82 MB	18.86 GB	1006.85 GB	223	2.82 MB (0%)	3.3.6
/default-rack/hadoop1:9866 (172.18.0.2:9866)	http://hadoop1:9864	2s	209m	4.8 MB	18.86 GB	1006.85 GB	275	4.8 MB (0%)	3.3.6
/default-rack/hadoop2:9866 (172.18.0.3:9866)		Tue Dec 02 16:36:49 +0800 2025							

Showing 1 to 3 of 3 entries

Previous 1 Next

9.1.3 故障恢复

```
# 重新启动DataNode
docker exec hadoop2 hdfs --daemon start datanode
```



9.2 ZooKeeper节点故障

9.2.1 故障模拟

停止Leader节点的ZooKeeper

```
docker exec hadoop3 zkServer.sh stop
```

9.2.2 故障现象

```
# 检查各节点ZooKeeper状态
docker exec hadoop1 zkServer.sh status
docker exec hadoop2 zkServer.sh status
docker exec hadoop3 zkServer.sh status
```

hadoop3显示未运行，其他两个节点会重新选举Leader

```
PS D:\Code\MyCode\HadoopHomework> docker exec hadoop1 zkServer.sh status
ZooKeeper JMX enabled by default
Using config: /usr/local/zookeeper/bin/../conf/zoo.cfg
Client port found: 2181. Client address: localhost. Client SSL: false.
Mode: follower
PS D:\Code\MyCode\HadoopHomework> docker exec hadoop2 zkServer.sh status
ZooKeeper JMX enabled by default
Using config: /usr/local/zookeeper/bin/../conf/zoo.cfg
Client port found: 2181. Client address: localhost. Client SSL: false.
Mode: leader
PS D:\Code\MyCode\HadoopHomework> docker exec hadoop3 zkServer.sh status
ZooKeeper JMX enabled by default
Using config: /usr/local/zookeeper/bin/../conf/zoo.cfg
Client port found: 2181. Client address: localhost. Client SSL: false.
Error contacting service. It is probably not running.
```

9.2.3 故障恢复

```
# 重新启动ZooKeeper
docker exec hadoop3 zkServer.sh start

# 验证恢复
docker exec hadoop1 zkServer.sh status
docker exec hadoop2 zkServer.sh status
docker exec hadoop3 zkServer.sh status
```

三个节点正常运行（1 Leader + 2 Followers）只不过Leader变更为hadoop2

```
PS D:\Code\MyCode\HadoopHomework> docker exec hadoop1 zkServer.sh status
ZooKeeper JMX enabled by default
Using config: /usr/local/zookeeper/bin/../conf/zoo.cfg
Client port found: 2181. Client address: localhost. Client SSL: false.
Mode: follower
PS D:\Code\MyCode\HadoopHomework> docker exec hadoop2 zkServer.sh status
ZooKeeper JMX enabled by default
Using config: /usr/local/zookeeper/bin/../conf/zoo.cfg
Client port found: 2181. Client address: localhost. Client SSL: false.
Mode: leader
PS D:\Code\MyCode\HadoopHomework> docker exec hadoop3 zkServer.sh status
ZooKeeper JMX enabled by default
Using config: /usr/local/zookeeper/bin/../conf/zoo.cfg
Client port found: 2181. Client address: localhost. Client SSL: false.
Mode: follower
```