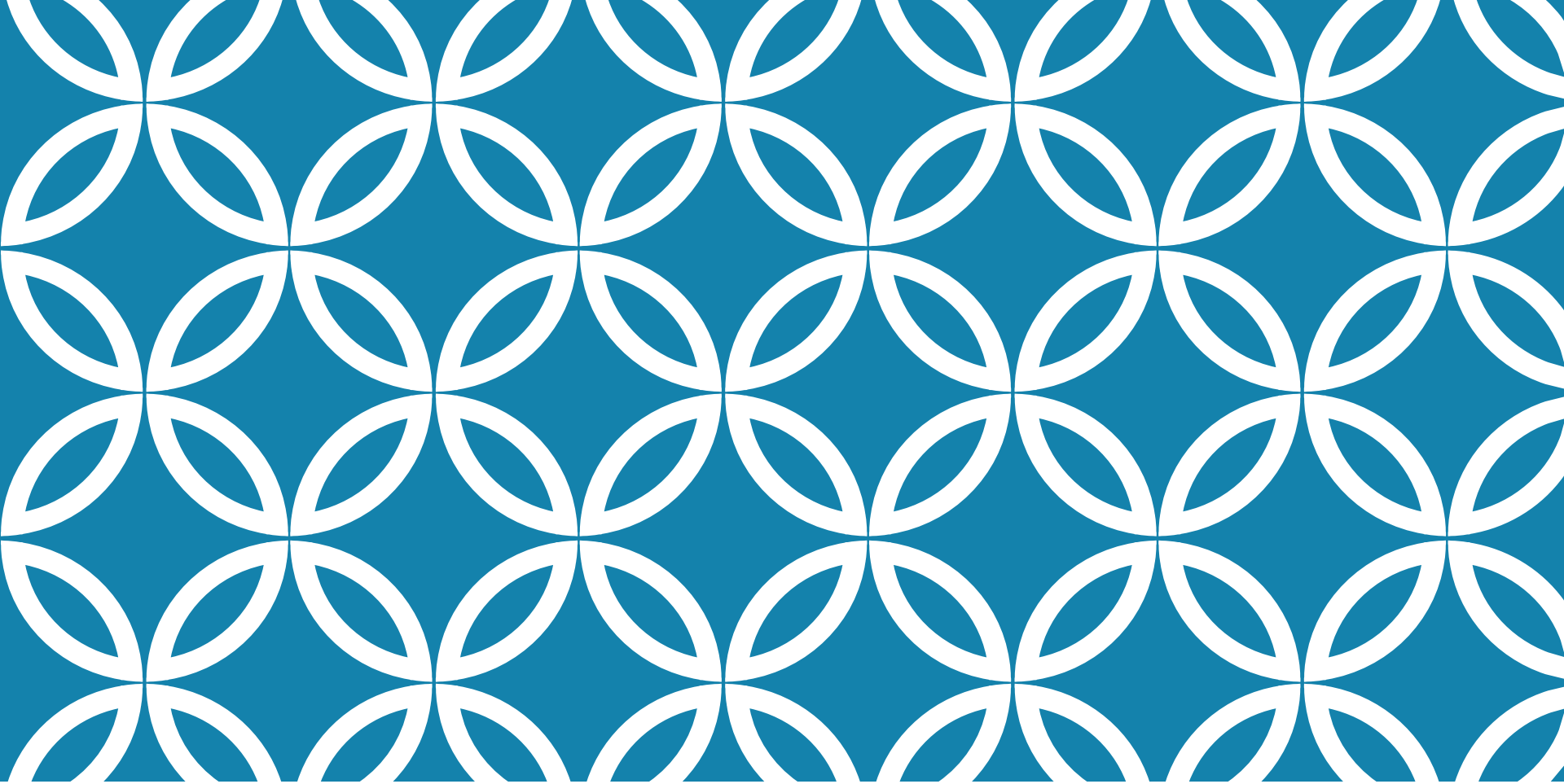
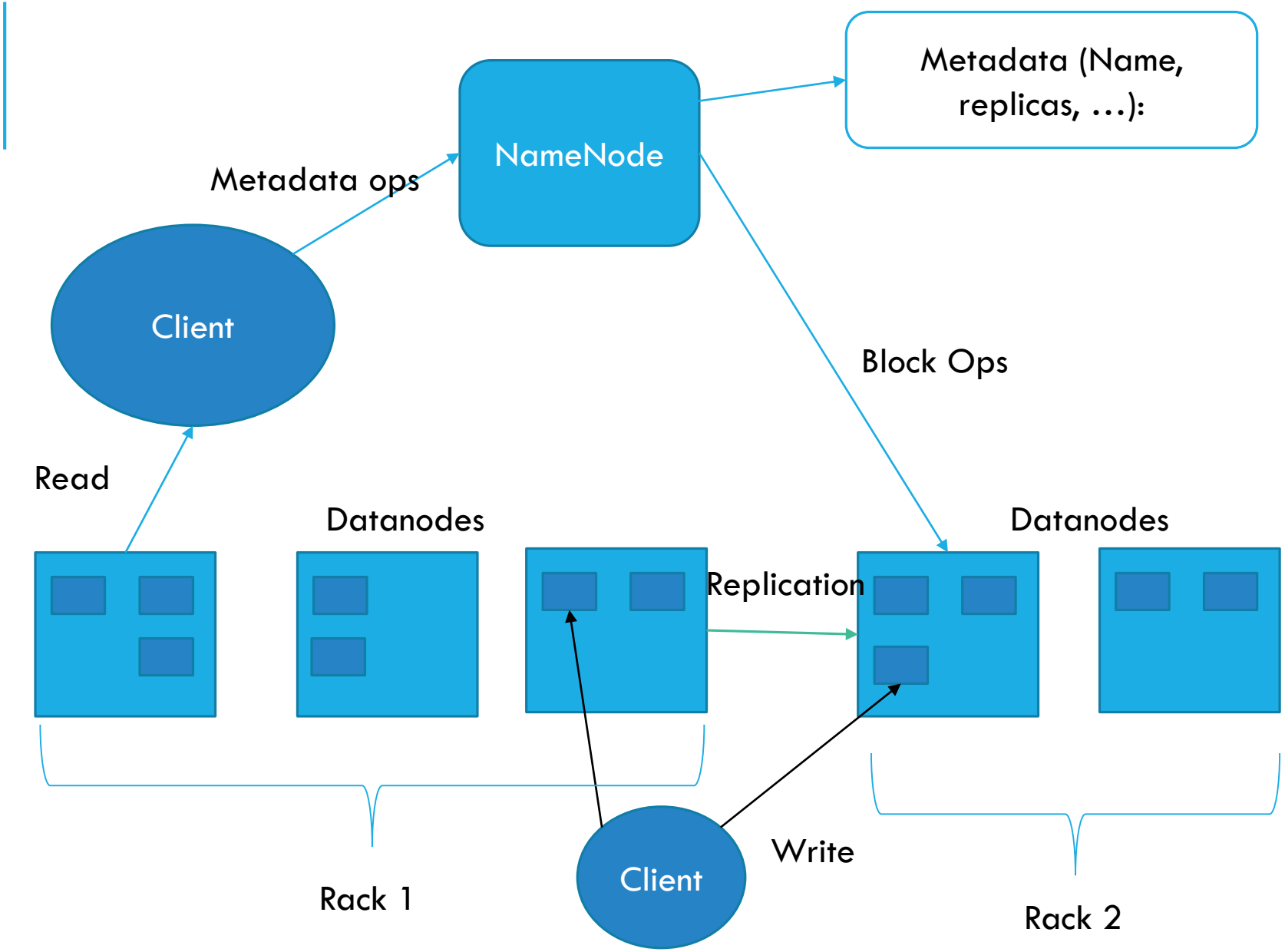


4314-HDFS CONCRETE ARCHITECTURE

By: Reverse ‘em all group

HDFS- Conceptual Diagram



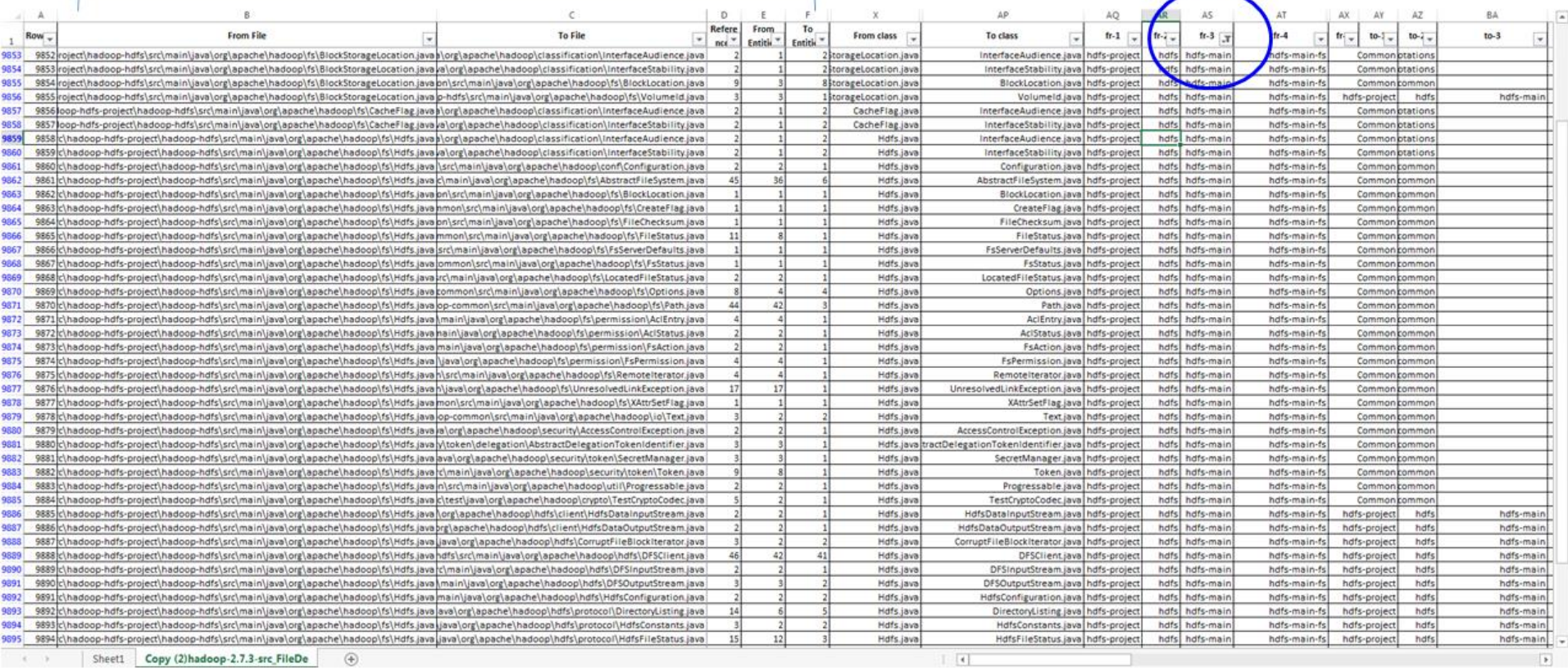
TOOLS USED TO EXTRACT CONCRETE ARCHITECTURE

1. Excel
2. IsEdit
3. NotePad++

TOOLS USED TO EXTRACT CONCRETE ARCHITECTURE

Data Imported from Dependeny report generated by Understand

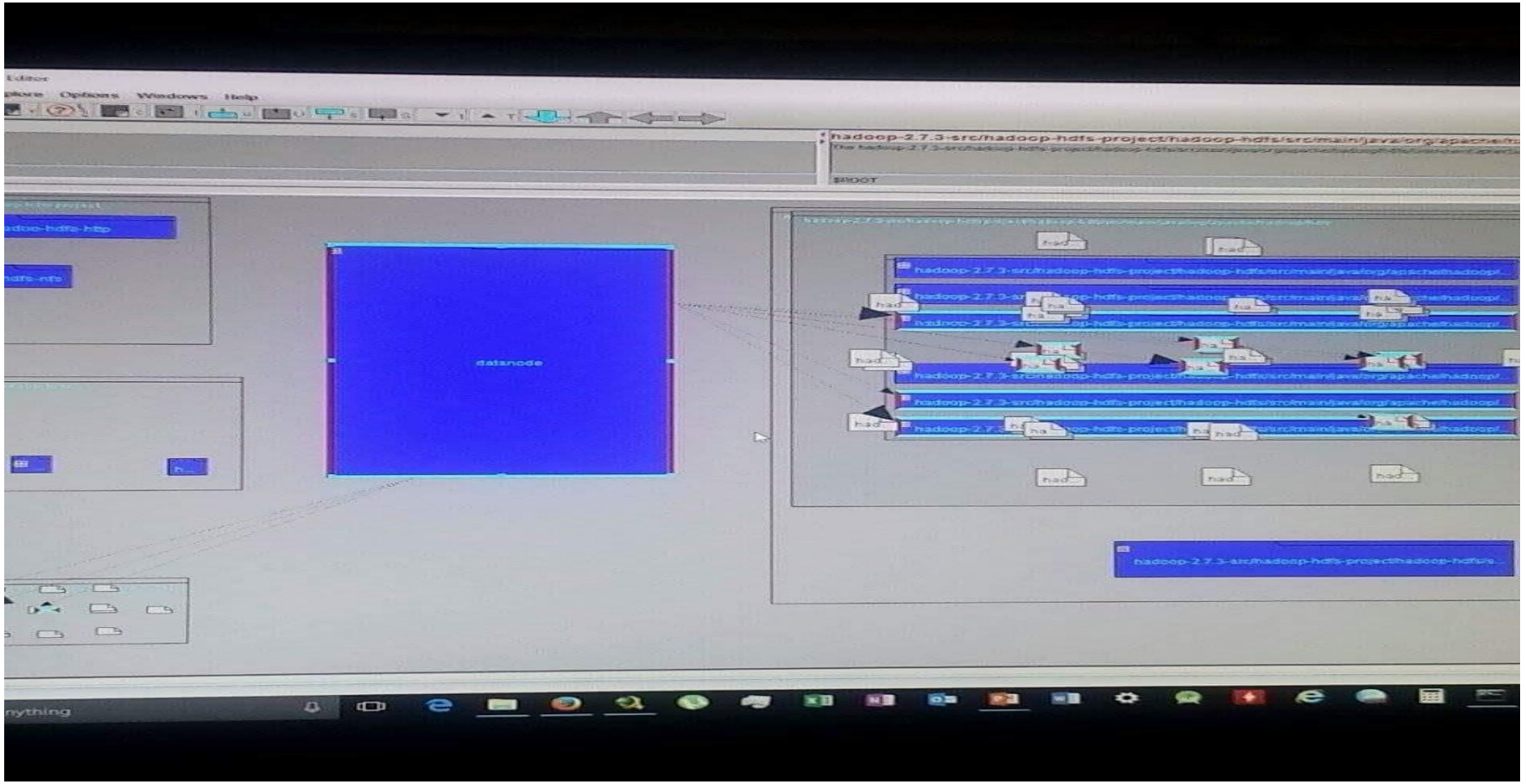
Filter for records of classes within the subdirectory hdfs-project\hdfs\hdfs-main



Row	From File	To File	Reference	From Entity	To Entity	From class	To class	fr-1	fr-2	fr-3	fr-4	to-1	to-2	to-3
9852	roject\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\BlockStorageLocation.java	a\org\apache\hadoop\classification\InterfaceAudience.java	2	1	2	storageLocation.java	InterfaceAudience.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	tations	
9853	roject\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\BlockStorageLocation.java	va\org\apache\hadoop\classification\InterfaceStability.java	2	1	2	storageLocation.java	InterfaceStability.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	tations	
9854	roject\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\BlockStorageLocation.java	on\src\main\java\org\apache\hadoop\fs\BlockLocation.java	9	3	8	storageLocation.java	BlockLocation.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9855	roject\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\BlockStorageLocation.java	p-hdfs\src\main\java\org\apache\hadoop\fs\VolumeId.java	3	3	1	storageLocation.java	VolumeId.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	hdfs-project	hdfs	hdfs-main
9856	oop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\CacheFlag.java	a\org\apache\hadoop\classification\InterfaceAudience.java	2	1	2	CacheFlag.java	InterfaceAudience.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	tations	
9857	oop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\CacheFlag.java	va\org\apache\hadoop\classification\InterfaceStability.java	2	1	2	CacheFlag.java	InterfaceStability.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	tations	
9858	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	a\org\apache\hadoop\classification\InterfaceAudience.java	2	1	2	Hdfs.java	InterfaceAudience.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	tations	
9859	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	va\org\apache\hadoop\classification\InterfaceStability.java	2	1	2	Hdfs.java	InterfaceStability.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	tations	
9860	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	\src\main\java\org\apache\hadoop\conf\Configuration.java	2	2	1	Hdfs.java	Configuration.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9861	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	c\main\java\org\apache\hadoop\fs\AbstractFileSystem.java	45	36	6	Hdfs.java	AbstractFileSystem.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9862	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	on\src\main\java\org\apache\hadoop\fs\BlockLocation.java	1	1	1	Hdfs.java	BlockLocation.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9863	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	mmon\src\main\java\org\apache\hadoop\fs\CreateFlag.java	1	1	1	Hdfs.java	CreateFlag.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9864	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	on\src\main\java\org\apache\hadoop\fs\FileChecksum.java	1	1	1	Hdfs.java	FileChecksum.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9865	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	mmon\src\main\java\org\apache\hadoop\fs\FileStatus.java	11	8	1	Hdfs.java	FileStatus.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9866	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	src\main\java\org\apache\hadoop\fs\FsServerDefaults.java	1	1	1	Hdfs.java	FsServerDefaults.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9867	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	ommon\src\main\java\org\apache\hadoop\fs\FsStatus.java	1	1	1	Hdfs.java	FsStatus.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9868	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	src\main\java\org\apache\hadoop\fs\LocatedFileStatus.java	2	2	1	Hdfs.java	LocatedFileStatus.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9869	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	common\src\main\java\org\apache\hadoop\fs\Options.java	8	4	4	Hdfs.java	Options.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9870	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	op-common\src\main\java\org\apache\hadoop\fs\Path.java	44	42	3	Hdfs.java	Path.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9871	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	\main\java\org\apache\hadoop\fs\permission\AclEntry.java	4	4	1	Hdfs.java	AclEntry.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9872	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	main\java\org\apache\hadoop\fs\permission\AclStatus.java	2	2	1	Hdfs.java	AclStatus.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9873	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	main\java\org\apache\hadoop\fs\permission\FsAction.java	2	2	1	Hdfs.java	FsAction.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9874	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	java\org\apache\hadoop\fs\permission\FsPermission.java	4	4	1	Hdfs.java	FsPermission.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9875	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	n\src\main\java\org\apache\hadoop\fs\RemoteIterator.java	4	4	1	Hdfs.java	RemoteIterator.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9876	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	n\java\org\apache\hadoop\fs\UnresolvedLinkException.java	17	17	1	Hdfs.java	UnresolvedLinkException.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9877	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	mon\src\main\java\org\apache\hadoop\fs\XAttrSetFlag.java	1	1	1	Hdfs.java	XAttrSetFlag.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9878	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	op-common\src\main\java\org\apache\hadoop\io\Text.java	3	2	2	Hdfs.java	Text.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9879	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	a\org\apache\hadoop\security\AccessControlException.java	2	2	1	Hdfs.java	AccessControlException.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9880	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	y\token\delegation\AbstractDelegationTokenIdentifier.java	3	3	1	Hdfs.java	tractDelegationTokenIdentifier.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9881	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	ava\org\apache\hadoop\security\token\SecretManager.java	3	3	1	Hdfs.java	SecretManager.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9882	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	c\main\java\org\apache\hadoop\security\token\Token.java	9	8	1	Hdfs.java	Token.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9883	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	n\src\main\java\org\apache\hadoop\util\Progressable.java	2	2	1	Hdfs.java	Progressable.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9884	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	c\test\java\org\apache\hadoop\crypto\TestCryptoCodec.java	5	2	1	Hdfs.java	TestCryptoCodec.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	Common	common	
9885	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	\org\apache\hadoop\hdfs\client\HdfsDataInputStream.java	2	2	1	Hdfs.java	HdfsDataInputStream.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	hdfs-project	hdfs	hdfs-main
9886	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	org\apache\hadoop\hdfs\client\HdfsDataOutputStream.java	2	2	1	Hdfs.java	HdfsDataOutputStream.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	hdfs-project	hdfs	hdfs-main
9887	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	java\org\apache\hadoop\hdfs\CorruptFileBlockIterator.java	3	2	2	Hdfs.java	CorruptFileBlockIterator.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	hdfs-project	hdfs	hdfs-main
9888	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	hdfs\src\main\java\org\apache\hadoop\hdfs\DFSClient.java	46	42	41	Hdfs.java	DFSClient.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	hdfs-project	hdfs	hdfs-main
9889	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	c\main\java\org\apache\hadoop\hdfs\DFSInputStream.java	2	2	1	Hdfs.java	DFSInputStream.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	hdfs-project	hdfs	hdfs-main
9890	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	\main\java\org\apache\hadoop\hdfs\DFSOutputStream.java	3	3	2	Hdfs.java	DFSOutputStream.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	hdfs-project	hdfs	hdfs-main
9891	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	main\java\org\apache\hadoop\hdfs\HdfsConfiguration.java	2	2	2	Hdfs.java	HdfsConfiguration.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	hdfs-project	hdfs	hdfs-main
9892	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	ava\org\apache\hadoop\hdfs\protocol\DirectoryListing.java	14	6	5	Hdfs.java	DirectoryListing.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	hdfs-project	hdfs	hdfs-main
9893	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	java\org\apache\hadoop\hdfs\protocol\HdfsConstants.java	3	2	2	Hdfs.java	HdfsConstants.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	hdfs-project	hdfs	hdfs-main
9894	c\hadoop-hdfs-project\hadoop-hdfs\src\main\java\org\apache\hadoop\fs\Hdfs.java	java\org\apache\hadoop\hdfs\protocol\HdfsFileStatus.java	15	12	3	Hdfs.java	HdfsFileStatus.java	hdfs-project	hdfs	hdfs-main	hdfs-main-fs	hdfs-project	hdfs	hdfs-main

Sheet1 | Copy (2)hadoop-2.7.3-src_FileDe

TOOLS USED TO EXTRACT CONCRETE ARCHITECTURE

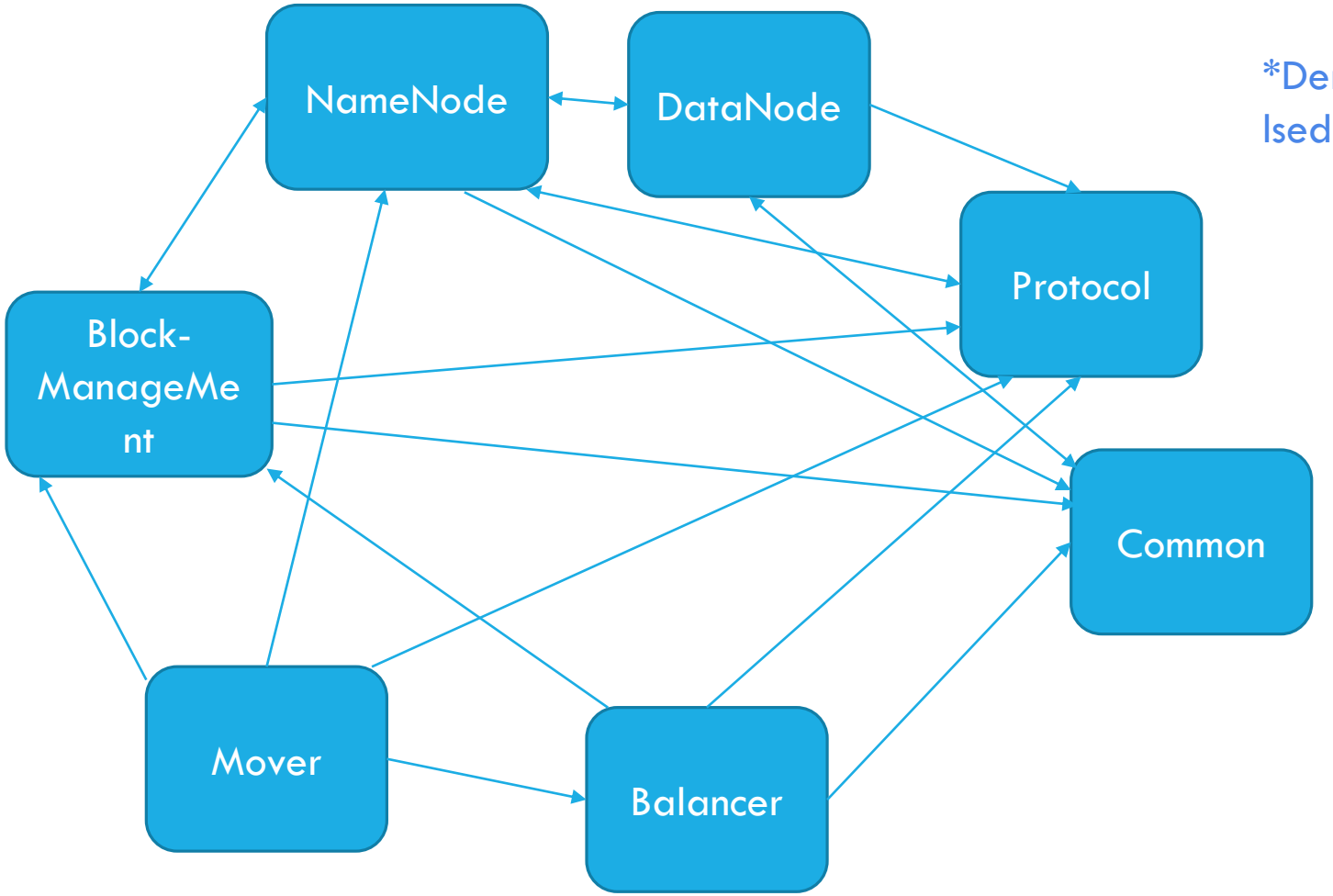


TOOLS USED TO EXTRACT CONCRETE ARCHITECTURE

TextFX Plugins Window ?

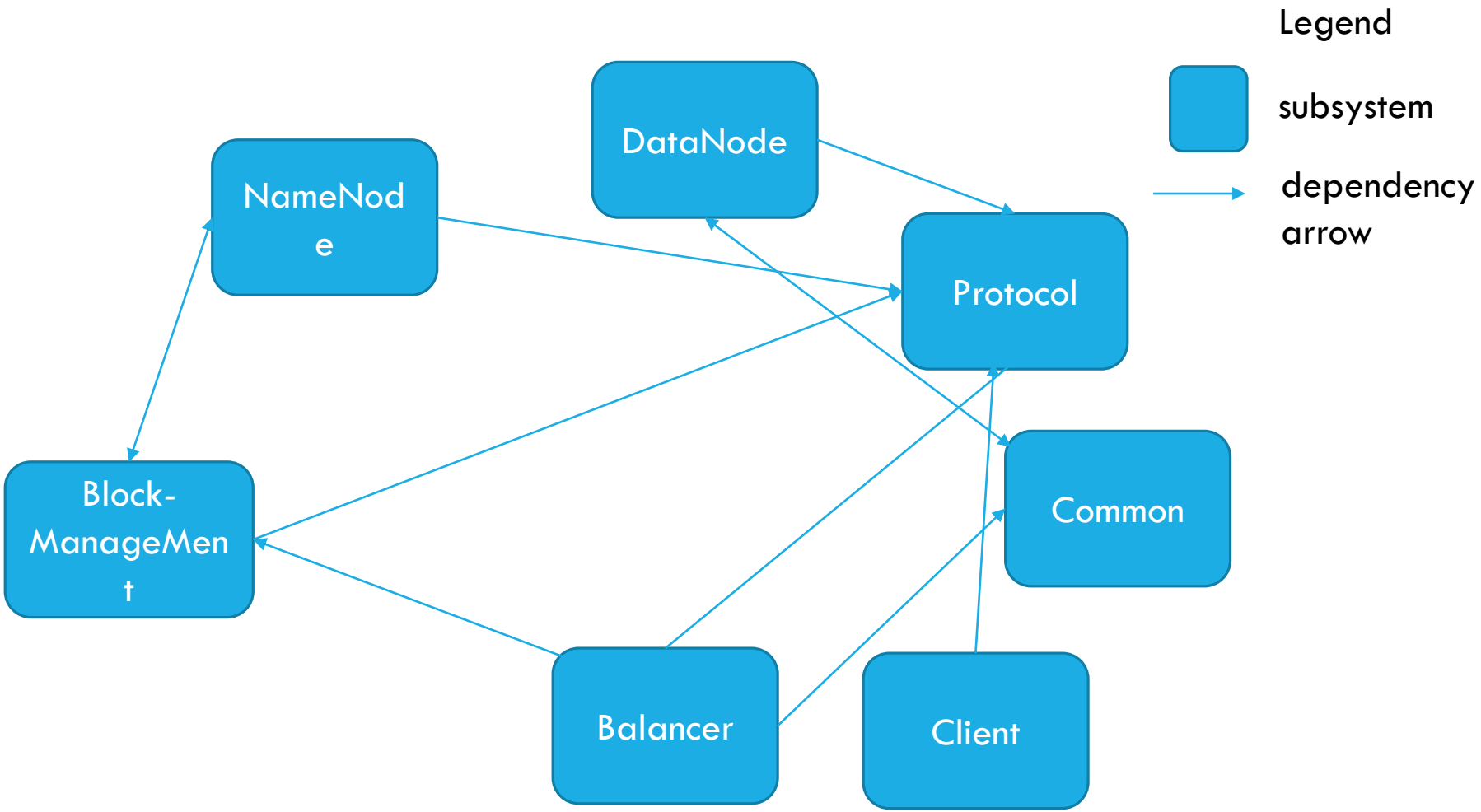
```
============================================================
File searched          :hadoop_FileDependencies.ls.ta
Searched for           :"hadoop-2.7.3-src/hadoop-hdfs-project/hadoop-hdfs/src/main/java/org/apache/hadoop/hdfs/server"
Wildcard search        :no
Upper/lower case       :Ignore
#lines with hit        :7272
#File searched         :dependency_server
 Searched for          <>"hadoop-2.7.3-src/hadoop-hdfs-project/hadoop-hdfs/src/test"
 Wildcard search       :no
 Upper/lower case      :Ignore
 #lines with hit       :5233

File searched          :dependency_server w/o test
Searched for           :"hadoop-2.7.3-src/hadoop-hdfs-project/hadoop-hdfs/src/main/java/org/apache/hadoop/hdfs/server/namenode"
Wildcard search        :no
Upper/lower case       :Ignore
#lines with hit        :3170
File searched          :dependencyRecord_nameNode
Searched for           :"hadoop-2.7.3-src/hadoop-hdfs-project/hadoop-hdfs/src/main/java/org/apache/hadoop/hdfs/server/datanode"
Wildcard search        :no
Upper/lower case       :Ignore
#lines with hit        :8
#lines searched        :3181
/hadoop/hdfs/server/datanode/BPServiceActor.java hadoop-2.7.3-src/hadoop-hdfs-project/hadoop-hdfs/src/main/java/org/apache/hadoop/hdfs/server/namenode/FSNamesystem.java
/hadoop/hdfs/server/datanode/web/DatanodeHttpServer.java hadoop-2.7.3-src/hadoop-hdfs-project/hadoop-hdfs/src/main/java/org/apache/hadoop/hdfs/server/namenode/FileChecks
/hadoop/hdfs/server/datanode/web/DatanodeHttpServer.java hadoop-2.7.3-src/hadoop-hdfs-project/hadoop-hdfs/src/main/java/org/apache/hadoop/hdfs/server/namenode/StreamFile
/hadoop/hdfs/server/namenode/FileChecksumServlets.java hadoop-2.7.3-src/hadoop-hdfs-project/hadoop-hdfs/src/main/java/org/apache/hadoop/hdfs/server/datanode/DataNode.jav
/hadoop/hdfs/server/namenode/FileChecksumServlets.java hadoop-2.7.3-src/hadoop-hdfs-project/hadoop-hdfs/src/main/java/org/apache/hadoop/hdfs/server/datanode/DatanodeJspH
/hadoop/hdfs/server/namenode/NamenodeFsck.java hadoop-2.7.3-src/hadoop-hdfs-project/hadoop-hdfs/src/main/java/org/apache/hadoop/hdfs/server/datanode/CachingStrategy.java
/hadoop/hdfs/server/namenode/StreamFile.java hadoop-2.7.3-src/hadoop-hdfs-project/hadoop-hdfs/src/main/java/org/apache/hadoop/hdfs/server/datanode/DataNode.java
/hadoop/hdfs/server/namenode/StreamFile.java hadoop-2.7.3-src/hadoop-hdfs-project/hadoop-hdfs/src/main/java/org/apache/hadoop/hdfs/server/datanode/DatanodeJspHelper.java
```

CONCRETE DIAGRAM- **BEFORE** REPAIRING

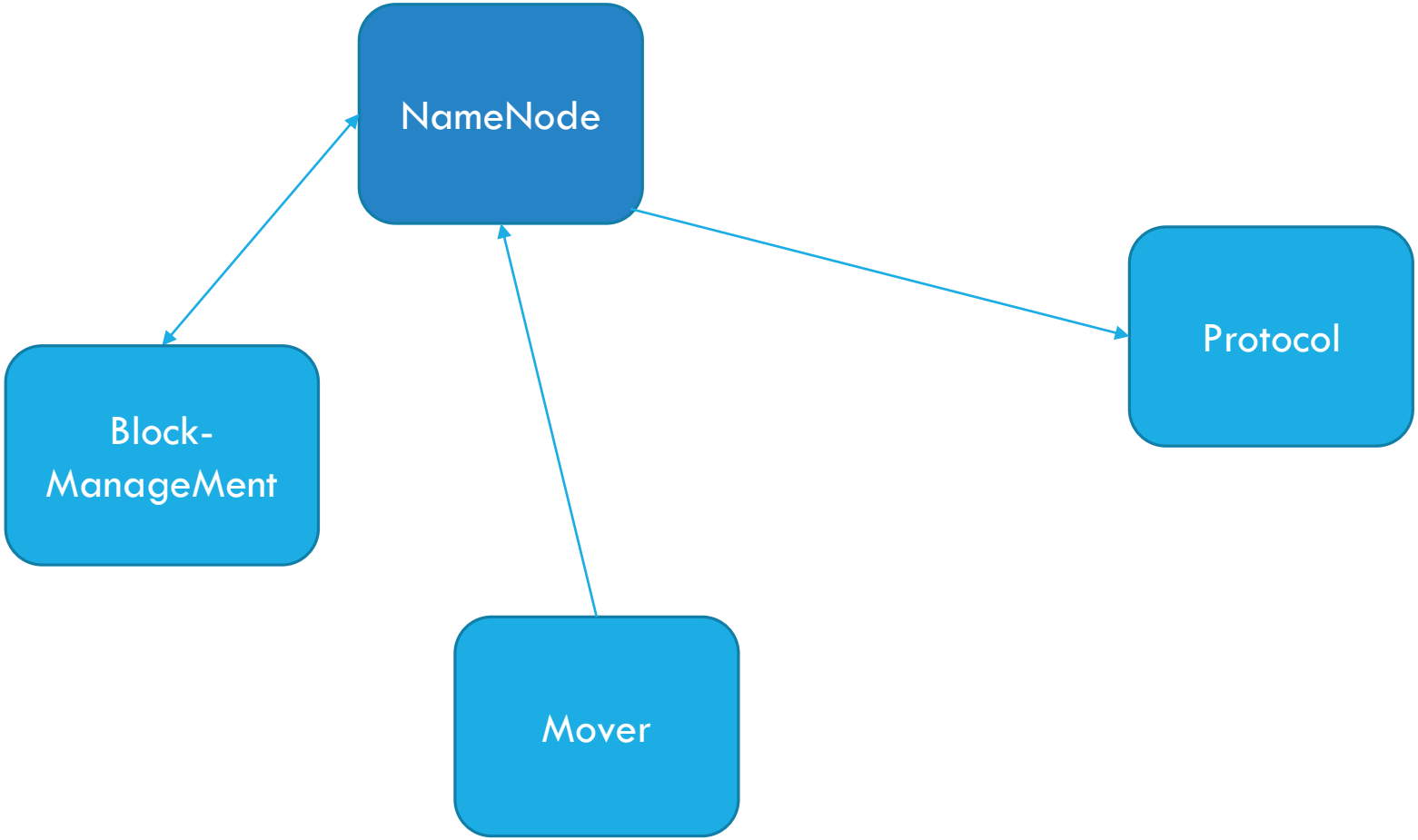


*Derived from lsedit

CONCRETE DIAGRAM- AFTER REPAIRING



NAMENODE



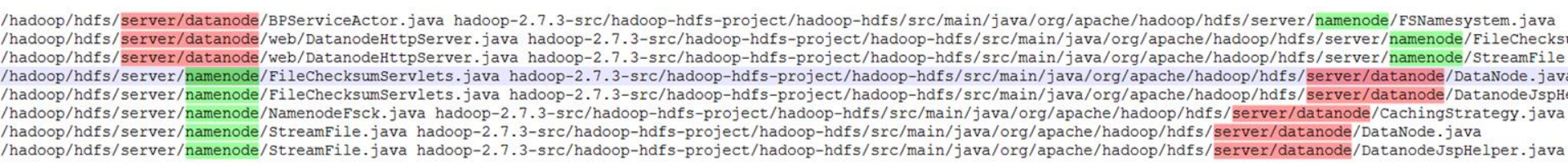
NAMENODE

- Fsimage, Editlog: is to store the “snapshot” of namenode
- Secondary node
- Checkpointer
- Backup node

- Guess: secondary node is going to be replaced by warm standby node. To keep it in same folder easier for development.

NAMENODE

- Remove dependency relation between datanode and namenode.
- Intuitively, it is thought that there is strong coupling relation between datanode and namenode.
- In fact, the dependence relation is not strong.
- Namenode communicate with datanode via protocol.



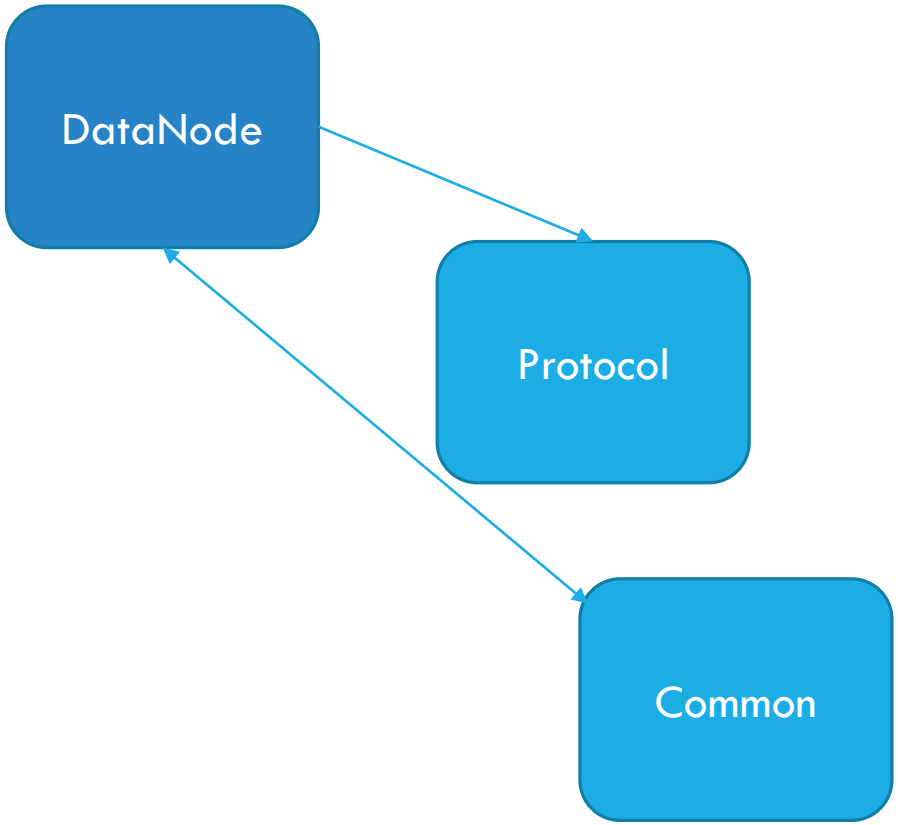
NAMENODE

- Removal of the dependence relation between balancer and namenode
- Balancer invokes only one class from namenode. And the class is an exception class.

'hadoop/hdfs/server/balancer/Balancer.java hadoop-2.7.3-src/hadoop-hdfs-project/hadoop-hdfs/src/main/java/org/apache/hadoop/hdfs/server/namenode/UnsupportedActionException.java

```
private static void checkReplicationPolicyCompatibility(Configuration conf
    ) throws UnsupportedActionException {
  if (!(BlockPlacementPolicy.getInstance(conf, null, null, null) instanceof
      BlockPlacementPolicyDefault)) {
    throw new UnsupportedActionException(
        "Balancer without BlockPlacementPolicyDefault");
  }
}
```

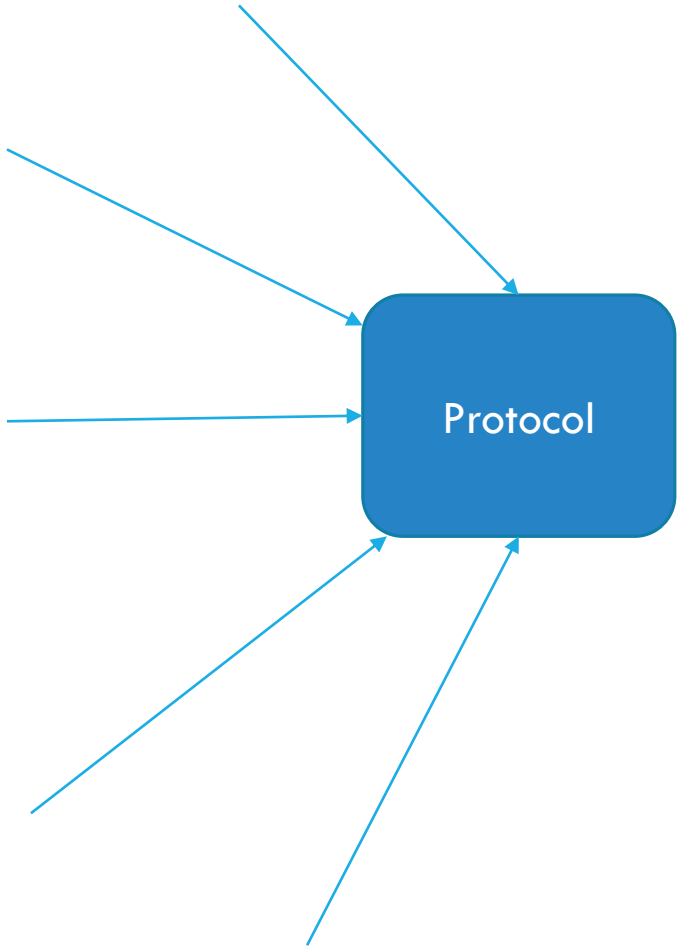
DATANODE



DATANODES- HOW IT WORKS?

- It cannot contact the namenode directly instead it relies on another component to talk to namenode.
- It uses the server.protocol to contact the nameNode.
- It can contact the client directly using protocol -> clientprotocol.java
- Datanodes send heart beats to the nameNode using the class BPServiceActor.java

PROTOCOL



PROTOCOL

- Protocols define how each subsystem speaks, communicates, and gives commands between each other
- Communication between NameNode and DataNode as well as NameNode and balancer
- Examples: block information, block replication, heartbeat response
- Many classes within Protocol are defined as demands
- Instructions are wrapped around an object along with any necessary information about that instruction

PROTOCOL

- The conceptual diagram did not define a way in which NameNodes and DataNodes interact except through dependency
- After repairment, there was also no change. Every subsystem needs protocols for communication

COMMON

- GenerationStamp.java
  - DataNode, Block Management
- HdfsServerConstants.java
  - NameNode, DataNode, server,protocol, Block Management, Balancer
- JspHelper.java
  - NameNode, HDFS (web) main system
- Util.java
  - NameNode

COMMON

- Storage.java
- StorageInfo.java
- InconsistentFSStateException.java
- IncorrectVersionException.java
  - ↖ NameNode, DataNode, server.protocol

CLIENT

- User Applications access HDFS using CLIENT
- Support general conventional file system operation
  - Create, read, delete
  - Rename, open, close
- Include classes supporting ‘Staging’: caching of block of data before flushing to DataNode

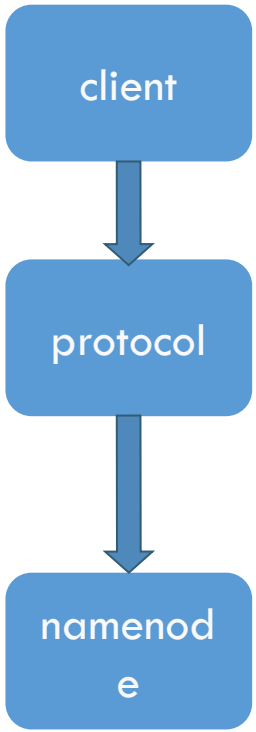
CLIENT - STAGING

- Data cached locally until reached block size
- Client request to NameNode for DataNode id and destination for the data block
- Client flushed the block of data to DataNode

Rationale:

- Process use streaming write to file
- Without buffering will impact throughput
- Because writing remote file directly will affect network speed and congestion in network

CLIENT <-> NAMENODE

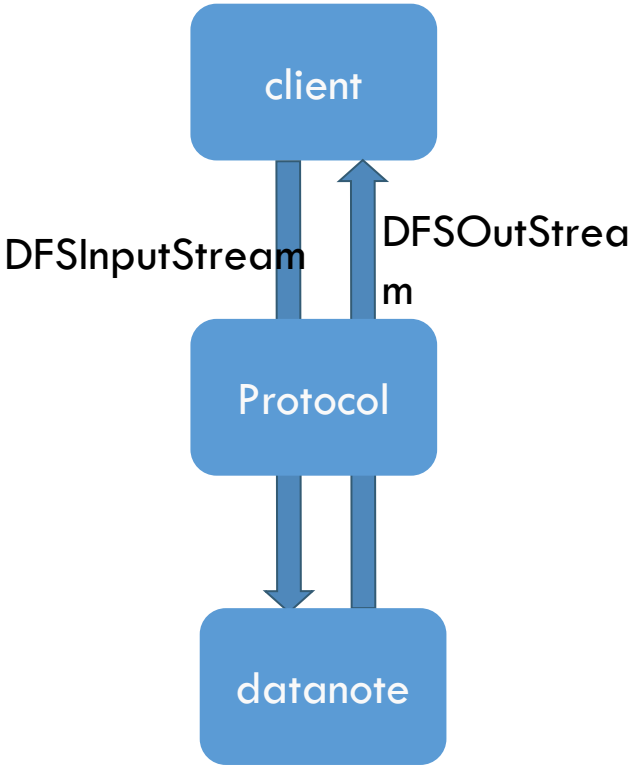


- Client communicate with NameNode via Protocol
- I.e Protocol acts as Facade between NameNode and Client
- Client notify NameNode when it is done accessing a file or if there is ‘faulty’ file

Rationale:

- To decouple the subsystem

CLIENT <-> DATANODE



- Client communicate with DataNode via Protocol

  Rationale: decoupling via facade
- Send/receive Data directly to DataNode
- Transfer via streaming, not RPC (as mentioned in Staging)

BLOCKMANAGEMENT

- Handles the replication of blocks
  - 1st choice: within the same rack
  - 2nd choice: within the same switchband
  - 3rd choice: external
- Replication implement pipe & filter design
- Send Heartbeat and Blockreport messaged to Namenode

BALANCER

- Rebalances data across DataNotes
  - Moving blocks from over-utilized to under-utilized nodes
- Threshold set is relative to usage of overall cluster

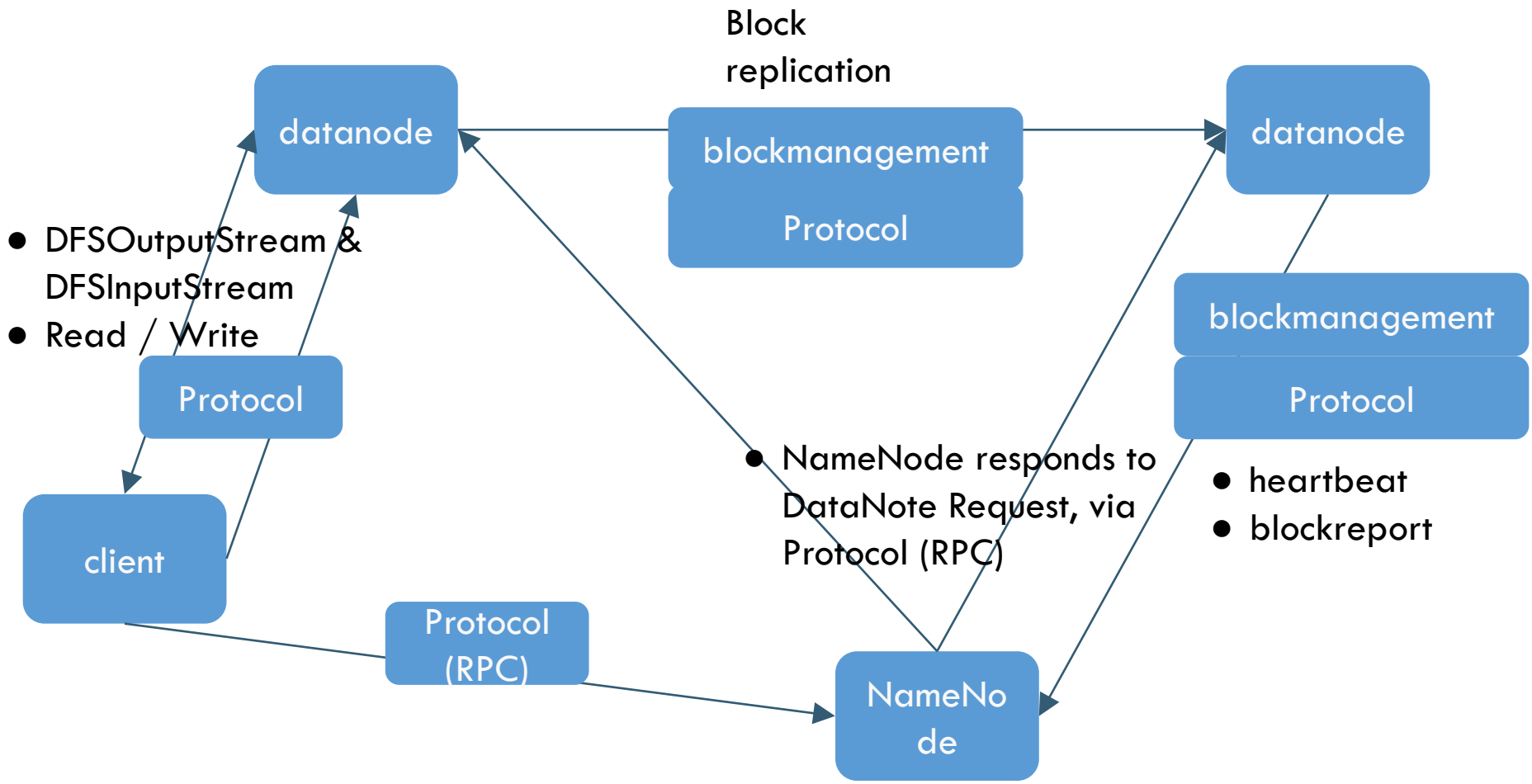
Rationale:

- Avoid recently added nodes into the cluster become bottleneck

Drawback:

- Time-consuming Mechanism

AMENDED CONCEPTUAL ARCHITECT AFTER REPAIR

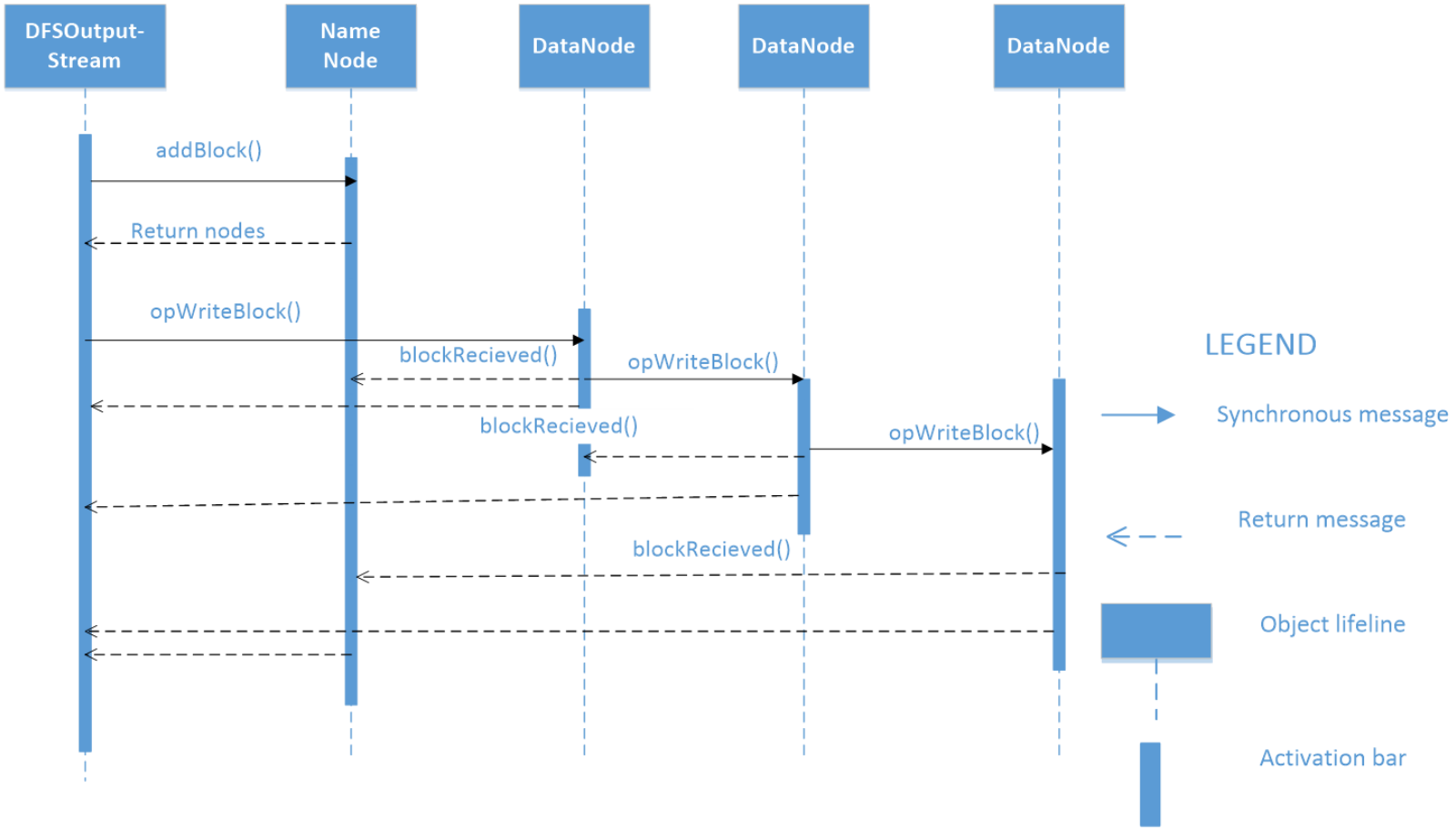


MASTER-SLAVES DESIGN IN HADOOP

NameNode being the master, where the central data control is, and multiple DataNodes being the slaves, constantly reporting their status to NameNode

- DataNodes, being the slaves, can run on low commodity machine, thus reducing cost
- Support concurrency, boosting performance

USE CASE: WRITING TO HDFS



LESSONS LEARNED

- Process of finding actual architecture is complex; it involves many search & investigate operations.
- Concrete architecture contains more dependencies than the conceptual ones.
- Going over classes one by one is not feasible in large programs instead using the dependency files is an important asset to use but still requires time to do it but it's an accurate process.
- There might be different versions of concrete architecture.

LIMITATIONS OF REPORTED FINDINGS

- There are an overwhelmingly large number of classes
- We chose the most relevant ones based on what we observed during the process of extracting the concrete architect
- Hence we might missed out certain points by ignoring those classes