Hadoop Distributed File System (HDFS)

Introduction

The Hadoop Distributed File System (HDFS) is the primary storage system used by Hadoop applications. It provides high-throughput access to application data and is designed to scale out from a single server to thousands of machines, each offering local computation and storage.

Architecture

HDFS follows a master-slave architecture where an HDFS cluster consists of a single NameNode and multiple DataNodes.

1. **NameNode**: The master server that manages the file system namespace and controls access to files by clients. It keeps the directory tree of all files in the file system, and tracks where across the cluster the file data is kept.
   - **Responsibilities**:
     - Manages the metadata of all files and directories.
     - Keeps track of the replication factor of files.
     - Monitors DataNode health and coordinates recovery of data blocks in case of failure.
2. **DataNode**: The slave nodes which are responsible for storing the actual data.
   - **Responsibilities**:
     - Stores and retrieves blocks when they are told to (by clients or the NameNode).
     - Reports to the NameNode periodically with lists of blocks that they are storing.

Key Features of HDFS

- **Fault Tolerance**: Data is automatically replicated to multiple nodes to ensure reliability in case of node failures.
- **High Throughput**: Optimized for streaming data access, providing high data throughput.
- **Scalability**: Designed to scale out by adding more nodes to the cluster.
- **Data Locality**: Moves computation to where the data is stored to improve performance.

HDFS Data Flow

1. **File Write Operation**:
   - Client contacts the NameNode to create a new file.
   - NameNode allocates DataNodes for data blocks.
   - Client writes data in blocks to the DataNodes, which replicate the blocks to other DataNodes.
   - After successful replication, the DataNodes report back to the NameNode.
2. **File Read Operation**:
   - Client contacts the NameNode to retrieve file metadata.
   - NameNode provides the list of DataNodes where the blocks are stored.

        o   Client reads the data directly from the DataNodes.

Block Management

HDFS stores each file as a sequence of blocks. All blocks in a file except the last block are the same size.

- **Block Size**: The default block size is 128 MB, but it can be configured based on the requirements.
- **Replication**: Each block is replicated across multiple DataNodes. The default replication factor is three.
- **Block Placement**: Ensures high availability and reliability by placing replicas across different nodes and racks.

HDFS Configuration

HDFS configuration files are located in the `conf/` directory of the Hadoop installation.

1. **core-site.xml**: Contains configuration settings for Hadoop Core, such as I/O settings and file system settings.
2. **hdfs-site.xml**: Contains configuration settings specific to HDFS, such as replication factor and NameNode/ DataNode settings.
3. **Conclusion**
4. HDFS is a robust, scalable, and fault-tolerant file system designed to store large volumes of data across a distributed environment. Its design ensures high availability and reliability, making it a fundamental component of the Hadoop ecosystem.