APACHE ZOOKEEPER

Overview – What is ZooKeeper?

- An open source, high-performance coordination service for distributed application.
- Exposes common services in simple interface:
  - Naming
  - Configuration management
  - Locks & synchronization
  - Groups services
- Build your own on it for specific needs

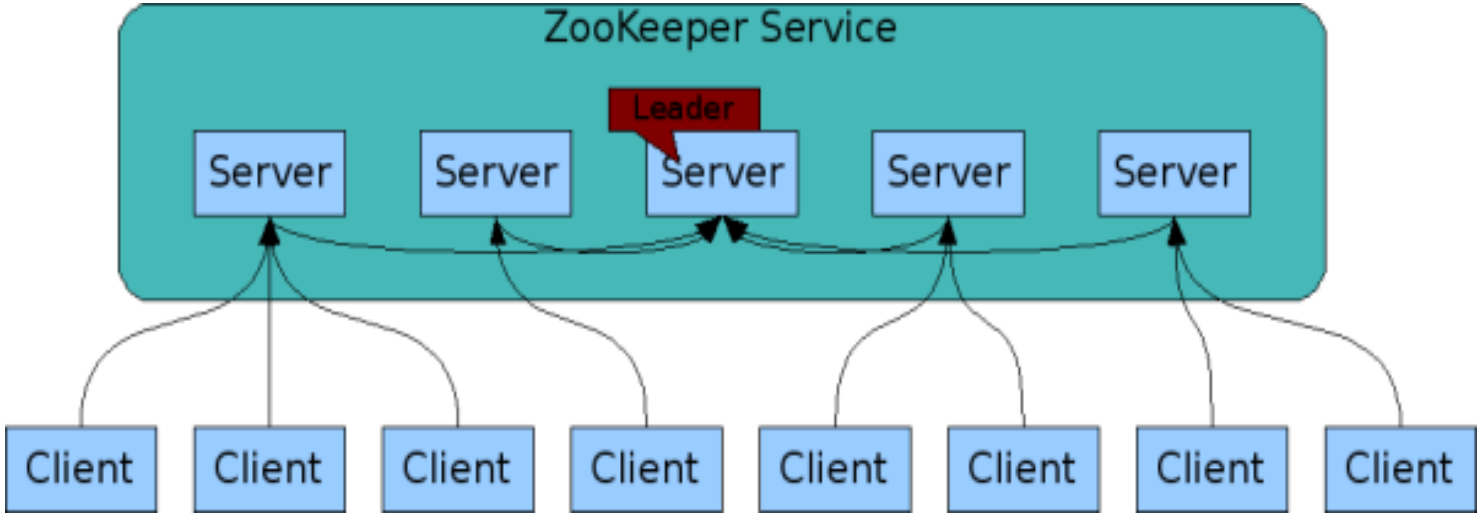
Overview – Who uses ZooKeeper?

- Companies:
  - Yahoo!
  - Zynga
  - Rackspace
  - Linkedlin
  - Netflix, and many more…
- Projects:
  - Apache Map/Reduce (Yarn)
  - Apache HBase
  - Apache Kafka
  - Apache Storm
  - Neo4j, and many more…

Overview – ZooKeeper Use Cases

- Configuration Management
  - Cluster member nodes bootstrapping configuration from a centralized source in unattended way
- Distributed Cluster Management
  - Node join / leave
  - Node statuses in real time
- Naming service – e.g. DNS
- Distributed synchronization – locks, barriers, queues
- Leader election in a distributed system

The ZooKeeper Service (ZKS)



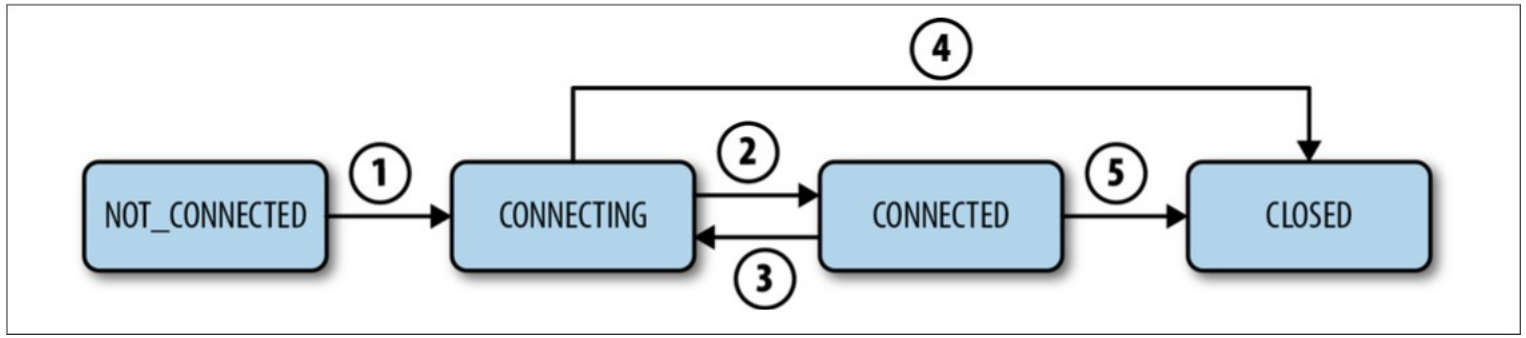
- ZooKeeper Service is replicated over a set of machines
- All machines store a copy of the data (in-memory)
- A leader is elected on service startup
- Clients only connect to a single ZooKeeper server and maintain a TCP connection

The ZKS - Sessions

- Before executing any request, client must establish a session with service
- All operations client summits to service are associated to a session
- Client initially connects to any server in ensemble, and only to single server.
- Session offer *order guarantees* – requests in session are executed in FIFO order

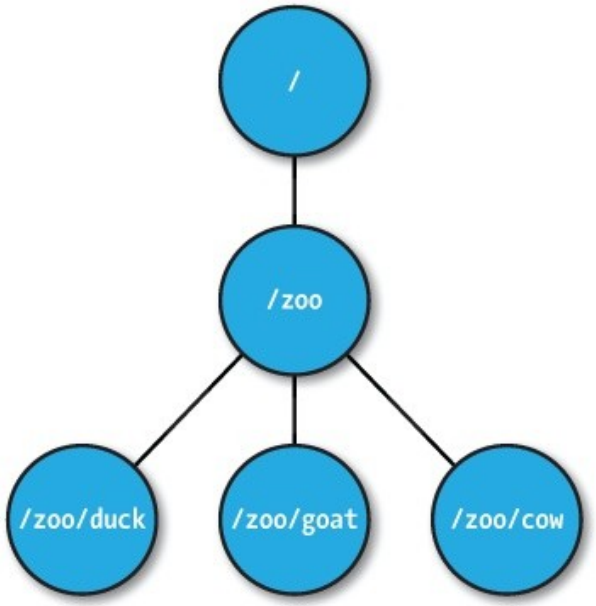
The ZKS – Session States and Lifetime

- Main possible states: CONNECTING, CONNECTED, CLOSED, NOT_CONNECTED



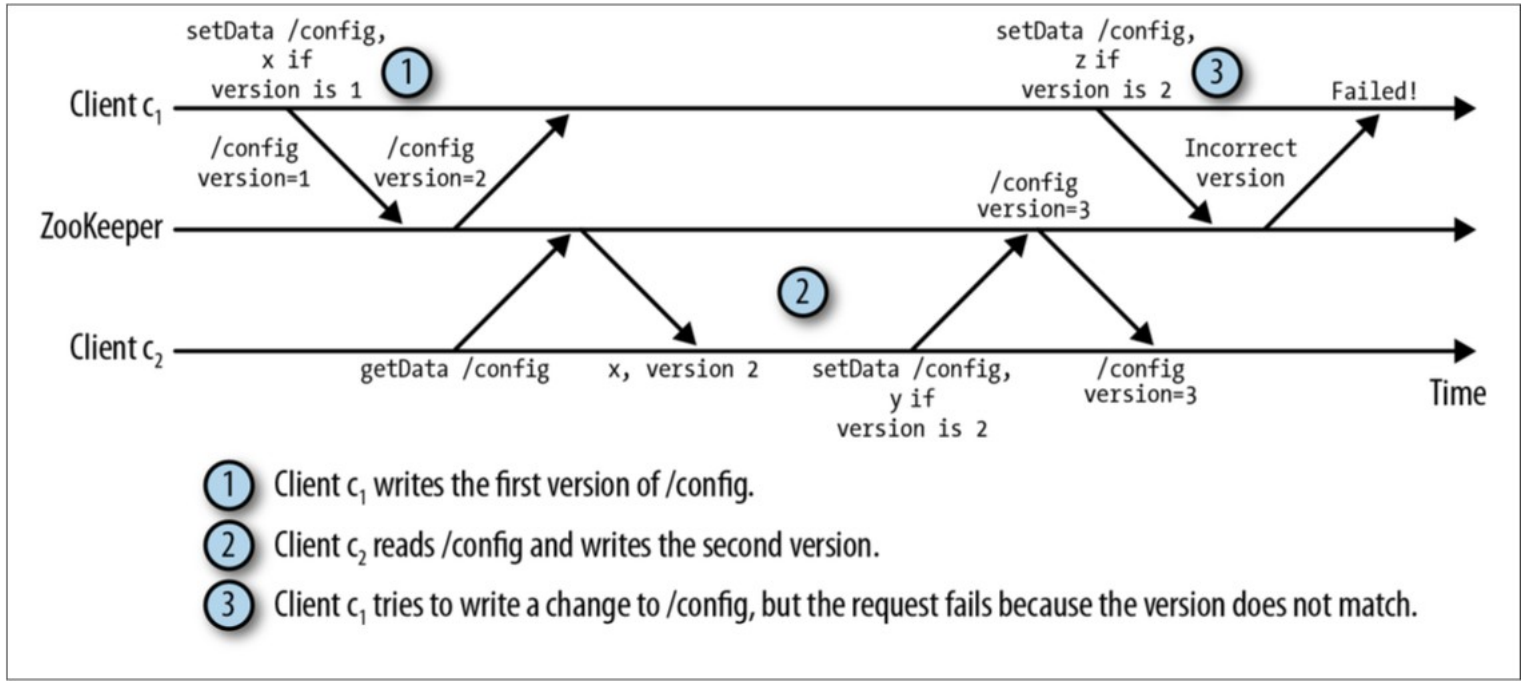
The ZooKeeper Data Model (ZDM)

- Hierarchal name space
- Each node is called as a ZNode
- Every ZNode has data (given as byte[]) and can optionally have children
- ZNode paths:
  - Canonical, absolute, slash-separated
  - No relative references
  - Names can have Unicode characters
- ZNode maintain **stat structure**



ZDM - Versions

- Eash Znode has version number, is incremented every time its data changes
- *setData* and *delete* take version as input, operation succeeds only if client's version is equal to server's one



ZDM – ZNodes –Stat Structure

- The Stat structure for each znode in ZooKeeper is made up of the following fields:
  - **czxid**
  - **mzxid**
  - **pzxid**
  - **ctime**
  - **mtime**
  - **dataVersion**
  - **cversion**
  - **aclVersion**
  - **ephemeralOwner**
  - **dataLength**
  - **numChildren**

```
[zk: localhost(CONNECTED) 0] stat /zookeeper
cZxid = 0x0
ctime = Thu Jan 01 05:30:00 IST 1970
mZxid = 0x0
mtime = Thu Jan 01 05:30:00 IST 1970
pZxid = 0x0
cversion = -1
dataVersion = 0
aclVersion = 0
ephemeralOwner = 0x0
dataLength = 0
numChildren = 1
```

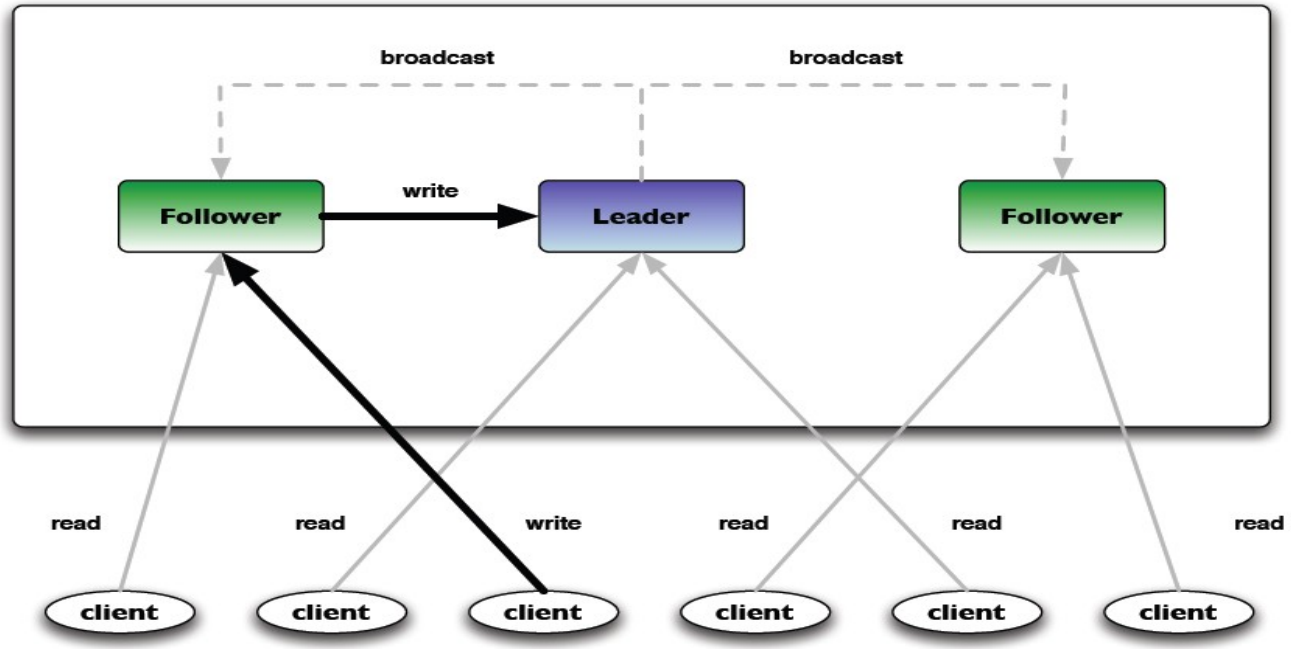
ZDM – Types of ZNode

- Persistent ZNode
  - Have lifetime in ZooKeeper's namespace until they're explicitly deleted (can be deleted by *delete* API call)
- Ephemeral ZNode
  - Is deleted by ZooKeeper service when the creating client's session ends
  - Can also be explicitly deleted
  - Are not allowed to have children
- Sequential Znode
  - Is assigned a sequence number by ZooKeeper as a part of name during creation
  - Sequence number is integer (4bytes) with format of 10 digits with 0 padding. E.g. /path/to/znode-0000000001

ZDM – Znode Operations

Operation	Description
`create`	Creates a znode in a specified path of the ZooKeeper namespace
`delete`	Deletes a znode from a specified path of the ZooKeeper namespace
`exists`	Checks if a znode exists in the path
`getChildren`	Gets a list of children of a znode
`getData`	Gets the data associated with a znode
`setData`	Sets/writes data into the data field of a znode
`getACL`	Gets the **ACL** of a znode
`setACL`	Sets the **ACL** in a znode
`sync`	Synchronizes a client's view of a znode with ZooKeeper

ZDM – Znode – Reads & Writes



- Read requests are processed locally at the ZooKeeper server to which client is currently connected
- Write requests are forwarded to leader and go through majority consensus before a response is generated

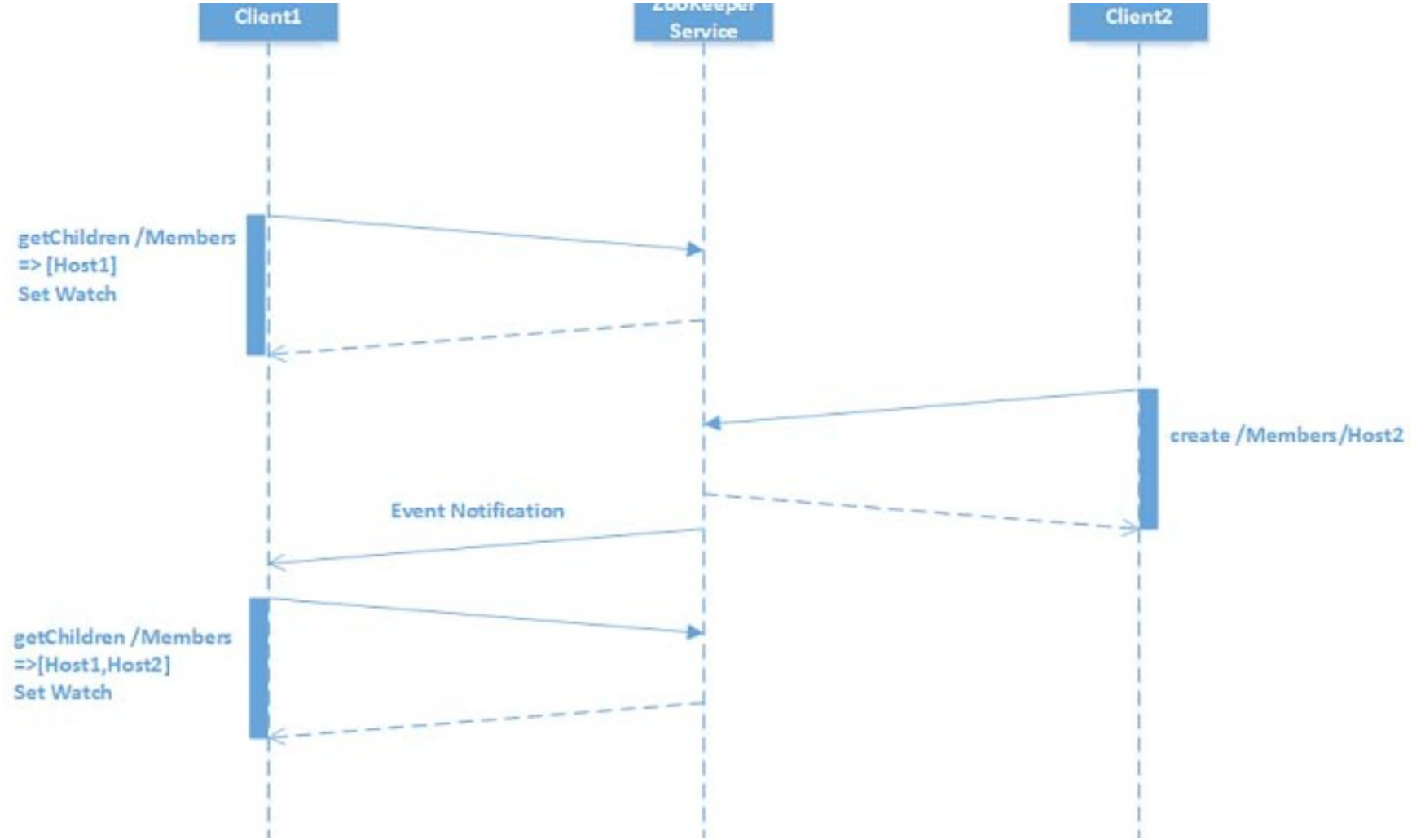
ZDM – Consistency Guarantees

- Sequential Consistency
- Atomicity
- Single System Image
- Reliability
- Timeliness (Eventual Consistency)

ZDM - Watches

- A watch event is one-time trigger, sent to client that set watch, which occurs when data for which watch was set changes.
- Watches allow clients to get notifications when a znode changes in any way (NodeChildrenChanged, NodeCreated, NodeDataChanged,NodeDeleted)
- All of read operations – **getData()**, **getChildren()**, **exists()** – have option of setting watch
- ZooKeeper Guarantees about Watches:
  - Watches are ordered, order of watch events corresponds to the order of the updates
  - A client will see a watch event for znode it is watching before seeing the new data that corresponds to that znode

ZDM – Watches (cont)



ZDM – Access Control List

- ZooKeeper uses ACLs to control access to its znodes
- ACLs are made up of pairs of (scheme:id, permission)
- Build-in ACL schemes
  - **world**: has single id, *anyone*
  - **auth**: doesn't use any id, represents any authenticated user
  - **digest**: use a *username:password*
  - **host**: use the client host name as ACL id identity
  - **ip**: use the client host IP as ACL id identity
- ACL Permissions:
  - **CREATE**
  - **READ**
  - **WRITE**
  - **DELETE**
  - **ADMIN**
- E.g. (ip:192.168.0.0/16, READ)

Recipe : Group Membership

- A persistent Znode */membership* represent the root of the group in ZooKeeper tree
- Any client that joins the cluster creates ephemeral znode under /membership to locate memberships in tree and set a watch on /membership
- When another node joins or leaves the cluster, this node gets a notification and becomes aware of the change in group membership

Recipe : Group Membership (cont)

- Let **/_MEMBERSHIP_** represent root of group membership
- Client joining the group create ephemeral nodes under root
- All members of group will register for watch events on /_MEMBERSHIP, thereby being aware of other members in group

  L = getChildren("/_MEMBERSHIP", true)
- When new client joins group, all other members are notified
- Similarly, a client leaves due to failure or otherwise, ZooKeeper automatically delete node, trigger event
- Live members know which node joined or left by looking at the list of children L

Leader Election – SID-ZXID(epoch+count)

2020-08-31 21:24:35,972 [myid:2] - INFO [QuorumPeer[myid=2](plain=[0:0:**0**:0:0:0:0:0]:2182)(secure=disabled):QuorumPeer@1371] – LOOKING

2020-08-31 21:24:35,975 [myid:2] - INFO [QuorumPeer[myid=2](plain=[0:0:0:0:0:0:0:0]:2182)(secure=disabled):FastLeaderElection@944] - New election. My id = 2, proposed zxid=0x0

2020-08-31 21:24:35,999 [myid:2] - INFO [WorkerReceiver[myid=2]:FastLeaderElection$Messenger$WorkerReceiver@389] - Notification: **my state:LOOKING; n.sid:2, n.state:LOOKING, n.leader:2**, n.round:0x1, n.peerEpoch:0x0, n.zxid:0x0, message format version:0x2, n.config version:0x0

2020-08-31 21:24:36,004 [myid:2] - INFO [QuorumConnectionThread-[myid=2]-2:QuorumCnxManager@513] - Have smaller server identifier, so dropping the connection**: (myId:2 --> sid:3)**

2020-08-31 21:24:36,009 [myid:2] - INFO [WorkerReceiver[myid=2]:FastLeaderElection$Messenger$WorkerReceiver@389] - Notification: **my state:LOOKING; n.sid:3, n.state:LOOKING, n.leader:3, n.round:0x1**, n.peerEpoch:0x0, n.zxid:0x0, message format version:0x2, n.config version:0x0

2020-08-31 21:24:36,017 [myid:2] - INFO [WorkerReceiver[myid=2]:FastLeaderElection$Messenger$WorkerReceiver@389] - Notification: **my state:LOOKING; n.sid:1, n.state:FOLLOWING, n.leader:3**, n.round:0x1, n.peerEpoch:0x1, n.zxid:0x0, message format version:0x2, n.config version:0x0

2020-08-31 21:24:36,018 [myid:2] - INFO [QuorumPeer[myid=2](plain=[0:0:0:0:0:0:0:0]:2182)(secure=disabled):QuorumPeer@857] - Peer state changed: following

2020-08-31 21:24:36,018 [myid:2] - INFO [QuorumPeer[myid=2](plain=[0:0:0:0:0:0:0:0]:2182)(secure=disabled):QuorumPeer@1453] - **FOLLOWING**

Lab : Zookeeper