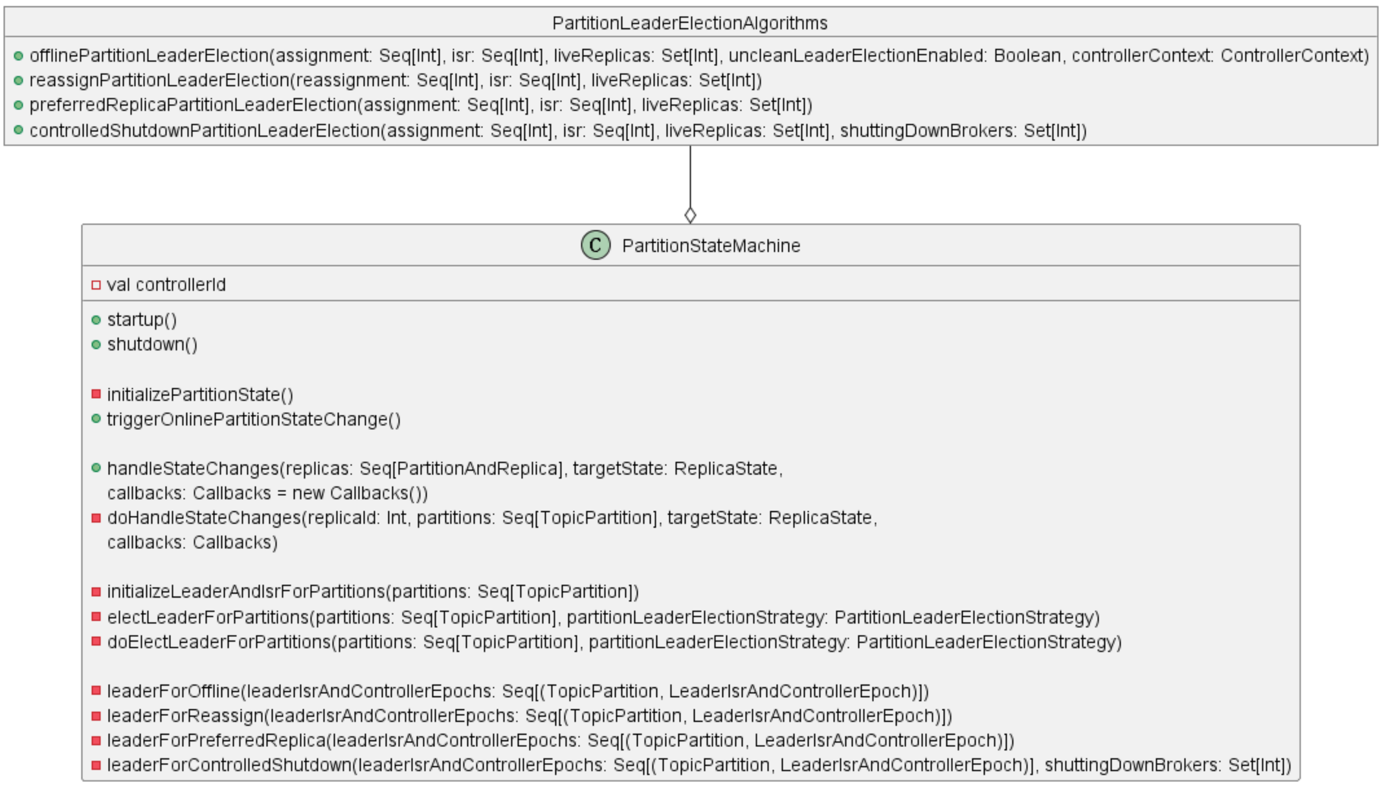
partitionStateMachine

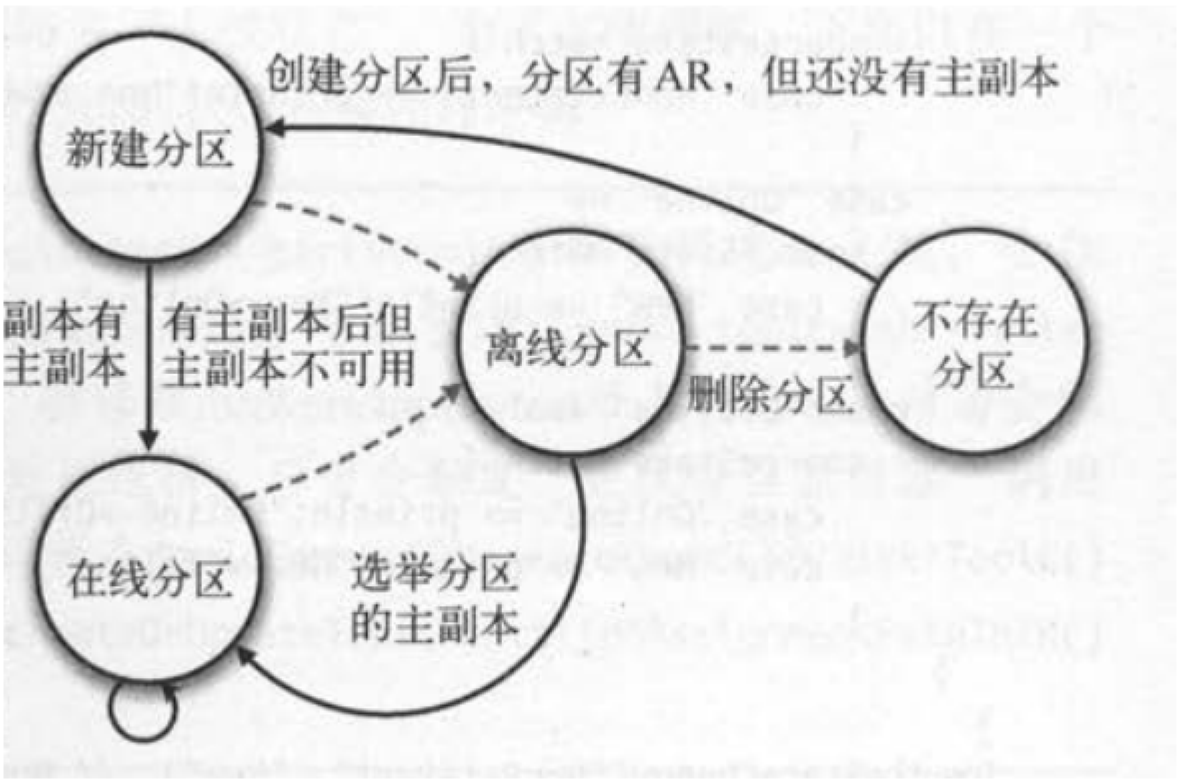
partitionStateMachine是controller模块中的分区状态机，主要负责分区在online,offline,new,non_existent几种状态间进行转化。分区状态机主要负责对于分区进行了副本领导的选举，将无副本的分区下线，更新controller的上下文，发送数据给各个代理节点更新等一系列事物。下面将根据partitionStateMachine中的一系列函数进行说明

类图如下：



```
PartitionLeaderElectionAlgorithms
offlinePartitionLeaderElection(assignment: Seq[Int], isr: Seq[Int], liveReplicas: Set[Int], uncleanLeaderElectionEnabled: Boolean, controllerContext: ControllerContext)
reassignPartitionLeaderElection(reassignment: Seq[Int], isr: Seq[Int], liveReplicas: Set[Int])
preferredReplicaPartitionLeaderElection(assignment: Seq[Int], isr: Seq[Int], liveReplicas: Set[Int])
controlledShutdownPartitionLeaderElection(assignment: Seq[Int], isr: Seq[Int], liveReplicas: Set[Int], shuttingDownBrokers: Set[Int])

C PartitionStateMachine
val controllerId
startup()
shutdown()

initializePartitionState()
triggerOnlinePartitionStateChange()

handleStateChanges(replicas: Seq[PartitionAndReplica], targetState: ReplicaState,
callbacks: Callbacks = new Callbacks())
doHandleStateChanges(replicaId: Int, partitions: Seq[TopicPartition], targetState: ReplicaState,
callbacks: Callbacks)

initializeLeaderAndIsrForPartitions(partitions: Seq[TopicPartition])
electLeaderForPartitions(partitions: Seq[TopicPartition], partitionLeaderElectionStrategy: PartitionLeaderElectionStrategy)
doElectLeaderForPartitions(partitions: Seq[TopicPartition], partitionLeaderElectionStrategy: PartitionLeaderElectionStrategy)

leaderForOffline(leaderIsrAndControllerEpochs: Seq[(TopicPartition, LeaderIsrAndControllerEpoch)])
leaderForReassign(leaderIsrAndControllerEpochs: Seq[(TopicPartition, LeaderIsrAndControllerEpoch)])
leaderForPreferredReplica(leaderIsrAndControllerEpochs: Seq[(TopicPartition, LeaderIsrAndControllerEpoch)])
leaderForControlledShutdown(leaderIsrAndControllerEpochs: Seq[(TopicPartition, LeaderIsrAndControllerEpoch)], shuttingDownBrokers: Set[Int])
```

分区状态机：



startUp()

```
  def startup() {
    info("Initializing partition state")
    initializePartitionState()
    info("Triggering online partition state changes")
    triggerOnlinePartitionStateChange()
    info(s"Started partition state machine with initial state -> $partitionState")
  }
```

startUp函数的主要功能

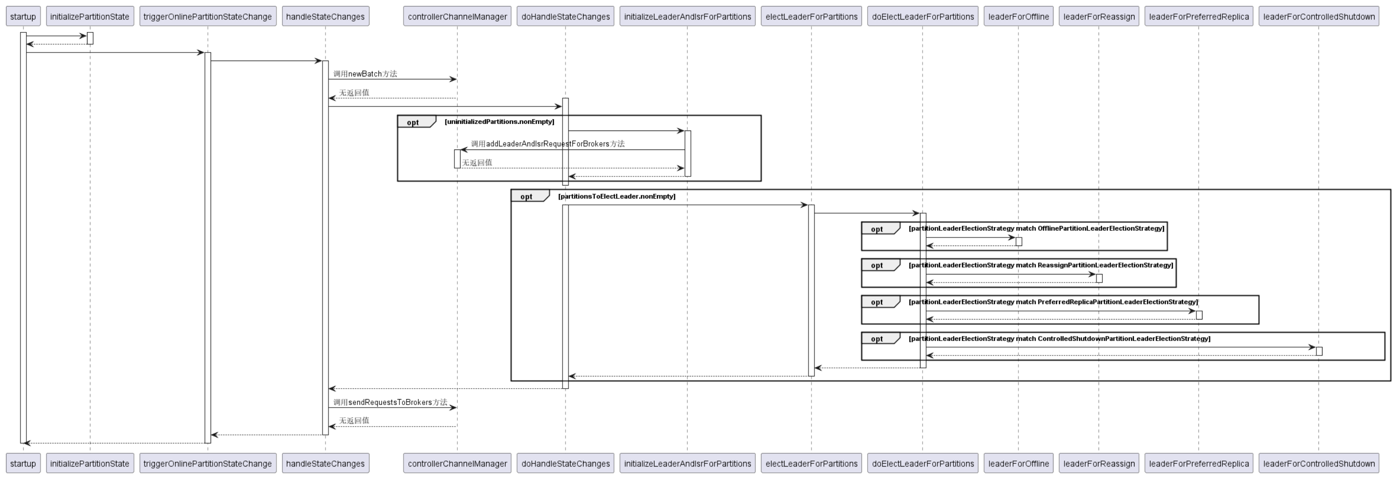
- init()判断分区的主副本是否存在，若存在则为online，不存在为offline
- triggerOnlinePartitionStateChange()将所有的分区状态变为新建或离线(除非分区要被删除)
- 以上的操作进行判断的前提，均从controller的上下文中获得

handleStateChanges()

```
def handleStateChanges(partitions: Seq[TopicPartition], targetState:
PartitionState,
                         partitionLeaderElectionStrategyOpt:
Option[PartitionLeaderElectionStrategy] = None): Unit = {
    if (partitions.nonEmpty) {
      try {
        controllerBrokerRequestBatch.newBatch()
        doHandleStateChanges(partitions, targetState,
partitionLeaderElectionStrategyOpt)
        controllerBrokerRequestBatch.sendRequestsToBrokers(controllerContext.epoch)
      } catch {
        case e: Throwable => error(s"Error while moving some partitions to
$targetState state", e)
      }
    }
  }
```

handleStateChanges()首先调用BrokerRequestBatch(ControllerChannelManager中的类)来建立与各个代理节点之间的通道，在中间调用dohandleStateChanges()函数

handleStateChanges()时序图如下：


startup
initializePartitionState
triggerOnlinePartitionStateChange
handleStateChanges
controllerChannelManager
doHandleStateChanges
initializeLeaderAndIsrForPartitions
electLeaderForPartitions
doElectLeaderForPartitions
leaderForOffline
leaderForReassign
leaderForPreferredReplica
leaderForControlledShutdown
调用newBatch方法
无返回值
opt
[uninitializedPartitions.nonEmpty]
调用addLeaderAndIsrRequestForBrokers方法
无返回值
opt
[partitionsToElectLeader.nonEmpty]
opt
[partitionLeaderElectionStrategy match OfflinePartitionLeaderElectionStrategy]
opt
[partitionLeaderElectionStrategy match ReassignPartitionLeaderElectionStrategy]
opt
[partitionLeaderElectionStrategy match PreferredReplicaPartitionLeaderElectionStrategy]
opt
[partitionLeaderElectionStrategy match ControlledShutdownPartitionLeaderElectionStrategy]
调用sendRequestsToBrokers方法
无返回值

doHandleStateChanges()

```
private def doHandleStateChanges(partitions: Seq[TopicPartition], targetState:
PartitionState,
                           partitionLeaderElectionStrategyOpt:
Option[PartitionLeaderElectionStrategy]): Unit = {
    val stateChangeLog =
stateChangeLogger.withControllerEpoch(controllerContext.epoch)
    partitions.foreach(partition => partitionState.getOrElseUpdate(partition,
NonExistentPartition))
    val (validPartitions, invalidPartitions) = partitions.partition(partition =>
isValidTransition(partition, targetState))
    invalidPartitions.foreach(partition => logInvalidTransition(partition,
targetState))
    targetState match {
      case NewPartition =>
        validPartitions.foreach { partition =>
          stateChangeLog.trace(s"Changed partition $partition state from
${partitionState(partition)} to $targetState with " +
            s"assigned replicas
${controllerContext.partitionReplicaAssignment(partition).mkString(",")}")
          partitionState.put(partition, NewPartition)
        }
      case OnlinePartition =>
```

```
        val uninitializedPartitions = validPartitions.filter(partition =>
partitionState(partition) == NewPartition)
        val partitionsToElectLeader = validPartitions.filter(partition =>
partitionState(partition) == OfflinePartition || partitionState(partition) ==
OnlinePartition)
        if (uninitializedPartitions.nonEmpty) {
          val successfulInitializations =
initializeLeaderAndIsrForPartitions(uninitializedPartitions)
          successfulInitializations.foreach { partition =>
            stateChangeLog.trace(s"Changed partition $partition from
${partitionState(partition)} to $targetState with state " +

s"${controllerContext.partitionLeadershipInfo(partition).leaderAndIsr}")
            partitionState.put(partition, OnlinePartition)
          }
        }
        if (partitionsToElectLeader.nonEmpty) {
          val successfulElections =
electLeaderForPartitions(partitionsToElectLeader,
partitionLeaderElectionStrategyOpt.get)
          successfulElections.foreach { partition =>
            stateChangeLog.trace(s"Changed partition $partition from
${partitionState(partition)} to $targetState with state " +

s"${controllerContext.partitionLeadershipInfo(partition).leaderAndIsr}")
            partitionState.put(partition, OnlinePartition)
          }
        }
      case OfflinePartition =>
        validPartitions.foreach { partition =>
          stateChangeLog.trace(s"Changed partition $partition state from
${partitionState(partition)} to $targetState")
          partitionState.put(partition, OfflinePartition)
        }
      case NonExistentPartition =>
        validPartitions.foreach { partition =>
          stateChangeLog.trace(s"Changed partition $partition state from
${partitionState(partition)} to $targetState")
          partitionState.put(partition, NonExistentPartition)
        }
    }
  }
```

doHandleStateChanges()步骤

1. 首先根据传进的partitions信息分出validPartitions和invalidPartitions；对于valid的partition如果目标是转成new，offline，nonexist都可以直接进行；若要转成online，则应根据该分区是否是新建而进行领导的选举，选举成功之后才可以转成online状态
2. 在要转为online的分区中，分为uninitializedPartitions和partitionsForLeader，分别对应新建未选举过的分区和已经经历过选举的分区；对于uninitializedPartitions调

用initializedLeaderAndIsrForPartitions()，对于partitionsForLeader调用electLeaderForPartitions()函数

initializeLeaderAndIsrForPartitions(partitions: Seq[TopicPartition])

```
private def initializeLeaderAndIsrForPartitions(partitions: Seq[TopicPartition]):
Seq[TopicPartition] = {
    val successfulInitializations = mutable.Buffer.empty[TopicPartition]
    val replicasPerPartition = partitions.map(partition => partition ->
controllerContext.partitionReplicaAssignment(partition))
    val liveReplicasPerPartition = replicasPerPartition.map { case (partition,
replicas) =>
        val liveReplicasForPartition = replicas.filter(replica =>
controllerContext.isReplicaOnline(replica, partition))
        partition -> liveReplicasForPartition
    }
    val (partitionsWithoutLiveReplicas, partitionsWithLiveReplicas) =
liveReplicasPerPartition.partition { case (_, liveReplicas) => liveReplicas.isEmpty
}

    partitionsWithoutLiveReplicas.foreach { case (partition, replicas) =>
      val failMsg = s"Controller $controllerId epoch ${controllerContext.epoch}
encountered error during state change of " +
        s"partition $partition from New to Online, assigned replicas are " +
        s"[${replicas.mkString(",")}], live brokers are
[${controllerContext.liveBrokerIds}]. No assigned " +
        "replica is alive."
      logFailedStateChange(partition, NewPartition, OnlinePartition, new
StateChangeFailedException(failMsg))
    }
    val leaderIsrAndControllerEpochs = partitionsWithLiveReplicas.map { case
(partition, liveReplicas) =>
      val leaderAndIsr = LeaderAndIsr(liveReplicas.head, liveReplicas.toList)
      val leaderIsrAndControllerEpoch = LeaderIsrAndControllerEpoch(leaderAndIsr,
controllerContext.epoch)
      partition -> leaderIsrAndControllerEpoch
    }.toMap
    val createResponses = try {
      zkClient.createTopicPartitionStatesRaw(leaderIsrAndControllerEpochs)
    } catch {
      case e: Exception =>
        partitionsWithLiveReplicas.foreach { case (partition,_) =>
logFailedStateChange(partition, partitionState(partition), NewPartition, e) }
        Seq.empty
    }
    createResponses.foreach { createResponse =>
      val code = createResponse.resultCode
      val partition = createResponse.ctx.get.asInstanceOf[TopicPartition]
      val leaderIsrAndControllerEpoch = leaderIsrAndControllerEpochs(partition)
      if (code == Code.OK) {
        controllerContext.partitionLeadershipInfo.put(partition,
leaderIsrAndControllerEpoch)

controllerBrokerRequestBatch.addLeaderAndIsrRequestForBrokers(leaderIsrAndControlle
rEpoch.leaderAndIsr.isr,
          partition, leaderIsrAndControllerEpoch,
controllerContext.partitionReplicaAssignment(partition), isNew = true)
        successfulInitializations += partition
      } else {
        logFailedStateChange(partition, NewPartition, OnlinePartition, code)
      }
    }
    successfulInitializations
  }
```

- initializeLeaderAndIsrForPartitions(partitions: Seq[TopicPartition])函数首先得到partitionWithoutReplicas和partitionsWithReplicas，前者会报错并记录在文件中
- 由partitionsWithReplicas出发，调用LeaderAndISR.api得到第一个副本与存活副本，并向zk节点创建createResponses。函数将Epoch更新，并更新上下文，发送给个代理节点完成initialization(successfulinitialization进行计数)，并根据createResponses进行交互

doElectLeaderForPartitions()

```
private def doElectLeaderForPartitions(partitions: Seq[TopicPartition],
partitionLeaderElectionStrategy: PartitionLeaderElectionStrategy):
  (Seq[TopicPartition], Seq[TopicPartition], Map[TopicPartition, Exception]) = {
    val getDataResponses = try {
      zkClient.getTopicPartitionStatesRaw(partitions)
    } catch {
      case e: Exception =>
        return (Seq.empty, Seq.empty, partitions.map(_ -> e).toMap)
    }
    val failedElections = mutable.Map.empty[TopicPartition, Exception]
    val leaderIsrAndControllerEpochPerPartition =
mutable.Buffer.empty[(TopicPartition, LeaderIsrAndControllerEpoch)]
    getDataResponses.foreach { getDataResponse =>
      val partition = getDataResponse.ctx.get.asInstanceOf[TopicPartition]
      val currState = partitionState(partition)
      if (getDataResponse.resultCode == Code.OK) {
        val leaderIsrAndControllerEpochOpt =
TopicPartitionStateZNode.decode(getDataResponse.data, getDataResponse.stat)
        if (leaderIsrAndControllerEpochOpt.isEmpty) {
          val exception = new StateChangeFailedException(s"LeaderAndIsr information
doesn't exist for partition $partition in $currState state")
          failedElections.put(partition, exception)
        }
        leaderIsrAndControllerEpochPerPartition += partition ->
leaderIsrAndControllerEpochOpt.get
      } else if (getDataResponse.resultCode == Code.NONODE) {
        val exception = new StateChangeFailedException(s"LeaderAndIsr information
doesn't exist for partition $partition in $currState state")
        failedElections.put(partition, exception)
      } else {
        failedElections.put(partition, getDataResponse.resultException.get)
      }
    }
    val (invalidPartitionsForElection, validPartitionsForElection) =
leaderIsrAndControllerEpochPerPartition.partition { case (partition,
leaderIsrAndControllerEpoch) =>
      leaderIsrAndControllerEpoch.controllerEpoch > controllerContext.epoch
    }
    invalidPartitionsForElection.foreach { case (partition,
leaderIsrAndControllerEpoch) =>
      val failMsg = s"aborted leader election for partition $partition since the
LeaderAndIsr path was " +
        s"already written by another controller. This probably means that the
current controller $controllerId went through " +
        s"a soft failure and another controller was elected with epoch
${leaderIsrAndControllerEpoch.controllerEpoch}."
      failedElections.put(partition, new StateChangeFailedException(failMsg))
    }
    if (validPartitionsForElection.isEmpty) {
      return (Seq.empty, Seq.empty, failedElections.toMap)
    }
    val shuttingDownBrokers  = controllerContext.shuttingDownBrokerIds.toSet
    val (partitionsWithoutLeaders, partitionsWithLeaders) =
partitionLeaderElectionStrategy match {
      case OfflinePartitionLeaderElectionStrategy =>
        leaderForOffline(validPartitionsForElection).partition { case (_,
newLeaderAndIsrOpt, _) => newLeaderAndIsrOpt.isEmpty }
      case ReassignPartitionLeaderElectionStrategy =>
        leaderForReassign(validPartitionsForElection).partition { case (_,
newLeaderAndIsrOpt, _) => newLeaderAndIsrOpt.isEmpty }
      case PreferredReplicaPartitionLeaderElectionStrategy =>
        leaderForPreferredReplica(validPartitionsForElection).partition { case (_,
newLeaderAndIsrOpt, _) => newLeaderAndIsrOpt.isEmpty }
      case ControlledShutdownPartitionLeaderElectionStrategy =>
        leaderForControlledShutdown(validPartitionsForElection,
shuttingDownBrokers).partition { case (_, newLeaderAndIsrOpt, _) =>
newLeaderAndIsrOpt.isEmpty }
    }
    partitionsWithoutLeaders.foreach { case (partition, leaderAndIsrOpt,
recipients) =>
      val failMsg = s"Failed to elect leader for partition $partition under
strategy $partitionLeaderElectionStrategy"
      failedElections.put(partition, new StateChangeFailedException(failMsg))
    }
    val recipientsPerPartition = partitionsWithLeaders.map { case (partition,
leaderAndIsrOpt, recipients) => partition -> recipients }.toMap
    val adjustedLeaderAndIsrs = partitionsWithLeaders.map { case (partition,
leaderAndIsrOpt, recipients) => partition -> leaderAndIsrOpt.get }.toMap
    val UpdateLeaderAndIsrResult(successfulUpdates, updatesToRetry, failedUpdates)
= zkClient.updateLeaderAndIsr(
      adjustedLeaderAndIsrs, controllerContext.epoch)
    successfulUpdates.foreach { case (partition, leaderAndIsr) =>
      val replicas = controllerContext.partitionReplicaAssignment(partition)
      val leaderIsrAndControllerEpoch = LeaderIsrAndControllerEpoch(leaderAndIsr,
controllerContext.epoch)
      controllerContext.partitionLeadershipInfo.put(partition,
leaderIsrAndControllerEpoch)
```

```
controllerBrokerRequestBatch.addLeaderAndIsrRequestForBrokers(recipientsPerPartitio
n(partition), partition,
        leaderIsrAndControllerEpoch, replicas, isNew = false)
    }
    (successfulUpdates.keys.toSeq, updatesToRetry, failedElections.toMap ++
failedUpdates)
  }
```

1. 用getDataResponse()拿到每个分区znode节点数据，然后译码产生EpochOpt将其加入到LeaderIsrControllerEpochPerPartition中，产生invalid与valid Partition

2. 对以上valid Partition分区进行选举，并最终发送给各个代理节点

   注意上面的过程，在对valid Partition进行选举时，会根据不同的选举逻辑调用不同的leader函数，如

   ```
   val (partitionsWithoutLeaders, partitionsWithLeaders) =
   partitionLeaderElectionStrategy match {
         case OfflinePartitionLeaderElectionStrategy =>
           leaderForOffline(validPartitionsForElection).partition { case (_,
   newLeaderAndIsrOpt, _) => newLeaderAndIsrOpt.isEmpty }
         case ReassignPartitionLeaderElectionStrategy =>
           leaderForReassign(validPartitionsForElection).partition { case (_,
   newLeaderAndIsrOpt, _) => newLeaderAndIsrOpt.isEmpty }
         case PreferredReplicaPartitionLeaderElectionStrategy =>
           leaderForPreferredReplica(validPartitionsForElection).partition { case
   (_, newLeaderAndIsrOpt, _) => newLeaderAndIsrOpt.isEmpty }
         case ControlledShutdownPartitionLeaderElectionStrategy =>
           leaderForControlledShutdown(validPartitionsForElection,
   shuttingDownBrokers).partition { case (_, newLeaderAndIsrOpt, _) =>
   newLeaderAndIsrOpt.isEmpty }
       }
   ```

在上述的选举中得到partitionWithLeaders，通过不同的四个函数来进行分区领导副本的选举，并最终将结果更新到controller的context中，将信息发送给各个代理节点