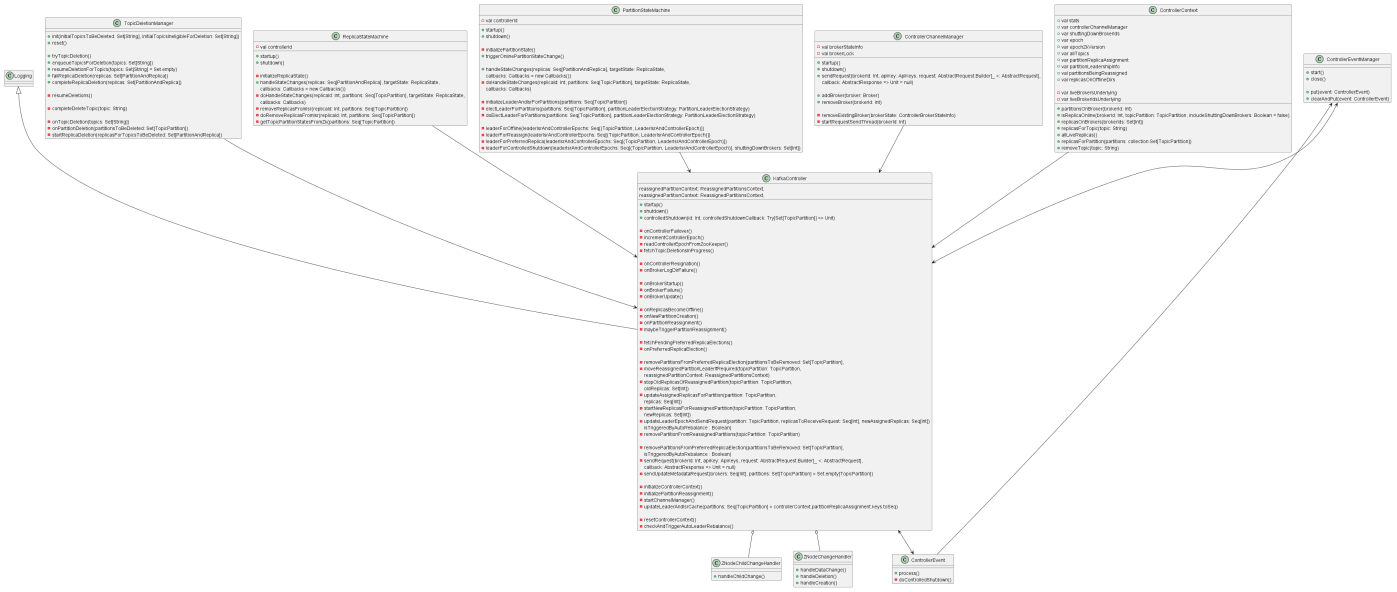
Kafka_Controller

Kafka_Controller作为controller模块中的核心组件，对整个Kafka控制器起着总管作用。kafka_controller由外界进行启动和关闭，主要功能有进行状态机和控制器上下文的初始化，并负责想不通的代理节点发送信息。kafka_controller通过调用其他类的方法来完成上述功能，并且注册监听器，将controllerEvent写进阻塞队列中供eventManager实例进行处理。下面通过对kafka_controller的重要函数来说明kafka_controller的主要功能

类图：



startUp()

```
def startup() = {
    zkClient.registerStateChangeHandler(new StateChangeHandler {
      override val name: String = StateChangeHandlers.ControllerHandler
      override def afterInitializingSession(): Unit = {
        eventManager.put(RegisterBrokerAndReelect)
      }
      override def beforeInitializingSession(): Unit = {
        val expireEvent = new Expire
```

```
        eventManager.clearAndPut(expireEvent)

        // Block initialization of the new session until the expiration event is
being handled,
        // which ensures that all pending events have been processed before
creating the new session
        expireEvent.waitUntilProcessingStarted()
      }
    })
    eventManager.put(Startup)
    eventManager.start()
  }
```

startUp函数的主要功能时注册registerStateChangeHandler监听器，并且对eventManager类中的阻塞队列进行清空，方便之后controllerEventmanager事件发生时成功写进阻塞队列并且由eventManager实例进行处理

Shutdown()

```
def shutdown() = {
    eventManager.close()
    onControllerResignation()
  }
```

Shutdown函数的主要功能是关闭eventManager实例

onControllerFailover()

```
private def onControllerFailover() {
    info("Reading controller epoch from ZooKeeper")
    readControllerEpochFromZooKeeper()
    info("Incrementing controller epoch in ZooKeeper")
    incrementControllerEpoch()
    info("Registering handlers")

    // before reading source of truth from zookeeper, register the listeners to get
broker/topic callbacks
    val childChangeHandlers = Seq(brokerChangeHandler, topicChangeHandler,
topicDeletionHandler, logDirEventNotificationHandler,
      isrChangeNotificationHandler)
    childChangeHandlers.foreach(zkClient.registerZNodeChildChangeHandler)
    val nodeChangeHandlers = Seq(preferredReplicaElectionHandler,
partitionReassignmentHandler)

nodeChangeHandlers.foreach(zkClient.registerZNodeChangeHandlerAndCheckExistence)

    info("Deleting log dir event notifications")
    zkClient.deleteLogDirEventNotifications()
```

```
    info("Deleting isr change notifications")
    zkClient.deleteIsrChangeNotifications()
    info("Initializing controller context")
    initializeControllerContext()
    info("Fetching topic deletions in progress")
    val (topicsToBeDeleted, topicsIneligibleForDeletion) =
fetchTopicDeletionsInProgress()
    info("Initializing topic deletion manager")
    topicDeletionManager.init(topicsToBeDeleted, topicsIneligibleForDeletion)

    // We need to send UpdateMetadataRequest after the controller context is
initialized and before the state machines
    // are started. The is because brokers need to receive the list of live brokers
from UpdateMetadataRequest before
    // they can process the LeaderAndIsrRequests that are generated by
replicaStateMachine.startup() and
    // partitionStateMachine.startup().
    info("Sending update metadata request")
    sendUpdateMetadataRequest(controllerContext.liveOrShuttingDownBrokerIds.toSeq)

    replicaStateMachine.startup()
    partitionStateMachine.startup()

    info(s"Ready to serve as the new controller with epoch $epoch")

maybeTriggerPartitionReassignment(controllerContext.partitionsBeingReassigned.keySe
t)
    topicDeletionManager.tryTopicDeletion()
    val pendingPreferredReplicaElections = fetchPendingPreferredReplicaElections()
    onPreferredReplicaElection(pendingPreferredReplicaElections)
    info("Starting the controller scheduler")
    kafkaScheduler.startup()
    if (config.autoLeaderRebalanceEnable) {
      scheduleAutoLeaderRebalanceTask(delay = 5, unit = TimeUnit.SECONDS)
    }

    if (config.tokenAuthEnabled) {
      info("starting the token expiry check scheduler")
      tokenCleanScheduler.startup()
      tokenCleanScheduler.schedule(name = "delete-expired-tokens",
        fun = tokenManager.expireTokens,
        period = config.delegationTokenExpiryCheckIntervalMs,
        unit = TimeUnit.MILLISECONDS)
    }
  }
```

onControllerFailover()首先对zk节点的Epoch进行更新，然后initializeControllerContext()更新上下文。然后分别对实例topicDeletionManager()，replicaStateMachine，partitionStateMachine进行初始化和启动，并在中间发送元数据个各个broker。最终调用

- maybeTriggerPartitionReassignment(controllerContext.partitionsBeingReassigned.keySet)，topicDeletionManager.tryTopicDeletion()进行可能之前节点下线时出现问题而没有进行的关于主题的删除以及分区的重新分配

- onPreferredReplicaElection(pendingPreferredReplicaElections)进行分区领导的选举

与onControllerFailover()相对的函数为onControllerResignation()，负责再当前节点没有成功选举为控制器的情况下，对之前注册的监听器，启动或初始化的topicDeletionManager，partitionStateMachine，replicaStateMachine进行关闭，并重置上下文

onBrokerStartup(newBrokers: Seq[Int])

```
private def onBrokerStartup(newBrokers: Seq[Int]) {
    info(s"New broker startup callback for ${newBrokers.mkString(",")}")
    newBrokers.foreach(controllerContext.replicasOnOfflineDirs.remove)
    val newBrokersSet = newBrokers.toSet
    // send update metadata request to all live and shutting down brokers. Old
brokers will get to know of the new
    // broker via this update.
    // In cases of controlled shutdown leaders will not be elected when a new
broker comes up. So at least in the
    // common controlled shutdown case, the metadata will reach the new brokers
faster
    sendUpdateMetadataRequest(controllerContext.liveOrShuttingDownBrokerIds.toSeq)
    // the very first thing to do when a new broker comes up is send it the entire
list of partitions that it is
    // supposed to host. Based on that the broker starts the high watermark threads
for the input list of partitions
    val allReplicasOnNewBrokers =
controllerContext.replicasOnBrokers(newBrokersSet)
    replicaStateMachine.handleStateChanges(allReplicasOnNewBrokers.toSeq,
OnlineReplica)
    // when a new broker comes up, the controller needs to trigger leader election
for all new and offline partitions
    // to see if these brokers can become leaders for some/all of those
    partitionStateMachine.triggerOnlinePartitionStateChange()
    // check if reassignment of some partitions need to be restarted
    val partitionsWithReplicasOnNewBrokers =
controllerContext.partitionsBeingReassigned.filter {
      case (_, reassignmentContext) =>
reassignmentContext.newReplicas.exists(newBrokersSet.contains)
    }
    partitionsWithReplicasOnNewBrokers.foreach { case (tp, context) =>
onPartitionReassignment(tp, context) }
    // check if topic deletion needs to be resumed. If at least one replica that
belongs to the topic being deleted exists
    // on the newly restarted brokers, there is a chance that topic deletion can
resume
    val replicasForTopicsToBeDeleted = allReplicasOnNewBrokers.filter(p =>
topicDeletionManager.isTopicQueuedUpForDeletion(p.topic))
    if (replicasForTopicsToBeDeleted.nonEmpty) {
      info(s"Some replicas ${replicasForTopicsToBeDeleted.mkString(",")} for topics
scheduled for deletion " +
        s"${topicDeletionManager.topicsToBeDeleted.mkString(",")} are on the newly
```

```
restarted brokers " +
        s"${newBrokers.mkString(",")}. Signaling restart of topic deletion for
these topics")

topicDeletionManager.resumeDeletionForTopics(replicasForTopicsToBeDeleted.map(_.top
ic))
    }
    registerBrokerModificationsHandler(newBrokers)
  }
```

- sendUpdateMetadataRequest()：上线新节点以后向新节点发送元数据
- replicaStateMachine.handleStateChanges(allReplicasOnNewBrokers.toSeq, OnlineReplica) partitionStateMachine.triggerOnlinePartitionStateChange()，对于新上线的节点而言可能会涉及到分区状态机和副本状态机的修改，因此调用两个状态机的函数进行此动作
- 对于新上线的节点上的副本，可能会涉及到删除，因此调用topicDeletionManager里的resumeDeletionForTopics()对需要进行删除的副本进行删除。删除之后在zk节点上注册registerBrokerModificationsHandler监听器

与onBrokerStartup(newBrokers: Seq[Int])相对应的，对代理节点进行操作的函数有onBrokerFailure(deadBrokers: Seq[Int])与onBrokerUpdate(updatedBrokerId: Int)。Failure函数负责将下线节点上的所有副本转为offline状态，并注销registerBrokerModificationsHandler监听器；onBrokerUpdate()函数负责给代理节点发送元数据并进行更新

以上说的onReplicasBecomeOffline()负责调用分区状态机和副本状态机的handlestatechanges()函数将分区和副本均改为下线状态

onPartitionReassignment(topicPartition: TopicPartition, reassignedPartitionContext: ReassignedPartitionsContext)

这是kafka_controller类中最为重要的函数之一，它负责在有新的副本上线时，进行分区的重新分配。并且它会被多次调用。每次被调用时，由于要考虑到当前的ISR与AR是否都包含了OAR与RAR，因此只有当上述条件满足时，才会进行第二步操作，否则条件判断将一直为false

```
private def onPartitionReassignment(topicPartition: TopicPartition,
reassignedPartitionContext: ReassignedPartitionsContext) {
    val reassignedReplicas = reassignedPartitionContext.newReplicas
    if (!areReplicasInIsr(topicPartition, reassignedReplicas)) {
      info(s"New replicas ${reassignedReplicas.mkString(",")} for partition
$topicPartition being reassigned not yet " +
        "caught up with the leader")
      val newReplicasNotInOldReplicaList = reassignedReplicas.toSet --
```

```
controllerContext.partitionReplicaAssignment(topicPartition).toSet
      val newAndOldReplicas = (reassignedPartitionContext.newReplicas ++
controllerContext.partitionReplicaAssignment(topicPartition)).toSet
      //1. Update AR in ZK with OAR + RAR.
      updateAssignedReplicasForPartition(topicPartition, newAndOldReplicas.toSeq)
      //2. Send LeaderAndIsr request to every replica in OAR + RAR (with AR as OAR
+ RAR).
      updateLeaderEpochAndSendRequest(topicPartition,
controllerContext.partitionReplicaAssignment(topicPartition),
        newAndOldReplicas.toSeq)
      //3. replicas in RAR - OAR -> NewReplica
      startNewReplicasForReassignedPartition(topicPartition,
reassignedPartitionContext, newReplicasNotInOldReplicaList)
      info(s"Waiting for new replicas ${reassignedReplicas.mkString(",")} for
partition ${topicPartition} being " +
        "reassigned to catch up with the leader")
    } else {
      //4. Wait until all replicas in RAR are in sync with the leader.
      val oldReplicas =
controllerContext.partitionReplicaAssignment(topicPartition).toSet --
reassignedReplicas.toSet
      //5. replicas in RAR -> OnlineReplica
      reassignedReplicas.foreach { replica =>
        replicaStateMachine.handleStateChanges(Seq(new
PartitionAndReplica(topicPartition, replica)), OnlineReplica)
      }
      //6. Set AR to RAR in memory.
      //7. Send LeaderAndIsr request with a potential new leader (if current leader
not in RAR) and
      //   a new AR (using RAR) and same isr to every broker in RAR
      moveReassignedPartitionLeaderIfRequired(topicPartition,
reassignedPartitionContext)
      //8. replicas in OAR - RAR -> Offline (force those replicas out of isr)
      //9. replicas in OAR - RAR -> NonExistentReplica (force those replicas to be
deleted)
      stopOldReplicasOfReassignedPartition(topicPartition,
reassignedPartitionContext, oldReplicas)
      //10. Update AR in ZK with RAR.
      updateAssignedReplicasForPartition(topicPartition, reassignedReplicas)
      //11. Update the /admin/reassign_partitions path in ZK to remove this
partition.
      removePartitionFromReassignedPartitions(topicPartition)
      //12. After electing leader, the replicas and isr information changes, so
resend the update metadata request to every broker

sendUpdateMetadataRequest(controllerContext.liveOrShuttingDownBrokerIds.toSeq,
Set(topicPartition))
      // signal delete topic thread if reassignment for some partitions belonging
to topics being deleted just completed
      topicDeletionManager.resumeDeletionForTopics(Set(topicPartition.topic))
    }
```

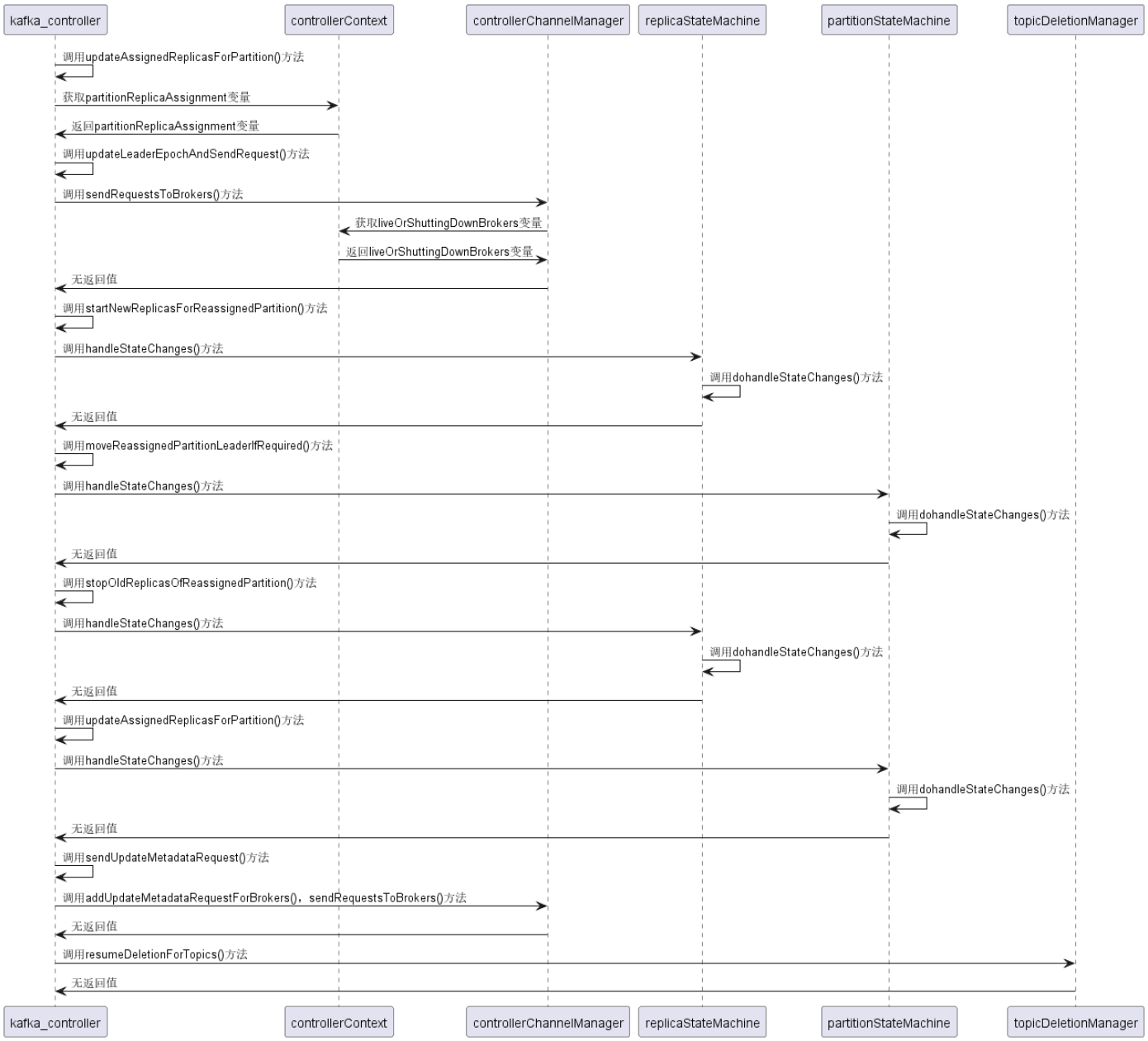
在上述函数关于分区的重新分配中，可以大致分为以下五个步骤：

1. 将RAR加入AR，此时AR=OAR+RAR

2. 将RAR加入ISR，此时ISR=OAR+RAR
3. ISR不变，但分区的主副本从RAR中选举
4. 将OAR从ISR中移除，此时ISR=RAR
5. 将OAR从AR中移除，此时AR=RAR

关于onPartitionReassignment()为什么可能要执行两次的原因，因为onPartitionReassignment()每次执行时关于allNewReplicas的判断，如果为假，则说明还并没有将新建的所有副本加入进ISR中，因此需要在执行一次；当该条件判断为真时，则说明第一步操作已经完成，此时再将之前的旧的副本分别从ISR和AR中移除就可以了

关于该函数的调用时序图如下。



kafka_controller中其他的函数，比如resetControllerContext()更新上下文，fetchPendingPreferredReplicaElections()进行副本领导机制选举，在此不过多赘述。

kafka_contoller中的方法，最终被contoller_event类的子类所用，即prossess()函数调用kafka_contoller中的函数(主要由由startUp类进行调用)

关于controller中的其他类，如TopicDeletionStopReplicaResponseReceived，Startup，BrokerChange，TopicChange它们均继承自controllerEvent类，并且会加入到controllerEvent队列中。其中的process()犯法多来自于kafkacontroller中的函数，同时其中也会有诸多监听器类，如TopicDeletionHandler，PartitionReassignmentHandler等用来监听controllerEvent的完成情况。