Final Presentation

Team Blue

Test Result

- Completed in ~40s
- 4 worker nodes with 2 * 32MB input files each
- More test cases at the github repo

```
blue@vm42:~/cs434-project$ java -jar master.jar 4
20:25:45.713 [main] INFO  Master -- Server started at 2.2.2.142:30962
20:25:57.598 [grpc-default-executor-0] INFO  Master -- Received register request from 2.2.2.146
20:25:59.300 [grpc-default-executor-0] INFO  Master -- Received register request from 2.2.2.143
20:25:59.895 [grpc-default-executor-0] INFO  Master -- Received register request from 2.2.2.144
20:26:00.657 [grpc-default-executor-0] INFO  Master -- Received register request from 2.2.2.145
20:26:00.672 [scala-execution-context-global-14] INFO  Master -- Received all register requests, worker ips: List(2.2.2.143, 2.2.2.144, 2.2.2.145, 2.2.2.146)
20:26:00.728 [scala-execution-context-global-15] INFO  Master -- Received all register requests, ranges: List(<ByteString@51855b06 size=10 contents="  l;w?EBj0">, <ByteS
yteString@5e59fcd2 size=10 contents="f{UbSY+,Cy">)
20:26:00.752 [scala-execution-context-global-14] INFO  Master -- opened channels to all workers
20:26:01.352 [scala-execution-context-global-14] INFO  Master -- Sent distribute start request to all workers
20:26:08.622 [grpc-default-executor-2] INFO  Master -- Received distribute complete request from 2.2.2.146
20:26:10.596 [grpc-default-executor-2] INFO  Master -- Received distribute complete request from 2.2.2.145
20:26:12.321 [grpc-default-executor-2] INFO  Master -- Received distribute complete request from 2.2.2.144
20:26:12.574 [grpc-default-executor-2] INFO  Master -- Received distribute complete request from 2.2.2.143
20:26:12.576 [scala-execution-context-global-20] INFO  Master -- Received all distribute complete requests, worker ips: List(2.2.2.143, 2.2.2.144, 2.2.2.145, 2.2.2.146)
20:26:12.629 [scala-execution-context-global-19] INFO  Master -- Sent sort start request to all workers
20:26:17.659 [grpc-default-executor-2] INFO  Master -- Received sort complete request from 2.2.2.146
20:26:20.563 [grpc-default-executor-2] INFO  Master -- Received sort complete request from 2.2.2.145
20:26:22.652 [grpc-default-executor-2] INFO  Master -- Received sort complete request from 2.2.2.143
20:26:24.247 [grpc-default-executor-2] INFO  Master -- Received sort complete request from 2.2.2.144
20:26:24.248 [main] INFO  Master -- All the workers finished sorting, MasterComplete
```

Test Result

- By shell script(written by github copilot)
- Check each worker’s integrity -> checked whole workers

```
Records: 617098
Checksum: 4b417db3c855c
Duplicate keys: 0
SUCCESS - all records are in order
```

Worker 1

```
Records: 640160
Checksum: 4e32aedd8a12a
Duplicate keys: 0
SUCCESS - all records are in order
```

Worker 2

```
Records: 631097
Checksum: 4d14856f1b433
Duplicate keys: 0
SUCCESS - all records are in order
```

Worker 3

```
Records: 671645
Checksum: 520ae34eb55bb
Duplicate keys: 0
SUCCESS - all records are in order
```

Worker 4

Test Result

- By shell script(written by github copilot)
- Check each worker’s integrity -> checked whole workers

```
blue@vm43:~/val$ ../gensort/64/valsort -s final.sum
Records: 2560000
Checksum: 13893954f23074
Duplicate keys: 0
SUCCESS - all records are in order
```

Milestones

- Milestone 1
  - Generate input data - done
  - Connect Master & Worker nodes - done
  - Configure gRPC - done
- Milestone 2
  - Worker samples data: done
  - Master computes ranges for each worker nodes given worker's range -> distribute it to workers with (range, ipaddress) list: done
  - Workers merge data : Moved from 3 to 2, done
  - Can execute(send) protocols in other, concurrently in Worker & Master using future & promise with dummy data, done
- Milestone 3
  - Workers sort and partition its data (should decide the size of partitioned file - done) - done
  - Workers distribute its files to appropriate node range. - done
  - Workers terminate & notify master - done
  - Can execute(send) protocols in other, concurrently in Worker & Master using future & promise with real data (merge top-down & bottom-up work) - done

What we did

- Jeongho:
- Overall design
- Master/Worker general control/communication flow
- Local sorting
- Attach sample/merge logics

What we did

- Jihun:
- Overall design
- Sample/Merge logics
- Integration/Smoke test

Design

No polling(no while() {sleep})

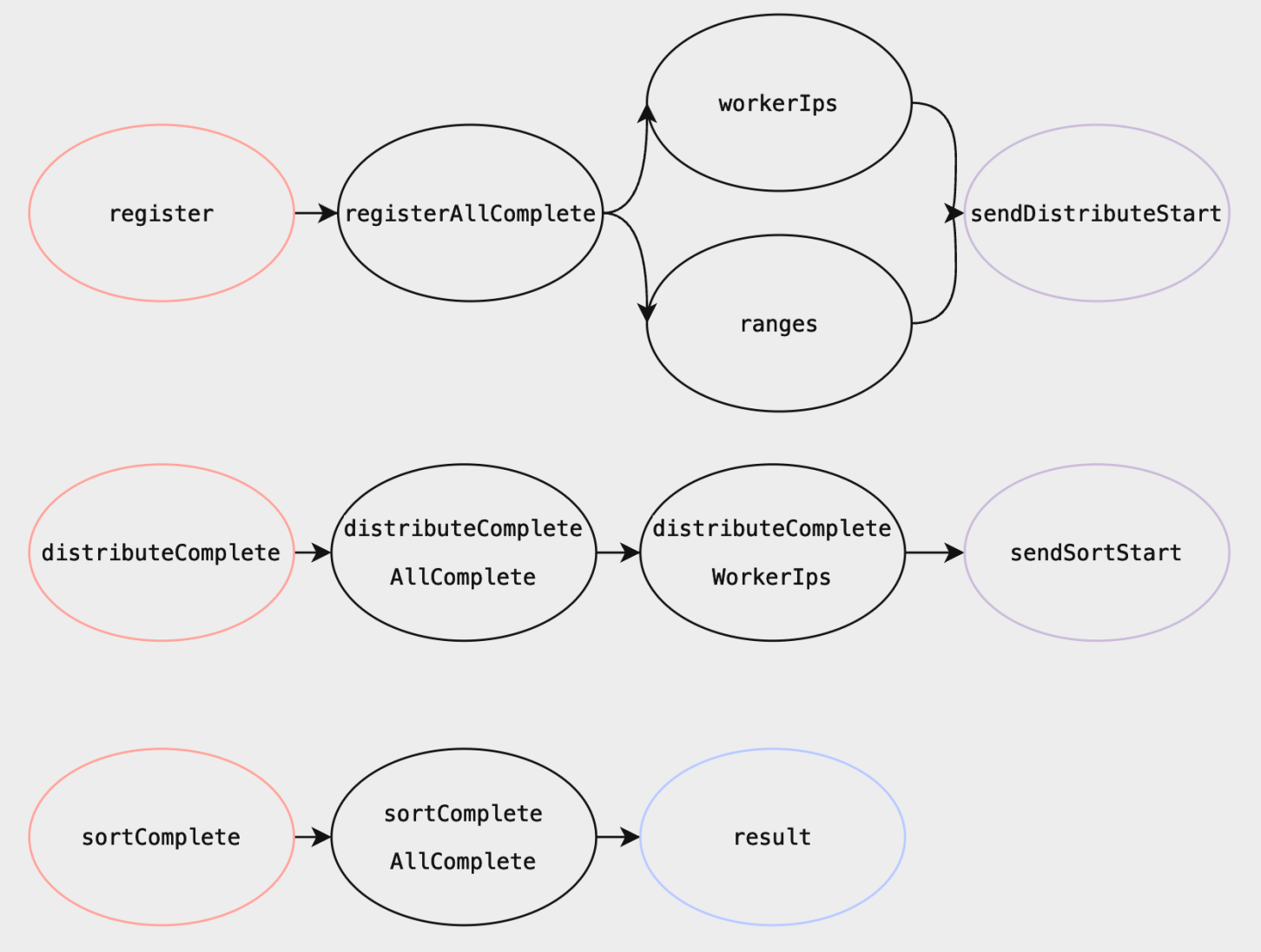
Only Future, Promise

Terminology

Distribute = shuffle

Sort = merge

Master



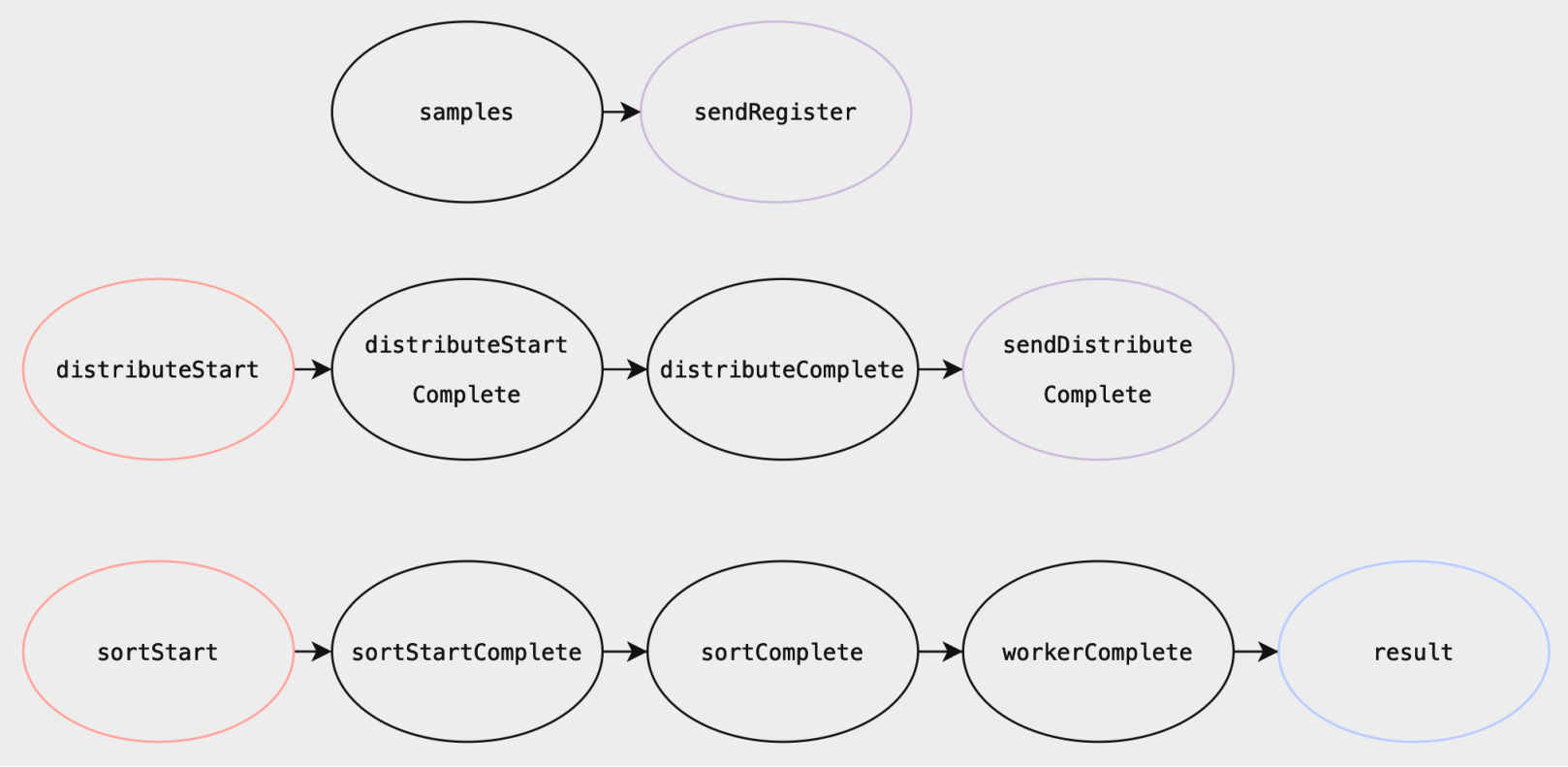
Pink: gRPC Service

Black: Promise(or Future)

Purple: function returning Future[Unit]

Blue: Result of Await.Result

Worker



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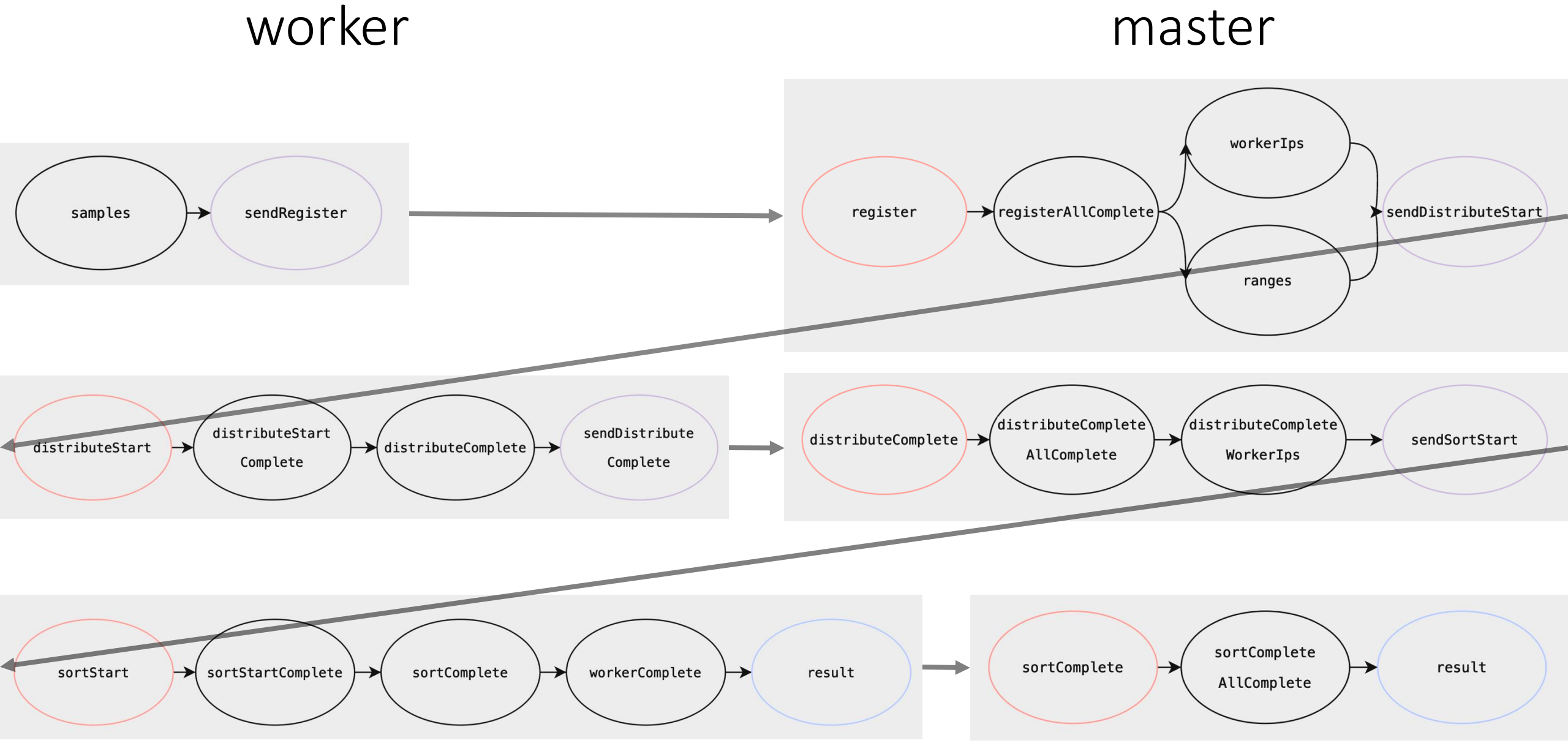

worker
master
samples
sendRegister
register
registerAllComplete
workerIps
ranges
sendDistributeStart
distributeStart
distributeStart Complete
distributeComplete
sendDistribute Complete
distributeComplete
distributeComplete AllComplete
distributeComplete WorkerIps
sendSortStart
sortStart
sortStartComplete
sortComplete
workerComplete
result
sortComplete
sortComplete AllComplete
result

```
private val distributeComplete: Future[Unit] = sendDistribute
```

```
private def sendDistribute: Future[Unit] = async {
  val ranges: SortedMap[String, ByteString] = await(distributeStartComplete.future)
  val workerIps: List[String] = ranges.keys.toList
  val rangeBegins: List[ByteString] = ranges.values.toList
  val (toClose: List[BufferedSource], recordsToDistribute: List[Iterator[Record]]) =
    await(recordFileManipulator.getRecordsToDistribute).unzip
  try {
    logger.info(s"Sending DistributeRequest for all samples to designated workers(Distribution started)")
    val channels: List[ManagedChannel] = workerIps map {...}
    val blockingStubs: List[WorkerGrpc.WorkerBlockingStub] = channels map WorkerGrpc.blockingStub

    @tailrec
    def distributeOneBlock(records: List[Record]): Unit = {...}

    def getDesignatedWorker(record: Record): Int = {...}

    blocking {
      recordsToDistribute foreach { iter: Iterator[Record] => distributeOneBlock(iter.toList) }
    }
    channels foreach (_.shutdown)
  } finally {
    toClose foreach recordFileManipulator.closeRecordsToDistribute
  }
  /.../
  logger.info(s"Sent DistributeRequest for all samples to designated workers(Wait for response)")
  ()
}
```

Distribute(Shuffling)

Shuffling is done in sendDistribute.
sendDistribute sends distribute requests.

When worker receives a distribute request(containing records less than 2MB), it simply saves the records as a file.

```
override def distribute(request: DistributeRequest): Future[DistributeResponse] = {
  val records = request.records
  logger.info(s"Received DistributeRequest from ${request.ip} with ${records.size} records")
  recordFileManipulator saveDistributedRecords records
  Future(DistributeResponse())
}
```

Merging

Need to merge “m” sorted record blocks into 1 sorted record block.

Let there are total ”n” records.

We need to find the smallest record among m blocks. (and repeat this n times)

Basic way is to simply compare m times O(n m)

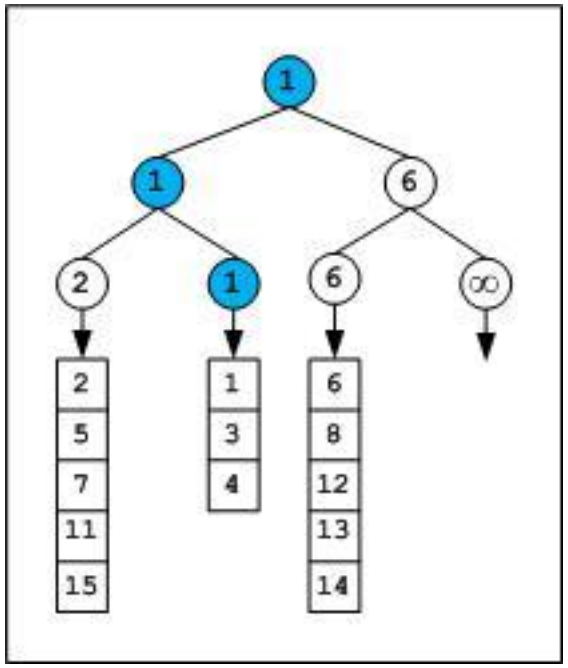
We use tournament tree O(n log m)

If there are total 2GB of records, m is 2 GB / 2 MB = 1000.

m increases linearly as the total size increases

Tournament tree

Basically a modified merge sort



Tournament tree

Implemented in RecordFileManipulator

```
private def mergeIterators(iter1: Iterator[Record], iter2: Iterator[Record]): Iterator[Record] = {
  val head1: Option[Record] = if (iter1.hasNext) Some(iter1.next()) else None
  val head2: Option[Record] = if (iter2.hasNext) Some(iter2.next()) else None
  (head1, head2) match {
    case (None, None) => Iterator()
    case (None, Some(record)) => Iterator(record) ++ iter2
    case (Some(record), None) => Iterator(record) ++ iter1
    case (Some(record1), Some(record2)) =>
      if (record1.key < record2.key)
        Iterator(record1) ++ mergeIterators(iter1, Iterator(record2) ++ iter2)
      else
        Iterator(record2) ++ mergeIterators(Iterator(record1) ++ iter1, iter2)
  }
}
```

```
private def mergeSortIterators(iterators: List[Iterator[Record]]): Iterator[Record] = {
  val (iter1: List[Iterator[Record]], iter2: List[Iterator[Record]]) =
    splitIterators(iterators, List(), List())
  (iter1, iter2) match {
    case (Nil, Nil) => Iterator()
    case (_, Nil) =>
      Check.weakAssert(logger)(iter1.length == 1, s"iter1.length is not equal to 1")
      iter1.head
    case (_, _) =>
      val (iter1_sorted: Iterator[Record], iter2_sorted: Iterator[Record]) =
        (mergeSortIterators(iter1), mergeSortIterators(iter2))
      mergeIterators(iter1_sorted, iter2_sorted)
  }
}
```

Design Remarks

- Control states as future & promise to schedule the overall flow
- Sort&Sample before register to the master
- Separate DistributeStart/DistributeFinish & SortStart/SortFinish requests so that the distribution and sorting(merging) does not happen in the httpclient’s request-response context
- Decided the size of temp&output files as 2MB, because of OOM error during file save

If we were to redo the project from beginning

- Jihun:
- Decide the data representation of the saved file & protocol & method interfaces first more than anything else.
- Change the signature and communication protocol more test friendly
- Set detailed milestone & due date

- Jeongho:
- Think more about time complexity(e.g., list concat vs flatmap?, list or cats chain?)
- Automate testing, formatting