Recap

- Data vs Information
- Evolution of Data Management Technologies
- Big Data and its characteristics
- Application
- How to process Big Data?
- Various computing technologies
- History of Hadoop
- RDBMS vs Hadoop
- Major components of Hadoop cluster

Agenda for today

- The Hadoop Distributed File System
- MapReduce detailed discussion
- Hadoop 1 vs 2
- Various Hadoop installation modes
- Running your first MapReduce program

Design your own HDFS

- Parameters to consider
  - Storing very large files
  - Underlying hardware is commodity hence failures are common
  - Physical hardware can be located anywhere
  - Any missed out?

HDFS

- HDFS is a file system designed for storing very large files with streaming data access patterns, running on clusters of commodity hardware
- Very large files
- Streaming data access
- Commodity hardware

HDFS Blocks

- Single unit of storage
- Size of block will drive the ratio of time to read a block to the seek for a block

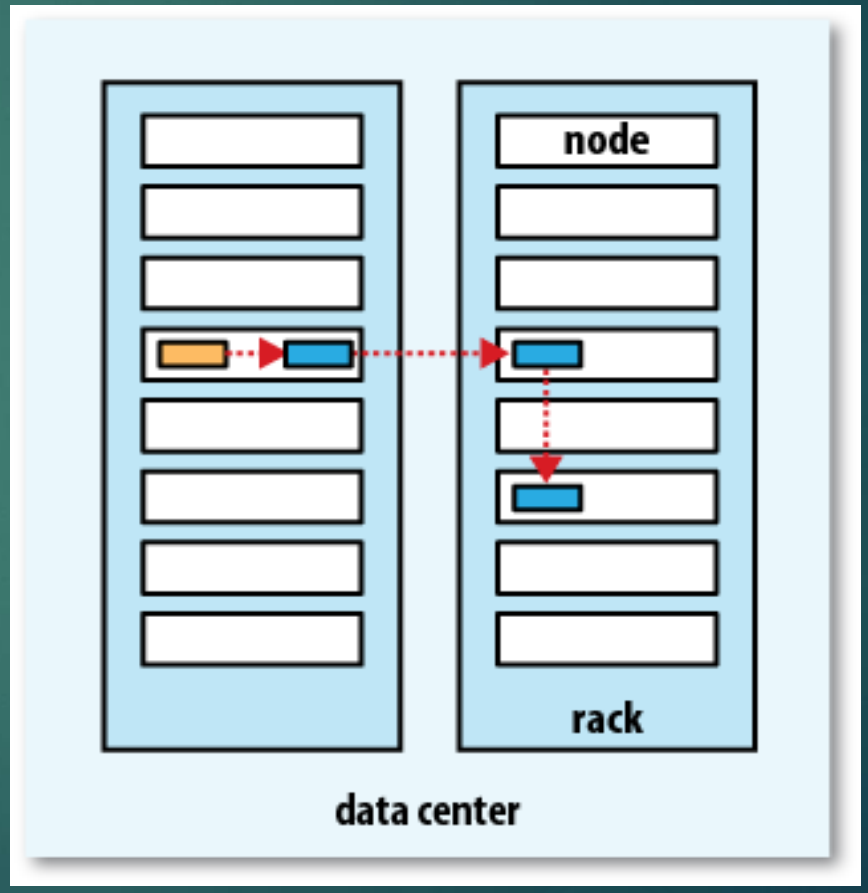


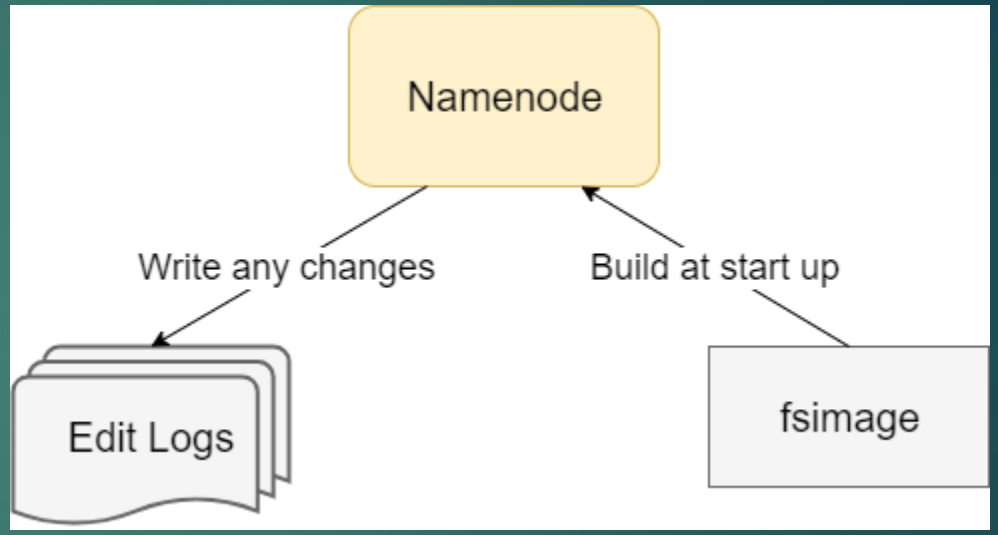
Image Ref: Hadoop definitive guide 4th edition

Benefits of blocks

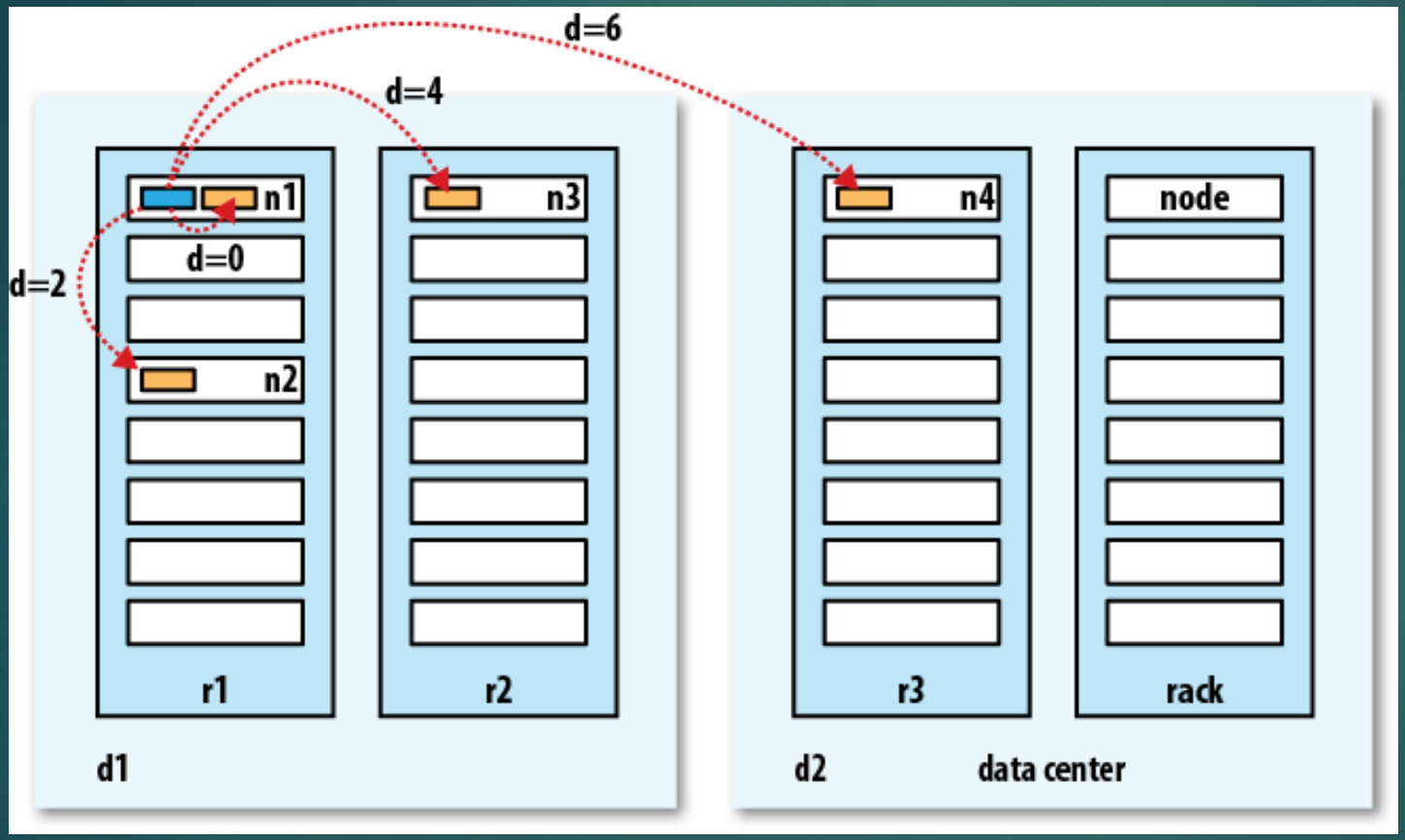
- Files can be larger than a single disk
- Simplicity at storage level as data node doesn't store any metadata
- Easy to calculate capacity of a node
- Fault tolerance by replicating blocks

File system metadata

- Who stores the metadata?
- Backup of metadata
- Role of secondary namenode



Network Topology



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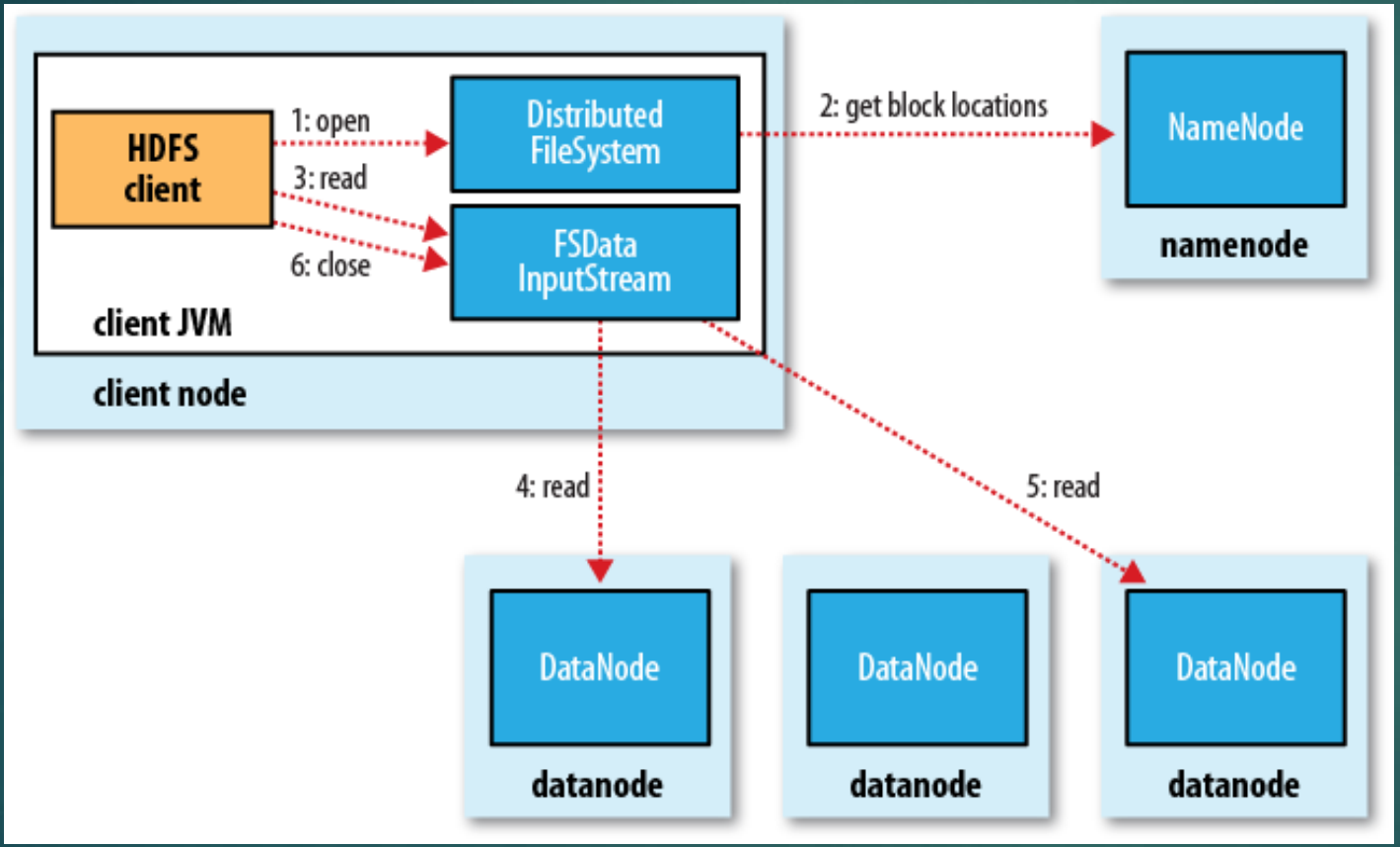
HDFS Read operation



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HDFS Write operation

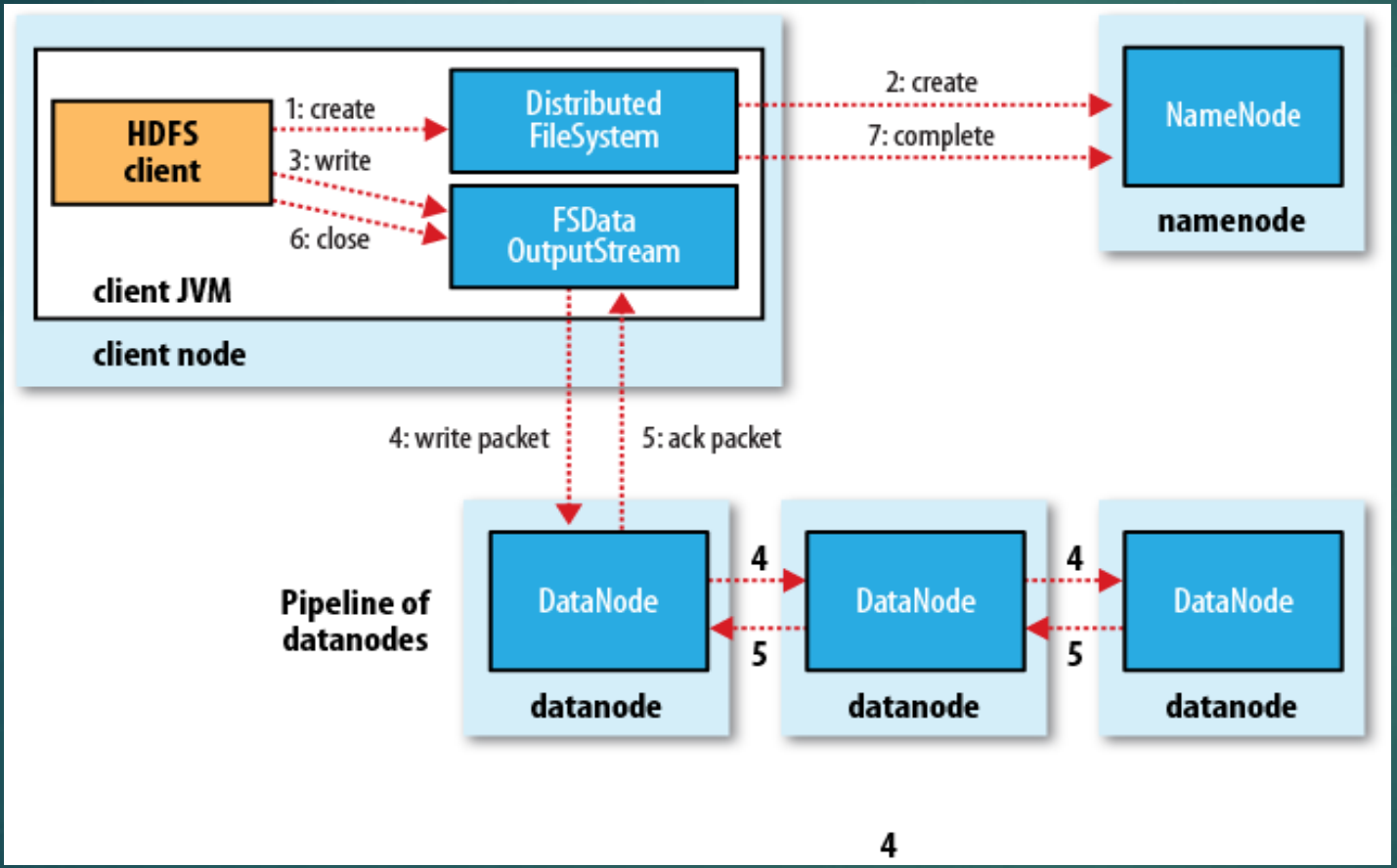


Image Ref: Hadoop definitive guide 4th edition

HDFS not made for

- Low-latency data access
- Lots of small files
- Multiple writers, arbitrary file modifications

Activity

- Data file: http://ita.ee.lbl.gov/html/contrib/NASA-HTTP.html
- Goal is to count #requests per day
- Discuss a programming approach for that

MapReduce

- Two major phases: Map and Reduce
- Notion of <Key, Value> pairs
- Divides job into multiple tasks
- Map: extract important information from each record
- Reduce: Aggregate, Summarize, Filter, Transform

MapReduce Stages

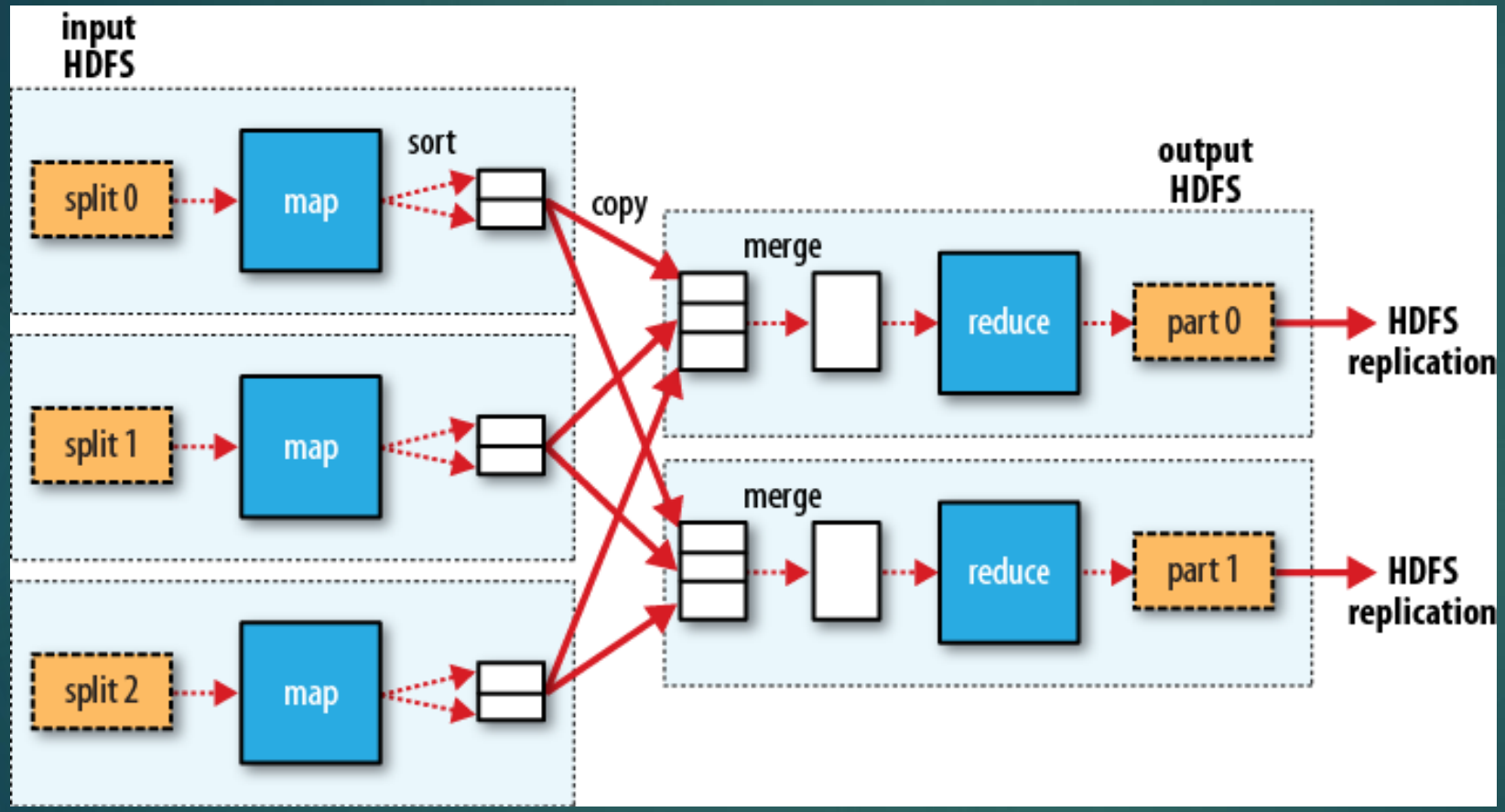


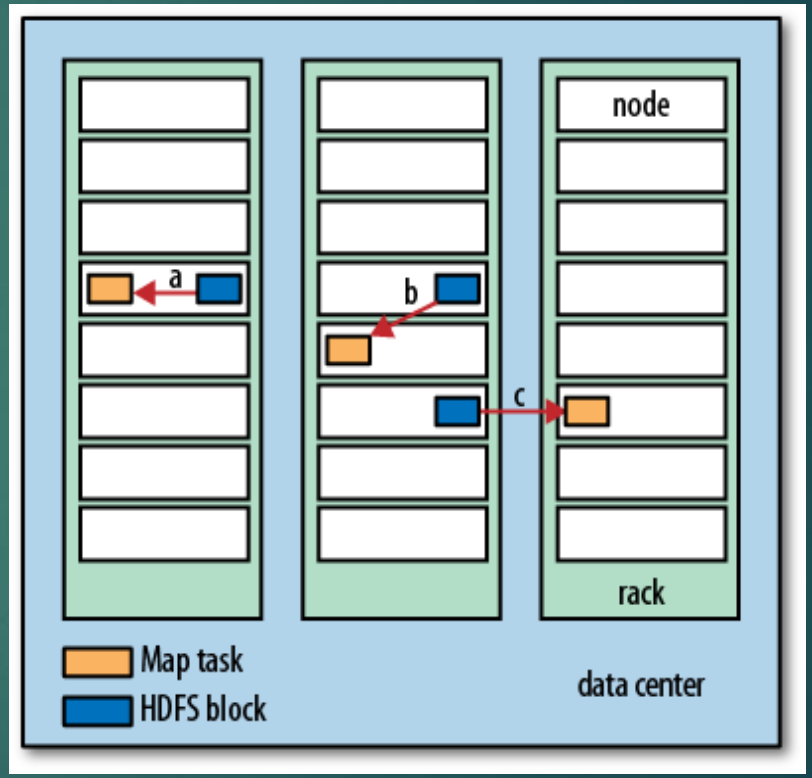
Image Ref: Hadoop definitive guide 4th edition

Map Tasks

- What is a good approach to decide how many map tasks a job should launch?
- Less number of big tasks

  vs

  higher number of small tasks
- Normally same as input data blocks
- Task to node mapping
- Notion of data locality



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Input formats

Input format	Description
TextInputFormat	Read Text file line by line. Key is offset and value is record text
KeyValueTextInputFormat	Tab separated key values from a text file
SequenceFileInputFormat<K,V>	Hadoop's file format
NLineInputFormat	Each split is guaranteed of N lines for TextInputFormat.

Input Splits

- Blocks are of fixed size
- Good chances of records being split between two block

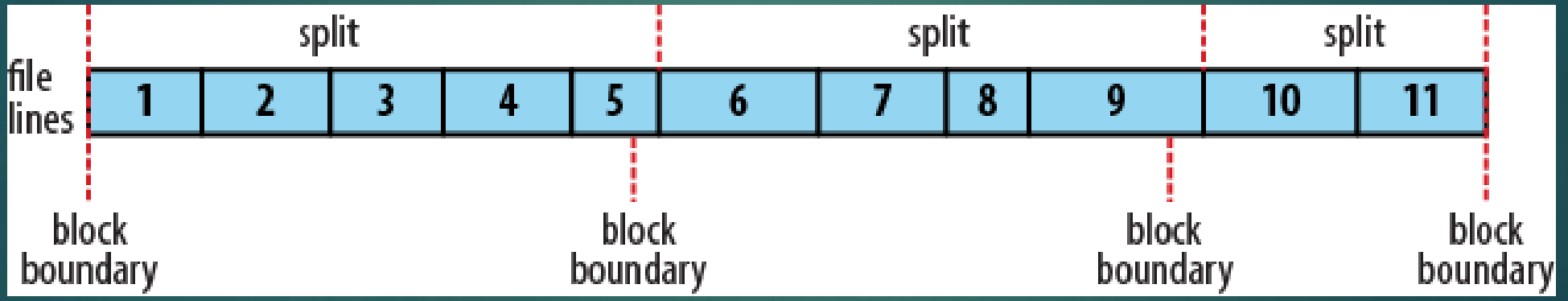

Image Ref: Hadoop definitive guide 4th edition

Reduce Tasks

- Can be configured by programmer
- Normally same as #datanodes participating in execution
- Input Key and Value type should be same as output type of mapper
- One output file per reducer under output directory
- Generates exception if output directory already exists. Why?

Output Formats

Output Format	Description
TextOutputFormat<K,V>	Tab separated key value pairs in plain text format. One record per key value pair
SequenceFileOutputFormat<K, V>	Hadoop's Sequence file format
NullOutputFormat<K,V>	Nothing. Helps in map only job

Intermediate Operations

- Sort
- Partition
- Shuffle
- Merge and Sort

MapReduce: Mapper Code


```
public class WebHitCounterMapper extends Mapper<Input Key, Input Value, Output Key, Output Value> {

    public void map(Input Key, Input Value, Context context) throws IOException, InterruptedException {




            context.write(Output Key, Output Value)
    }
}
```

MapReduce: Reducer Code


```
public class WebHitCounterReducer extends Reducer<Input Key, Input Value, Output Key, Output Value> {

    public void reduce(Input Key, Iterable<Value Data type> values,Context context) throws IOException, InterruptedException {









        context.write(Output Key, Output Value);
    }
}
```

MapReduce: Driver Code


```
public class WebHitCounterMain {
    public static void main(String[] args) throws Exception {

        Configuration conf = new Configuration();
        Job job = Job.getInstance(conf, "Daily Web Hit Counter");

        job.setJarByClass(main.WebHitCounterMain.class);
        job.setMapperClass(mapper.WebHitCounterMapper.class);
        job.setReducerClass(reducer.WebHitCounterReducer.class);

        job.setOutputKeyClass(Text.class);
        job.setOutputValueClass(IntWritable.class);

        FileInputFormat.addInputPath(job, new Path(args[0]));
        FileOutputFormat.setOutputPath(job, new Path(args[1]));

        System.exit(job.waitForCompletion(true) ? 0 : 1);
    }
}
```

Challenges with Hadoop 1

- Applications were limited to MapReduce implementations only
- Namenode machine crash or maintenance activity
- Namespace scaling
- Backup and Recovery
- Batch oriented architecture
- Support for various file formats
- Dual responsibilities of Job tracker

Image Ref: https://www.greycampus.com/blog/big-data/top-differences-between-hadoop-1-0-and-hadoop-2-2

Hadoop 2

- Support for other data processing engines
- High Availability
- HDFS Federation
- HDFS Snapshot
- Introduced Streaming and Interactive analysis
- Support for various file formats
- Yarn

YARN

- Yet Another Resource Negotiator

MapReduce 1	YARN
Job Tracker	Resource Manager, Application Master and Timeline server
Task Tracker	Node Manager
Slot	Containers

YARN model

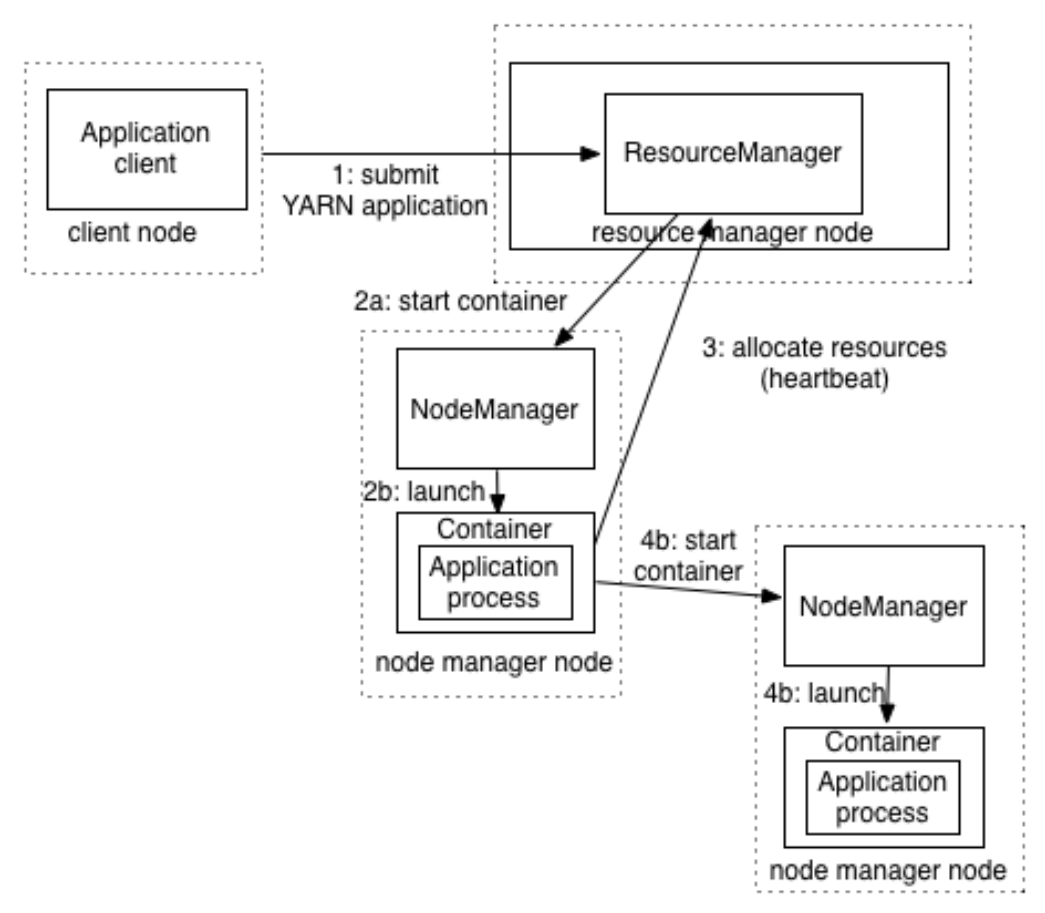

Image Ref: Hadoop definitive guide 4th edition

Pros of YARN

- Scalability
- Availability
- Utilization
- Multitenancy

Hadoop installation modes

- Standalone – Single node cluster
- Pseudo distributed mode - Single node cluster
- Distributed mode – Multi node cluster

Programming Exercise