

# Multithreading and multi-core CPUs (RV64IMFDQVA\_Zicsr\_Zifencei aka RV64GQV)

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## Part I

# Parallel programming

# Chapter 1

## Parallel processing

### 1.1 Parallel processing

#### 1.1.1 MapReduce

Framework for parallingising problems.

Say we have text and we want to do a word count. We can split the text into multiple subsections, do a word count on each and add these up.

MapReduce can do this.

##### 1: Splitting

The main server splits the database into subsections.

For example, the text document could be divided into  $M$  chunks, to be split across different servers.

The master server can then pass data to be Mapped when they have capacity. Each server could run Map on a large number of documents.

Each document here is stored as a key value pair. The value here would be the text, and the key would identify the document.

$\{2 : "AppleAppleCarrot"\}$

##### 2: Mapping

Rather than simply doing a word count on the subsections, we do a more complex, but more efficient approach.

We map the key value pair to a list of key value pairs. In our example we would map this to identifiers for each word.

The output here would be

```
[{"Apple" : 1}, {"Apple" : 1}, {"Carrot" : 1}]
```

The Map function will differ depending on the use case.

### 3: Shuffling

We now want to combine the key value pairs. There are  $R$  keys from the intermediate output of the Map program.

For each of the  $R$  keys, the master server assigns a server to reduce the key.

The master server then notifies the Reduce worker of the location of each relevant document output from the Map process. The Reduce server then copies the key value pair.

The Reduce worker now has an input of key value pairs. In our example one would have received:

```
{"Apple" : 1}
```

```
{"Apple" : 1}
```

It would also have received other instances from other servers.

The Reduce worker can then combine these to form the following:

```
{"Apple" : [1, 1]}
```

### 4: Reduce

Once all the data has been mapped, the data can be reduced.

In our example this involves creating:

```
{"Apple" : 2}
```

The Reduce function will differ depending on the use case.

### 5: Output

The outputs of each reduce can then be shared back to the main server.

We now have our word count.