UNIVERSITY OF EDINBURGH

COLLEGE OF SCIENCE AND ENGINEERING

SCHOOL OF INFORMATICS

INFR11088 EXTREME COMPUTING

Tuesday 3rd May 2016

14:30 to 16:30

INSTRUCTIONS TO CANDIDATES

Answer any TWO questions.

All questions carry equal weight.

CALCULATORS MAY NOT BE USED IN THIS EXAMINATION

Year 4 Courses

Convener: I. Stark

External Examiners: A. Burns, A. Cohn, P. Healey, T. Field, T. Norman

THIS EXAMINATION WILL BE MARKED ANONYMOUSLY

1. (a) On Linux, Docker can isolate applications without a virtual machine. Will applications run faster in Docker on Linux or in a virtual machine? [*1 mark*]

   (b) BigTable

      i. Name the read-only storage technology that BigTable is based on. [*1 mark*]

      ii. Does BigTable partition keys by hashing or by ranges? [*1 mark*]

   (c) Suppose you launch a job on 10,000 machines in your own data centre. The job is slow to start because all the machines are trying to load the same large executable file. Name two networking technologies you could use to distribute the file faster, in addition to storing it on more replicas. Explain why each is appropriate. [*6 marks*]

   (d) For every word, we want to know how many **unique** words immediately follow it. Nothing follows the last word of a line. For example, given the input

```
In San Francisco
San Francisco Is
In San Diego
```

   the output is (in any order, split across any number of files)

`In`	1
`San`	2
`Francisco`	1

   Formally, this is a function *follow* where

$$follow(\texttt{San}) = 2$$

   because both "`San Francisco`" and "`San Diego`" appear.

   Sketch a MapReduce program to compute *follow*. Your solution should be a single MapReduce pass, use constant memory (buffering an entire line is allowed), and support multiple mappers and reducers. You do not need to write code, but do need to state what the mapper, partitioner, sorting comparison function, and reducer do. Define any key-value pairs that these use to communicate.

      i. Sketch a MapReduce program without a combiner. [*9 marks*]

      ii. Add a combiner to your program. If you changed other components like the mapper, give the new components. [*4 marks*]

      iii. In running the single MapReduce job, you notice that the reducer responsible for "`the`" is taking too long. Explain why this is the case even with combiners. [*3 marks*]

2. (a) You see a new post on a social media site with an image. The text is there but the image is broken. Upon refreshing the page, the image shows up correctly. Is the site likely to be using ACID or BASE? [*1 mark*]

   (b) Write pseudocode to insert an item into a Bloom filter. Assume the hash function h is provided. [*5 marks*]

   (c) You are provided with a set of interesting words and a text file. The task is to count how many times each interesting word appears in the text file. In each scenario, name an appropriate join strategy and explain your choice in terms of efficiency.

      i. The text file is large and the set of interesting words fits in RAM. [*3 marks*]

      ii. The text file is large and the set of interesting words is too large to fit on one machine. [*4 marks*]

   (d) Build a simplified version of Twitter with two functions: post and search. Users can post text containing hash tags (for example: `#exc #exam`). A search query is a single hash tag. The search response is all posts containing the hash tag, including a stream of new posts as they come in.

      i. Name one framework you could use to handle new posts. [*2 marks*]

      ii. Name one framework you could use to periodically process old posts. [*2 marks*]

      iii. Design a distributed system to handle high post and search traffic. Do not rely on frameworks or services, though you may take inspiration from them. Describe what the groups of servers are, what they do, and how they communicate. You may assume that servers never fail. [*8 marks*]

3. (a) In Storm, what is the difference between a bolt and a spout? [*1 mark*]

   (b) Chord arranges machines and data in a circle. How are these positions determined? [*1 mark*]

   (c) In the strict consistency model, all reads and writes are ordered by time. In linearisability, there exists a timeline consistent with what happened, but it may not have actually happened in that order. Give an example combination of reads and writes that is linearisable but not strict. [*4 marks*]

   (d) Streaming.

      i. Name two techniques to approximately identify the most popular pages on a live website, as well as the number of visitors. [*2 marks*]

      ii. Using reservoir sampling, give pseudocode to uniformly sample one line from a large text file. [*6 marks*]

   (e) Distributed filesystems and fault tolerance.

      i. Briefly describe a technique to preserve **read** performance despite some slow nodes. [*2 marks*]

      ii. Briefly describe a technique to preserve performance for **writing** a new file despite some slow nodes. [*3 marks*]

      iii. Content on disk can sometimes be corrupted. Describe an efficient method to handle this problem, presuming that the storage servers are trustworthy. [*2 marks*]

      iv. Assume the metadata servers are trustworthy but the storage servers are run by potentially malicious third parties. Describe an efficient method to ensure files are read correctly. Your solution should be efficient for clients that read part or all of a file. [*4 marks*]