UNIVERSITY OF EDINBURGH

COLLEGE OF SCIENCE AND ENGINEERING

SCHOOL OF INFORMATICS

EXTREME COMPUTING

Friday 2nd May 2014

09:30 to 11:30

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. Cohn, T. Field

THIS EXAMINATION WILL BE MARKED ANONYMOUSLY

1. (a) Describe stateful and stateless models in distributed file systems. What semantics do they have and what are their properties? Describe one type of workload for each model that the model would be a good fit for. [*5 marks*]

   (b) What were the key assumptions of the Andrew File System and what design decisions did they result in? [*6 marks*]

   (c) Consider the case of process migration in a Cloud environment. Ideally, we would like to be able to freeze a process while it is running on some physical node, and seamlessly migrate it to another one.

      i. Describe three problems involved in enabling process migration for all user processes. **Briefly** explain each problem. (You do not need to provide a solution to the problem!) [*6 marks*]

      ii. Give a rough scketch of a method that would allow a cloud provider to offer process migration. You can impose certain constraints on the processes that you would allow to be migrated (*e.g.*, type of resources the process touches, operating system, properties of the process, *etc.*); if you do, make sure that you state them in your answer. [*8 marks*]

2. (a) The Instruction Set Architecture (ISA) of a processor supports two or more modes. Give definitions for the user and system modes of the instruction set architecture and briefly explain their key differences. [*6 marks*]

   (b) List the design goals and performance guarantees of Zookeeper. **Note**: you **do not** need to explain how a Zookeeper cluster is deployed or works; only its design goals and guarantees. [*7 marks*]

   (c) For each of the following problems describe how you would solve it using MapReduce. You should explain how the input is mapped into (key, value) pairs by the map stage, *i.e.*, specify what is the key and what is the associated value in each pair, and how the key(s) and value(s) are computed. Then you should explain how the (key, value) pairs produced by the map stage are processed by the reduce stage to get the final answer(s). If the job cannot be done in a single mapreduce pass, describe how it would be structured into two or more mapreduce jobs with the output of the first job becoming input to the next one(s). You should only describe your solution algorithm. You should not translate the solution into any detailed programming language.

      i. The input is a list of housing data where each input record contains information about a single house: (address, city, state, postcode, value). The output should be the average house value in postcode. [*4 marks*]

      ii. The input contains two lists. One list gives voter information for every registered voter: (voterid, name, age, postcode). The other list gives disease information: (postcode, age, disease). For each unique pair of age and postcode values, the output should give a list of names and a list of diseases for people in that postcode with that age. If a particular age/postcode pair appears in one input list but not the other, then that age/postcode pair can appear in the output with an empty list of names or diseases, or you can omit it from the output entirely, depending on which is easier. (*Hint: the keys in a map/reduce step do not need to be single atomic values.*) [*8 marks*]

3. (a) Give a brief description of BigTable. Focus on its semantics, the high-level architecture, and how it organises data in terms of the distributed storage layer (what we referred to during lectures as the building blocks of BigTable). **Note**: You **do not** need to discuss BigTable's lookup or maintenance algorithms in any way. [*7 marks*]

   (b) Consider fingerprints and Bloom filters, as described during lectures.

      i. What is the difference between a fingerprint and a Bloom filter in terms of what they are expected to look like? [*2 marks*]

      ii. How can a fingerprint be used to generate a Bloom filter? [*2 marks*]

      iii. When can a Bloom filter act as a fingerprint? [*2 marks*]

   (c) Suppose that you want to use Bloom filters to test whether two sets of values overlap. That is given sets S and T you want to compute whether there exists some value x such that $x \in S$ and $x \in T$.

      i. Give a simple algorithm to do that and comment on any of the problems caused by the use of a Bloom filter. [*4 marks*]

      ii. Suppose now that you want to extend the above computation so that not only will you test for overlap but also compute the overlap set: $I = \{x | x \in S \wedge x \in T\}$. You want to implement this computation so that it will run over a cluster and consider the case where the two sets reside on different nodes of the cluster. Sketch an algorithm to do so. Your algorithm should be exact, use Bloom filters, and make the best possible use of the computational and communication resources of the cluster. [*8 marks*]