

Answers included

CS27020: Modelling Persistent Data

WORKSHEET: NOSQL

Time allowed: 60 minutes

Calculators are not allowed in this worksheet.

Answer all questions

1. NoSQL (not only SQL) database management systems are based on a variety of data models. Name some NoSQL database management systems and indicate their underlying data model.

Answer:

Here are a few examples. There are many others.

- *MongoDB: BSON, binary format JSON*
- *MarkLogic: XML with support for JSON and other formats*
- *Apache CouchDB: JSON*
- *Apache Cassandra: key-value store*

2. NoSQL (not only SQL) databases are considered to be particularly suitable for certain kinds of application. Give some examples of users of NoSQL databases and the applications for which they are used.

Answer: *Here are some possibilities; there are many others.*

- *adform, digital advertising*
- *lovation, fraud prevention*
- *IBM, email client back-end*
- *HP, music streaming*

Answers included

3. List some advantages that NoSQL databases have over relational databases.

Answer:

- *Scaling using clusters of commodity hardware rather than bigger specialist servers*
- *Capacity to handle larger volumes of data and higher transaction rates than rdbms*
- *Less need for database administrators*
- *Lower costs, both to start up and to expand*
- *Few, if any data model restrictions*

Alternative answers are possible. For example, there may be a focus on faster queries rather than capacity to handle high transaction rates.

4. List some disadvantages of NoSQL databases when compared with relational databases.

Answer:

- *NoSQL databases are relatively immature, so expert support can be difficult to obtain*
- *NoSQL data models emphasise whole documents, which eliminates the need for JOINS but which also makes analysis of data sets difficult*
- *There are many NoSQL data manipulation languages, which reduces portability of queries and transferability of skills*
- *The lack of a schema is likely to present problems for maintenance as a database matures*
- *Because data is not normalized, maintaining consistency is challenging*

Answers included

5. This question concerns Hadoop MapReduce and NoSQL databases.

a) What is a Hadoop MapReduce job?

Answer: *A MapReduce job splits input data, in the form of (key,value) pairs, into chunks that are processed in parallel.*

b) What is a MapReduce job configuration? How might a MapReduce job be configured to count occurrences of word in text files distributed across a network.

Answer: *A MapReduce job configuration typically specifies mapping, combination, partitioning, reducing, and input and output formats. A MapReduce job configuration to count the occurrences of words in text files distributed across a network could use the original files as chunks, and specify a map operation to count words, and a reduce operation to combine word counts.*

c) What is a map task? What kind of map task would you expect to find in the word counting application?

Answer: *A map task operates on a single chunk of data, producing as output a collection of {key,value} pairs. A map task in the word counting application could count the words in a single text file, producing a list of words each paired with its number of occurrences.*

d) What is a reduce task? What kind of reduce task would you expect to see in the word counting application?

Answer: *A reduce task takes two or more collections of {key,value} pairs and reduces these to a single collection. A reduce task in the word counting application might take several lists of words with their respective word counts and deliver a single list that gave the total count for each word.*

6. This question is taken from the lecture on Map Reduce Examples.

As part of a study, different insects are repeatedly counted in a location in West Wales over a period of several weeks. The data is stored in several files. Each file can contain multiple entries for a given species.

Here is some data that was collected.

(ant, 50), (bumblebee, 12), (dragonfly, 5) (wasp, 2), (hoverfly, 5), (ant 20),
(wasp, 3), (honeybee, 22), ...

Outline map and reduce tasks to identify the largest numbers of each kind of insect observed during the study. Illustrate your outline with output from the map and reduce tasks?

Answers included

Answer:

A map task finds the largest number of each species from a single file. It outputs (species,n), the largest number of each species, from the file. Several map tasks – one for each data file - could run in parallel.

A reduce task combines the results of map tasks to produce a single value (the highest count) for each species. This is done by repartitioning the output from the map tasks so that each partition contains all the values (counts) associated with a given key (insect) Within a partition, $jkey, value_i$ pairs are processed in ascending key order So outputs from each reduce task are sorted.

Map output:

- *(ant, 50), (bumblebee, 12), (dragonfly, 5), (hoverfly, 5), (wasp, 3), (honeybee, 22)*
- *(bumblebee, 5), (wasp, 5), (hawk moth, 6)*
- *(dragonfly, 4), (hoverfly, 15),*
- *... etc.*

Map outputs are are repartitioned so that each partition contains all the values (counts) associated with a given key (insect).

Within a partition (key,value) pairs are processed in ascending key order. This means that outputs from each reduce task are sorted.

Partitions

- *$jant, 50_i, jbumblebee, 12_i, jbumblebee, 5_i, jbumblebee, 40_i, jdragonfly, 5_i, jdragonfly, 4_i$*
- *$jhoneybee, 22_i, jhoverfly, 5_i, jhoverfly, 15_i, jwasp, 3_i, jwasp, 5_i, jwasp 30_i$*
- *... etc.*

Q. What happened to the hawk moth observation? A. It has been placed in another Reduce partiton – one that's not illustrated here.

Q. Where did $jbumblebee, 40_i$ come from? A. It came from another Map partition.

Reduce output:

- *$jant, 50_i, jbumblebee, 40_i, jdragonfly, 5_i$*
- *$jhoneybee, 22_i, jhoverfly, 15_i, jwasp 30_i$*
- *... etc.*

Answers included

7. A broadcasting company wishes to provide real-time access to information about an international music festival. Viewers will typically be using more than one device to watch concerts and to interact with social media in real time. Search, semantics and application services are required to work on huge volumes of data arriving at an enormous rate.

The company will use Hadoop MapReduce to process large data sets across clusters of computers, but is undecided as to whether to use MarkLogic or HBase for data management.

Write a short report advising the company about the relative merits of MarkLogic and HBase for this application.

Answer:

To answer a question like this, you should write two or three pages of text that addresses points like the ones listed below. These are not the only possible points – others are likely. Your report should start with an introduction that indicates who the report is for and how it should be used, and it should end with a conclusion, possibly recommending one of the systems but at least summarizing the main points that should be considered when a system is chosen.

Here are some possible points – see if you can think of some other ideas as well.

- *both HBase and MarkLogic provide immediate consistency, likely to be important for ensuring consistent reporting of sports results and news*
- *both provide APIs for a number of application programming languages*
- *both provide access control*
- *HBase is licensed using the Apache license version 2; MarkLogic is subject to a commercial license (though a restricted free version is available)*
- *HBase uses a wide column (extensible record) store; MarkLogic allows data to be transformed between several different data models (native XML, key-value store, RDF triples); native XML is likely to facilitate transformation between presentation formats*
- *HBase uses Hadoop directly; MarkLogic uses Hadoop via a Hadoop Connector;*
- *MarkLogic provides ACID transactions; HBase does not*

Answers included

8. Transactions on a conventional relational database system are normally required to maintain consistency; that is, the database must be in a consistent state (it must represent reality) before and after the transaction. Some NoSQL database management systems such as Couchbase and Riak relax this requirement and only guarantee 'eventual consistency' for their distributed data stores.

a) What is meant by the term 'eventual consistency'?

Answer: *Eventual consistency means that if a data item is not written or updated for a sufficiently long period of time, then all reads of that item will return the same value.*

b) How does eventual consistency challenge application developers?

Answer: *An application developer must allow for the possibility that an application may read data that has been superseded.*

c) Why is eventual consistency desirable in some situations?

Answer: *Eventual consistency makes it easier to provide readily scalable, highly available distributed systems that continue to operate even when nodes or connections between nodes fail.*