Informatica Biomedica

lezione21

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Informatica Biomedica: Lezione 21

- The CouchDB Project
  - Features
- MapReduce
  - Dataflow
- ERLANG for Concurrent programming

Contents

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- CouchDB also offers incremental replication with bi-directional conflict detection and resolution

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- CouchDB's built in Web administration console speaks directly to the database using HTTP requests issued from your browser

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- Erlang allows for a flexible design that is easily scalable and readily extensible

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- The documents in a collection need not share a schema, but retain query abilities via views
- Views are defined with aggregate functions and filters are computed in parallel, much like MapReduce

Document Storage

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- Field values can be simple things like strings, numbers, or dates
- But you can also use ordered lists (arrays) and associative maps (associative array, hash, whatever your language may call them)
- Every document in a CouchDB database has a unique id and there is no required document schema

Map/Reduce Views and Indexes

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- The logic in your JavaScript functions can be arbitrarily complex
- Since computing a view over a large database can be an expensive operation, CouchDB can index views and keep those indexes updated as documents are added, removed, or updated
- This provides a very powerful indexing mechanism that you get unprecedented control over compared to most databases

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- The biggest gotcha typically associated with this level of flexibility is conflicts

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- A lot of tools, software and hardware, are available to do all sorts of things with HTTP like caching, proxying and load balancing

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- The framework is inspired by map and reduce functions commonly used in functional programming, although their purpose in the MapReduce framework is not the same as their original forms.
- MapReduce libraries have been written in C++, C, Erlang, Java, Python, Ruby, F, R and other programming languages.

Overview

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MapReduce is a framework for processing huge datasets on certain kinds of distributable problems using a large number of computers (nodes), collectively referred to as a cluster.

Computational processing can occur on data stored:

1. either in a filesystem (unstructured)

2. or within a database (structured).

"Map" step

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- A worker node may do this again in turn, leading to a multi-level tree structure
- The worker node processes that smaller problem, and passes the answer back to its master node

"Reduce" step

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- it combines them in a way to get the output
- returning the answer to the problem it was originally trying to solve

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The advantage of MapReduce is that it allows for distributed processing of the map and reduction operations

- Provided each mapping operation is independent of the other, all maps can be performed in parallel - though in practice it is limited by the data source and/or the number of CPUs near that data
- Similarly, a set of *reducers* can perform the reduction phase - all that is required is that all outputs of the map operation which share the same key are presented to the same reducer, at the same time

Efficient process?

While this process can often appear inefficient compared to algorithms that are more sequential, MapReduce can be applied to significantly larger datasets than that which "commodity" servers can handle

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- A large server farm can use MapReduce to sort a petabyte of data in only a few hours
- The parallelism also offers some possibility of recovering from partial failure of servers or storage during the operation
- If one mapper or reducer fails, the work can be rescheduled — assuming the input data is still available

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The *hot spots*, which are application dependent, are:

1. an input reader
2. a Map function
3. a partition function
4. a compare function
5. a Reduce function
6. an output writer

Input reader

The input reader divides the input into 16MB to 128MB splits and the framework assigns one split to each Map function

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- A common example will read a directory full of text files and return each line as a record

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- The input and output types of the map can be (and often are) different from each other
- If the application is doing a word count, the map function would break the line into words and output the word as the key and "1" as the value

Partition function

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- The partition function is given the key and the number of reducers and returns the index of the desired reduce
- A typical default is to hash the key and modulo the number of reducers

Comparison function

The input for each reduce is pulled from the machine where the map ran and sorted using the application's comparison function.

Reduce function

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- The reduce can iterate through the values that are associated with that key and output 0 or more values
- In the word count example, the reduce function takes the input values, sums them and generates a single output of the word and the final sum

Output writer

The Output Writer writes the output of the reduce to stable storage, usually a distributed file system.

CouchDB uses a MapReduce framework for defining views over distributed documents and is implemented in Erlang.

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- was originally a proprietary language within Ericsson, but was released as open source in 1998.

Erlang concurrent programming model

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- Erlang provides language-level features for creating and managing processes with the aim of simplifying concurrent programming
- Though all concurrency is explicit in Erlang, processes communicate using message passing instead of shared variables, which removes the need for locks

Philosophy

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- Find the right methods: Design by Prototyping
- It is not good enough to have ideas, you must also be able to implement them and know they work.
- Make mistakes on a small scale, not in a production project.

Erlang Tutorial

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