Large-scale Data Systems

Fall 2020

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LIÈGE université

Us

This course is given by:

- Theory: Gilles Louppe (g.louppe@uliege.be)
- Practicals and projects: Joeri Hermans (joeri.hermans@doct.ulg.ac.be)

Feel free to contact any of us for help!

Goals and philosophy

Solid ground

- Understand the foundational principles of distributed systems, on top of which distributed databases and computing systems are operating.
- Understand why data systems are designed the way they are designed.

Practical

- Exposition to industrial software.
- Fun and challenging course project.
- Practice and improve your system engineering skills!

Critical thinking

- Assess the benefits and disadvantages of data systems.
- No hype!
-

We give you Lego bricks.

Your job is to assemble them into well-engineered solutions.

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Image credits: Kelly Sikkema.

Outline

- Lecture 1: Introduction
- Lecture 2: Basic distributed abstractions
- Lecture 3: Reliable broadcast
- Lecture 4: Shared memory
- Lecture 5: Consensus
- Lecture 6: Distributed file systems
- Lecture 7: Distributed hash tables
- Lecture 8: Blockchain
- Lecture 9: Cloud computing

Lectures

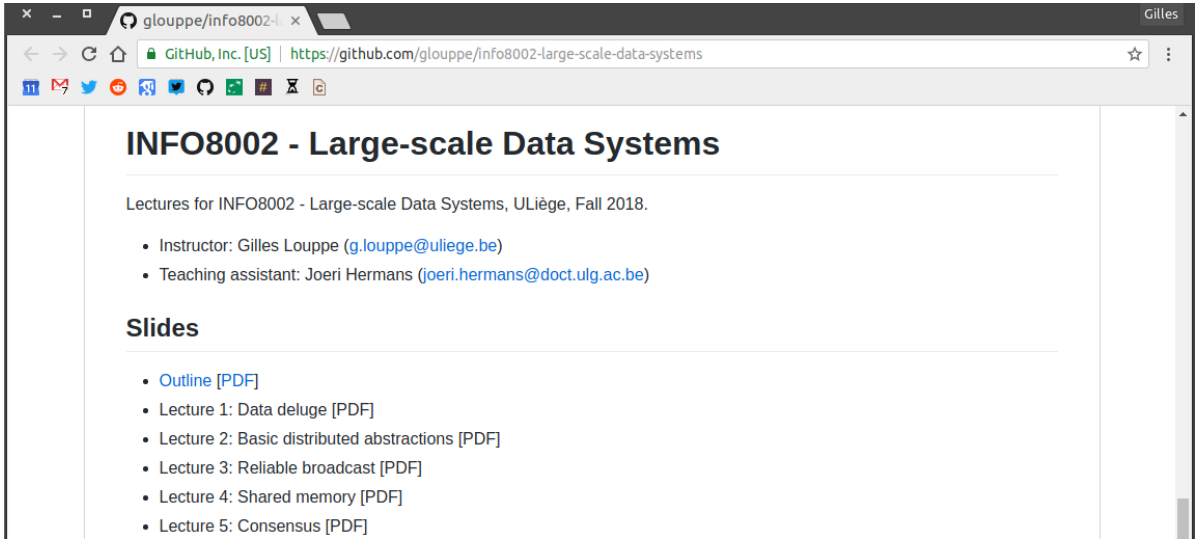
- Theoretical lectures
- Practicals

Slides

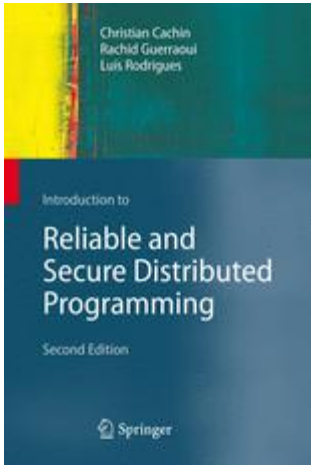
Slides are available at github.com/glouppe/info8002-large-scale-data-systems.

- In HTML and in PDFs.
- Published/Updated the day before the lesson.
- Slight differences/improvements/fixes from previous years.

Slides are partially adapted from CSE 486/585 Distributed systems (University at Buffalo) and CS425 Distributed systems (University of Illinois UC).



Textbook



The core content of this course (lectures 2 to 5) is based on the following textbook:

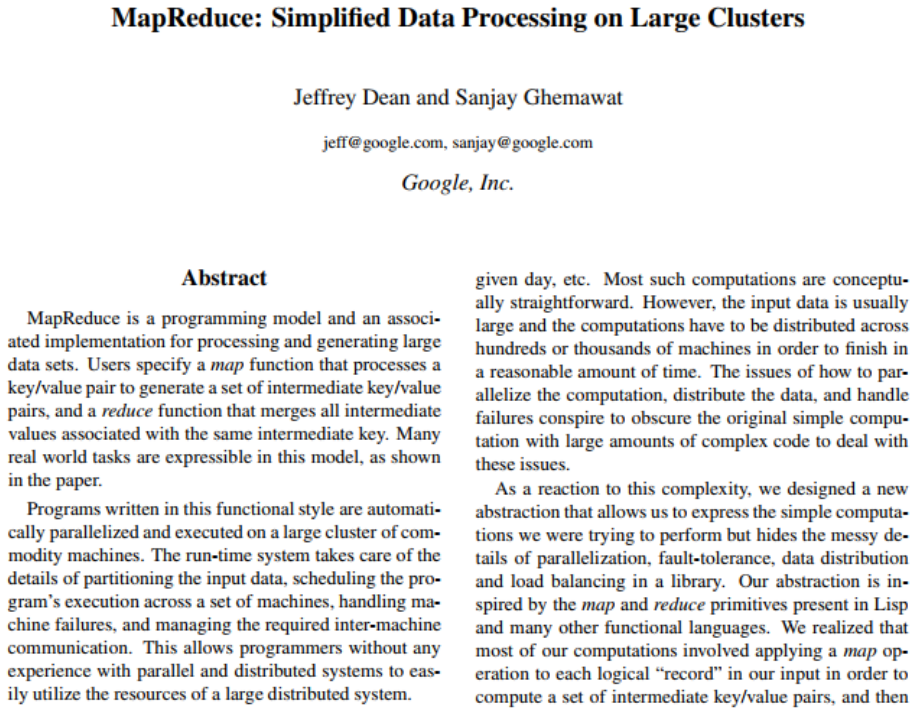
> *Christian Cachin, Rachid Guerraoui, Luis Rodrigues, "Introduction to Reliable and Secure Distributed Programming", Springer.*

This textbook is optional.

Projects

Reading assignment

Read, summarize and criticize a major scientific paper in Large-Scale Data Systems. (See GitHub for papers and instructions.)



MapReduce: Simplified Data Processing on Large Clusters

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Abstract

MapReduce is a programming model and an associated implementation for processing and generating large data sets. Users specify a *map* function that processes a key/value pair to generate a set of intermediate key/value pairs, and a *reduce* function that merges all intermediate values associated with the same intermediate key. Many real world tasks are expressible in this model, as shown in the paper.

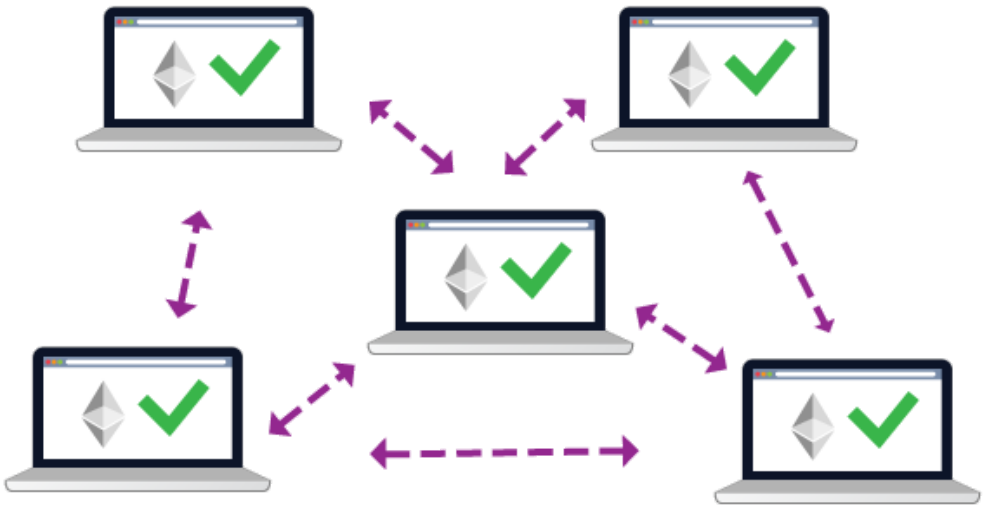
Programs written in this functional style are automatically parallelized and executed on a large cluster of commodity machines. The run-time system takes care of the details of partitioning the input data, scheduling the program's execution across a set of machines, handling machine failures, and managing the required inter-machine communication. This allows programmers without any experience with parallel and distributed systems to easily utilize the resources of a large distributed system.

given day, etc. Most such computations are conceptually straightforward. However, the input data is usually large and the computations have to be distributed across hundreds or thousands of machines in order to finish in a reasonable amount of time. The issues of how to parallelize the computation, distribute the data, and handle failures conspire to obscure the original simple computation with large amounts of complex code to deal with these issues.

As a reaction to this complexity, we designed a new abstraction that allows us to express the simple computations we were trying to perform but hides the messy details of parallelization, fault-tolerance, data distribution and load balancing in a library. Our abstraction is inspired by the *map* and *reduce* primitives present in Lisp and many other functional languages. We realized that most of our computations involved applying a *map* operation to each logical "record" in our input in order to compute a set of intermediate key/value pairs, and then

Programming project

Implement a distributed application. (Project to be announced later.)



Evaluation

- Oral exam (50%)
- Reading assignment (10%)
- Programming project (40%)

Projects are mandatory for presenting the exam.

Let's start!