CHRISTIAN-ALBRECHTS-UNIVERSITY

MASTER THESIS

Alternative Software Transaction Implementation in Haskell

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in the

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Declaration of Authorship

Hiermit erkläre ich an Eides statt, dass ich die vorliegende Arbeit selbstständig verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel verwendet habe.

Kiel, December 5, 2016

Christian-Albrechts-University

Abstract

Faculty of Engineering
Department of Computer Science

Master of Science

Alternative Software Transaction Implementation in Haskell

by Lasse Folger

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The Thesis Abstract is written here (and usually kept to just this page). The page is kept centered vertically so can expand into the blank space above the title too...

Acknowledgements

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The acknowledgments and the people to thank go here, don't forget to include your project advisor…

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List of Abbreviations

LAH	**L**ist **A**bbreviations **H**ere
WSF	**W**hat (it) **S**tands **F**or
STM	**S**oftware **T**ransactional **M**emory
ACID	**A**tomicity **C**onsistency **I**solation **D**urability

Chapter 1

Motivation

Modern computer architecture includes multicore processors. To utilize these multicore system to their full extend, concurrent and parallel programming is needed. By this new challenges arise. One challenge is the logical issue of splitting the problem in smaller problems which can be processed by different threads in parallel. Aditionally there are technical challenges. A new schedular is needed and hardware accesses (Printer, Display, etc.) need to be sequential for example. These are challenges the operating system usually handles. The are other challenges the operating system cannot handle, because they are specific for every program.

The most discussed challenge is the synchronization. If a program works with multiple threads, these threads usually communicate. Communications means to exchange data. Even a simple statement like an assignment can cause problem when used in the parallel threads. The problem is that these operations are non atomic operations. Thus (`x = x + 1`) consist of three parts. first reading the old value, second adding `1`, and thrid write the new value. This means two threads in parallel can both read the old value, then both add `1` to the old value, and then write the new value. The new value is the initial value incremented by `1`, even though two threads executed an increment operation on this value. This non inteded behaviour is called *lost update*. The efforts to avoid this non intended behaviour are called synchronization.

Even though multicore processors are new, the research in the field of synchronization has a long history, starting with (Dijkstra, 1965), which introduces the most basic synchronization tool, the semaphore. The semaphore is a abstract datatype which holds an Interger and provides two *atomic* operations, `P` and `V`. If the value of the semaphore is greater than `0`, `P` decrements the semaphore. If the value of the semaphore is `0` the thread that evoked `P` is suspended. When a thread evokes `V` the value of the semaphore is increased and in the case another thread is currently suspenden, because it called `P` on the semaphore, that thread is awakened. After the thread is awakened, it tries `P` again.

This seem to be a simple construct, but its capabilities are enormous. It is highly complex to use a semaphore correctly. The main problem of semaphores is the so called deadlock[1]. This means there is a schedule, where no progress of the systen is possible, because all threads are waiting for a semaphore. The term deadlock is not exclusive for semaphores. It is used for all blocking mechanisms. To avoid such deadlocks is verry hard even when using one or few semaphores. It is nearly impossible to avoid deadlocks when you trie to compose semaphore based functions.

To avoid the problems of semaphores while maintaining the expressiveness of semaphores the so called software transactions were introduced (Harris et al., 2005). Sofware transactions are inspired by the long known database transactions (Gray

[1]In the course of this thesis I will refer to deadlocks as a static propertie rather than a state of a system.

and Reuter, 1992). Software transactions provide an interface to program with single element buffers. If you are using this interface the underlying implementation ensures the so called *ACI(D)* properties. **A** for atomicity. This means a transactions appears to be processed instantaneous. **C** for consistency. This means that a consistent view of the system is always guaranteed. **I** stands for isolation. This means the programmer does not need to worry about concurrency and every thread can act as if it were the only thread. **D** stand for durability, but is relevant only for data base transactions.

There is a stable implementation for software transactions in Haskell, namely Software Transactional Memory (called STM in the following). STM provides the ACI(D) properties by optimistically executing the transaction. If a conflict is detected, the changes are discarded and the transactions is restarted (a so called rollback). This works, but is not optimal with regards to efficiency and performance. There are two problems. First the conflict detection. Sometimes the implementation detects a conflict a evokes a rollback, even though it is not necessary. The second problem is the rollback mechanism. Regardless of the conflict always the whole transaction is reexecuted. This includes operations on data that has not changed thus an unnecessary recomputation. These problems are discussed in detail in the following Chapter 2. The aim of this thesis is to provide an alternative implementation that avoids these problems while preserving the ACI(D) properties.

Chapter 2

Introduction

2.1 Welcome and Thank You

Welcome to this LaTeX Thesis Template, a beautiful and easy to use template for writing a thesis using the LaTeX typesetting system.

If you are writing a thesis (or will be in the future) and its subject is technical or mathematical (though it doesn't have to be), then creating it in LaTeX is highly recommended as a way to make sure you can just get down to the essential writing without having to worry over formatting or wasting time arguing with your word processor.

LaTeX is easily able to professionally typeset documents that run to hundreds or thousands of pages long. With simple mark-up commands, it automatically sets out the table of contents, margins, page headers and footers and keeps the formatting consistent and beautiful. One of its main strengths is the way it can easily typeset mathematics, even *heavy* mathematics. Even if those equations are the most horribly twisted and most difficult mathematical problems that can only be solved on a super-computer, you can at least count on LaTeX to make them look stunning.

Appendix A

Frequently Asked Questions

A.1 How do I change the colors of links?

The color of links can be changed to your liking using:
`\hypersetup{urlcolor=red}`, or
`\hypersetup{citecolor=green}`, or
`\hypersetup{allcolor=blue}`.
If you want to completely hide the links, you can use:
`\hypersetup{allcolors=.}`, or even better:
`\hypersetup{hidelinks}`.
If you want to have obvious links in the PDF but not the printed text, use:
`\hypersetup{colorlinks=false}`.

Bibliography

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