BECKERS LANDER, LAKIERE HENNING
HOW TO DISTRIBUTE EFFICIENTLY A COMPUTATION IN-
TENSIVE CALCULATION ON AN ANDROID DEVICE TO EX-
TERNAL COMPUTE UNITS WITH AN ANDROID API?

Master of Science thesis

Examiner: Prof. Nurmi Jari
Examiner and topic approved by the
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ABSTRACT

BECKERS LANDER, LAKIERE HENNING: How to distribute efficiently a computation intensive calculation on an Android device to external compute units with an Android API?
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Keywords:

The abstract is a concise 1-page description of the work: what was the problem, what was done, and what are the results. Do not include charts or tables in the abstract.

Put the abstract in the primary language of your thesis first and then the translation (when that is needed).

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PREFACE

This document template conforms to Guide to Writing a Thesis at Tampere University of Technology (2014) and is based on the previous template. The main purpose is to show how the theses are formatted using LaTeX (or LaTeX to be extra fancy) .

The thesis text is written into file `d_tyo.tex`, whereas `tutthesis.cls` contains the formatting instructions. Both files include lots of comments (start with %) that should help in using LaTeX. TUT specific formatting is done by additional settings on top of the original `report.cls` class file. This example needs few additional files: TUT logo, example figure, example code, as well as example bibliography and its formatting (`.bst`) An example makefile is provided for those preferring command line. You are encouraged to comment your work and to keep the length of lines moderate, e.g. ¡80 characters. In Emacs, you can use `Alt-Q` to break long lines in a paragraph and `Tab` to indent commands (e.g. inside figure and table environments). Moreover, tex files are well suited for versioning systems, such as Subversion or Git.

Acknowledgements to those who contributed to the thesis are generally presented in the preface. It is not appropriate to criticize anyone in the preface, even though the preface will not affect your grade. The preface must fit on one page. Add the date, after which you have not made any revisions to the text, at the end of the preface.

Tampere, 11.8.2014

On behalf of the working group, Erno Salminen

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LIST OF ABBREVIATIONS AND SYMBOLS

CC license	Creative Commons license
LaTeX	Typesetting system for scientific documentation
SI system	Système international d'units, International System of Units
TUT	Tampere University of Technology
URL	Uniform Resource Locator

a	acceleration
F	force
m	mass

The abbreviations and symbols used in the thesis are collected into a list in alphabetical order. In addition, they must be explained upon first usage in the text.

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1.   INTRODUCTION

BIBLIOGRAPHY

2. THEORETICAL BACKGROUND

2.1 Matrix multiplication

Before explaining why we chose a matrix multiplication, we will show how a matrix A and B are multiplied in equation 2.1

$$\begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix} * \begin{bmatrix} 5 & 6 \\ 7 & 8 \end{bmatrix} = \begin{bmatrix} 1*5+2*7 & 1*6+2*8 \\ 13*5+4*7 & 3*6+4*8 \end{bmatrix} = \begin{bmatrix} 19 & 22 \\ 93 & 50 \end{bmatrix} \tag{2.1}$$

When a problem is hard, people commonly divide the hard problem in multiple smaller/easier problems. Using matrices is one of those easier ways to deal with data, that's why the most common tools in electrical engineering and computer science are rectangular grids of numbers known as matrices. The numbers in a matrix can represent data, and they can also represent mathematical equations. In many time-sensitive engineering applications, multiplying matrices can give quick but good approximations of much more complicated calculations [**?**]. So the first reason why a matrix multiplication was chosen is the importance of calculations with matrices.

The second reason consist of the increasing computations when a matrix grows. The relation between the size of the matrix and the calculation is the following:

$$amountOfCalculations = (2 * size - 1) * size^2 \tag{2.2}$$

$$M = \begin{bmatrix} A & B \\ .. & .. \end{bmatrix} \tag{2.3}$$

$$N = \begin{bmatrix} F & .. \\ G & .. \end{bmatrix} \tag{2.4}$$

$$R1 = \begin{bmatrix} A*F+B*G & .. \\ .. & .. \end{bmatrix} \tag{2.5}$$

Deriving equation 2.2. First we count the amount of calculations to calculate the first element of the result matrix R1, when processing the matrix multiplication M * N. The amount of calculations is 3, 1 addition of 2 multiplications. When processing

the same calculation for a matrix of a bigger size, for example size 5, result matrix 2.6 will be calculated. In result matrix R2, 4 additions and 5 multiplications are calculated. Resulting in 4 * 5 calculations in the first element of result matrix R2 with size 5. The number of elements in the matrix is equal to size * size. When you put this all in a formula, we get equation 2.2.

$$R2 = \begin{bmatrix} A*F+B*G+C*H+D*I+E*J & .. & .. & .. & .. \\ & .. & & .. & .. & .. & .. \\ & .. & & .. & .. & .. & .. \\ & .. & & .. & .. & .. & .. \\ & .. & & .. & .. & .. & .. \end{bmatrix} \tag{2.6}$$

2.2 Parallel computing

2.3 SoC

2.3.1 FPGA

2.3.2 HPS

2.3.3 Bridges

lwHPS2FPGA

HPS2FPGA

FPGA2HPS

2.3.4 Quartus

Linux RHEL

Windows 10

2.3.5 Bluetooth

Master

slave

Bit error detection

Bit error correction

2.3.6 Web socket

BIBLIOGRAPHY

3. IMPLEMENTATION

3.1 SoC

3.1.1 coding

C++ host

OpenCL kernel

C ++ to bridge registers

Character error detection

3.1.2 Bluetooth connection

Verilog Bluetooth module

Websocket server

This document template conforms to Guide to Writing a Thesis Tampere University of technology (TUT) [**?**]. A thesis or a report typically include the following chapters:

> Title page
> Abstract
> Preface
> Contents
> List of abbreviations and symbols
> 1. Introduction
> 2. Theoretical background
> 3. Research methodology and materials
> 4. Results and analysis (possibly split into separate chapters)
> 5. Conclusions
> References
> Appendices (if applicable)

3.2 In-text citations

Formatting examples of an journal article in bibliography are provided below, first in the numeric style and then the name-year style.

Section **??** cannot appear alone, but needs some company (i.e. **??**).

4.   CONCLUSIONS

BIBLIOGRAPHY

APPENDIX A. SOMETHING EXTRA