Instituto Tecnológico de Costa Rica
Área Académica de Ingeniería en Computadores

Proyecto de Diseño en Ingeniería en Computadores

Requirements Specification

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1 Introduction

1.1 Purpose

The purpose of this research is to evaluate the design of Application-Specific Instruction Set Processors (ASIPs) for error-tolerant applications. The ASIPs are meant to execute with improved performance (for instance, energy consumption or execution time would be lower) compared to a General Purpose Proccesor (GPP) but also have greater flexibility than ASICs.

1.2 Scope

This research concerns both application selection and application optmization. For this, ASIP configurations using specific approximated instructions for the selected applications are to be delivered. Furthermore, each ASIP configuration will be described by a set of parameters that the final system will possess, such as energy efficiency, area, execution time, and output error. This project is expected to help make approximated computing a more widespread tendency and generate a strong base knowledge for future projects where there is freedom to choose the parameters of the hardware running a certain type of an application in terms of resource consumption and accepted error.

1.3 Product overview

1.3.1 Product perspective

The generated result will consist of studied and selected applications where one of its sections or just an instruction is replaced by an approximated version, to improve execution time, area, or power consumption while maintaining an acceptable error threshold. This research is a stand-alone project in the sense that the ASIP configurations made will be specific to a selected application and will not operate with other interfaces. This means that the configurations developed will only be constrained by each specific application's inherent constraints or limitations, for example, which section is error-tolerant or which parameter is the most critical.

1.3.2 Product functions

With the research on ASIPs, the approximate computing paradigm will be expanded, which will enable more personalized applications to balance flexibility and performance to have a good trade-off between those variables.

The ASIPs that will be integrated to an specific application will have the following char-

acteristics:

- Adjustable error threshold: The error threshold can vary according to a specific ASIP configuration.
- Adjustable resource consumption: The resource consumption can vary according to a specific ASIP configuration.
- Scalable: Regardless of the amount of hardware used, the ASIP parameters are expected to remain roughly the same.

1.3.3 User characteristics

Since approximated computing is still in its infancy, a lot of research and testing is still needed, so the users of the developed ASIPs are the same research groups of which this project is a part of. The research group members possess, in general, these characteristics:

- Technical knowledge: It is expected that users have an in-depth knowledge of the specific application that is being optimized, as well as a fair amount of knowledge of hardware architecture design.
- Access to specialized tools: Users are expected to have a set of tools that allow them to synthetize and simulate a hardware architecture, as well as a hardware board to implement a desired design.

1.3.4 Limitations

The following limitations are considered for the ASIPs developed:

- Performance gain: The gain in any of the four parameters (energy efficiency, area, execution time and output error) can never be greater than the theoretical possible gain given by the Amdahl equation, which is determined by the percentage of the application that is being optimized.
- Development time: The 16 weeks of the institutional calendar of the ITCR limit the scope of the project to the configurations that can be developed in such a short amount of time.

The resources needed for the project (e.g hardware platform) are not considered as limitations since they are already given by the research group and the academic institutions.

1.4 Definitions, acronyms and abbreviations

Table 1 contains the specific terms used in this document.

Table 1: Definitions

Term	Definition
ASIP	Application Specific Instruction Set Processors. this means that, although the processor can execute a wide range of applications, it is optimized for a specific one, in which it can execute with improved performance (for instance, energy consumption or execution time would be lower) compared to a General Purpose Proccesor (GPP).

References

[1] Qiang Xu, Todd Mytkowicz, and Nam Sung Kim. Approximate computing: A survey. *IEEE Design & Test*, 2018.

2 Specific Requirements

2.1 External interfaces

As explained in section 1.3.1, the entire optimizaded application will not have external interfaces.

2.2 Functions

2.2.1 Functional requirement 1.1

ID: FR-1
Title: ASIP optimization
Description: The generated knowledge shall provide the user with all the details of a specific optimization in a given application, so that the user can take this as a reference.

2.3 Usability requirements

As explained in section 1.3.3, the users are expected to be researchers, for this only few usability requirements are considered:

2.3.1 Usability requirement 1.1

ID: UR-1
Title: Knowledge documentation
Description: The research shall present the user a proper documentation for each selected application (application domain, i.e. the application without any modification) and the specific optimizations performed, which include test cases, gain in energy efficiency, area, and power consumption, as well as the output error.

2.4 Performance requirements

Since one of the objetives of this project is to identify how much a certain program can be optimized with the use of ASIPs to balance resource consumption and output error, therefore no performance requirements are presented because this is exactly the area which needs to be explored.

2.5 Logical database requirements

No database is used for this project, hence, no logical database requirements are presented.

2.6 Design constraints

Design contraints are understood as aspects which are fixed for the project. Since this is a research project, minimun design contraints besides the ones presented in section 1.3.4 are considered:

- Hardware development board: The project is going to use a Xilinx Virtex-V board, since it corresponds to the hardware that uses the development framework.
- Development framework: The ASIPs are going to be developed with the use of ASIP-Meister and Dlxsim, which are the ones already presented in the work environment.
- Software architecture: For a selected application, its general software architecture (i.e the algorithm or process done) is not going to be altered, since the optimizations are going to be implemented by hardware modules.

2.7 Software system attributes

Since the selection of an application is part of this project's objetive, no general software system attributes can be described. The ASIPs developed will be designed according to the

particular system attributes, which will be described in a future document.

2.8 Supporting information

Approximate computing has been studied by several authors, the survey presented on [1]

3 Verification

3.1 External interfaces

3.2 Functions

Xilinx, Mentor y Synopsys

3.3 Usability requirements

3.4 Performance requirements

3.5 Logical database requirements

3.6 Design constraints

3.7 Software system attributes

3.8 Supporting information

4 Appendices

4.1 Assumptions and dependencies

This project is based on the assumption that, given research and articles in the area of approximate computation, it is feasible to introduce functions or approximate blocks in a given application in order to introduce error and at the same time have an improvement in resources consumption, so that both variables can be manipulated.