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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 Processor (GPP) but also have greater flexibility than ASICs.

## **1.2 Scope**

This research concerns both application selection and application optimization. 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 a set of instructions, going from a single instruction up to an entire section 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**

This research on ASIPs is an attempt to expand on the computing paradigm, which is expected to enable more personalized applications that adjust flexibility and performance to achieve an optimal balance between the two variables.

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

acteristics:

- Adjustable error threshold: The application’s error level can vary according to a specific ASIP configuration.
- Adjustable resource consumption: The application’s 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 behind this project. 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 synthesize 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 developed ASIPs:

- 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 that amount of time.

The resources needed for the project (e.g hardware platform) are not considered as limitations since they are already available to 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 Procesor (GPP).
GPP	General Purpose Procesor. In general, they show better flexibility than ASIPs because all the programs are executed in general-purpose components, but since they are not optimized, they show less resource efficiency.
ASIC	Application Specific Integrated Circuits. In general, they show better performance results than ASIPs, nevertheless, they are less flexible when executing anything other than the specific application they are meant to.
ITCR	Instituto Tecnológico de Costa Rica. Place from where this project is being developed.

## 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 optimized application will not have external interfaces.

### 2.2 Functions

#### 2.2.1 Functional requirement 1.1

**ID: FR-1**

Title: ASIP customization

Description: The ASIP configurations developed shall provide the user flexibility between the original version of an application and the optimized one, allowing for a customized balance between resource consumption and output error.

## 2.3 Usability requirements

As explained in section 1.3.3, the users are expected to be researchers, for this, only a 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 objectives 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 constraints are understood as aspects which are fixed for the project. Since this is a research project, minimum design constraints 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 already present on 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, because 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 objective, 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 [1] gathers several ways to implement this paradigm both by hardware or by software.

# **3 Verification**

## **3.1 External interfaces**

The section does not apply for this project.

## **3.2 Functions**

Xilinx, Mentor and Synopsys programs will be used to simulate and verify the corresponding optimizations produced by the ASIPs, which then will be properly documented.

## **3.3 Usability requirements**

The produced documentation will be carefully revised by the supervisor in order to approve it.

## **3.4 Performance requirements**

The section does not apply for this project.

## **3.5 Logical database requirements**

The section does not apply for this project.

### **3.6 Design constraints**

The section does not apply for this project.

### **3.7 Software system attributes**

The section does not apply for this project.

### **3.8 Supporting information**

The section does not apply for this project.

## **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 approximate functions or 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.