1 Introduction

1.1 Problem Statement

Many modern graphics processing units (GPUs) are heavyweight high-power products; They take up a considerable amount of space in a computational network and have a high cost. For our project, we have elected to design and test a small footprint educational GPU through the Iowa State ChipForge organization's toolflow. This organization's focus is to give students an opportunity to experience application-specific integrated circuit (ASIC) design, and the toolflow is an open-source solution to design ASICs.

Our GPU is an educational GPU in the sense that it is not the fastest or most powerful GPU solution, but it will be used to help students explore GPU design in a more consumable way than self-research and exploration. Our documentation and weekly reports can be used by students to help them understand the architecture choices we made and to help them consume the design in modularized pieces. Additionally, at Iowa State University, there is a lack of formal instruction on hardware design for graphics. CPRE 4800 "Graphics Processing and Architecture" is the only computer architecture course that gives context on GPU design, but it is seldom offered. Students at other universities may not even have a course on GPU design offered and could use this document to help themselves learn key concepts for a relatively simple GPU design.

1.2 Intended Users

Following is a list of potential users for a small-scale GPU.

1.2.1 Embedded GPU Users

As our GPU has less logic and a smaller device count, it will take less power to drive it. Thus, applications where power has to be limited, such as an embedded system, could benefit from our design. Embedded GPU Users may not necessarily be searching for the fastest or highest resolution GPU, but instead something that is low power and easy to integrate into a system. As our GPU fits on a 10mm2 die, it has a very small footprint and can fit on most embedded systems with even a small amount of available space.

1.2.2 Chipforge Members

Members of ChipForge are students who have shown an interest in the ASIC design process. By being presented with a completed, programmable GPU design, members can dissect the choices of our group, suggest optimizations, and implement those optimizations themselves. By being presented with an educational GPU design, members can add their own ideas and

inspirations to the design. For example, a student could write a program that creates an interactive GUI or renders text on the screen, using this GPU as their hardware. Students could also create their own shaders to modify the image output.

1.2.3 ISU Faculty

ISU Faculty educate a wide range of topics, and having an open-source small GPU invigorates students to create their own designs. Similar to the i281 CPU used in CPRE 2810 "Digital Logic" to motivate students to learn digital logic, our GPU can be used to motivate students in CPRE 4800 "Graphics Processing and Architecture", CPRE 4880 "Embedded Systems Design", or CPRE 381 "Computer Organization and Design" to show design choices and dataflow outside of the course content.