MICHIGAN STATE UNIVERSITY

Project Plan Presentation

SmartSat™ Heterogeneous Computing in Space

The Capstone Experience

Team Lockheed Martin Space

Gorman, Thomas
Kurkowski, Jacob
Langer, Nolan
Mondol, Shawn
Pargan, Bilal

Department of Computer Science and Engineering
Michigan State University

Fall 2023

From Students…
…to Professionals

Project Sponsor Overview

- The world's largest military contractor
- In 2022, Lockheed Martin generated $66 billion in revenue
- Satellite manufacturing and design, missile defense, space exploration
- Lockheed Martin space systems account for $15 billion per year in revenue

Project Functional Specifications

- Create framework to allow for significant application portability
- Developers can write an application to multiple targets with little regard to hardware present
- Begin development on system-agnostic algorithms to allow cross-compatibility applications
- Doing so allows for faster development workflows

Project Design Specifications

- Receive instructions from the SmartSat system
- Articulate the load, unload start and stop commands to the hardware accelerators
- Manage processes based on priority
- Communicate application data with the application manager
- Log application data and errors

Screen Mockup: Load and Start

```
xilinx-zcu102-20221: Accelerator Manager Running...

[09/13/2023_1130309UTC]__Instruction Received

[09/13/2023_1130310UTC]___Process 0 (flySmartOperator#18927)

[09/13/2023_1130314UTC]____Preferred accelerator available,   loading to accelerator
1(AMD Radeon 7900s)   load 0

[09/13/2023_1130318UTC]___Process 1 (flySmartOperator#18927)

[09/13/2023_1130319UTC]____Starting process 1 on accelerator 0

[09/13/2023_1130323UTC]____   load 0 successful, starting process 0 on accelerator 1

[09/13/2023_1130335UTC]__Instruction Finished, Sending Status
```

Screen Mockup: Accelerator Status

```
xilinx-zcu102-20221: Accelerator Manager Running...

[09/13/2023_1130410UTC]__Instruction Received

[09/13/2023_1130412UTC]___processing accelerator report request

Accelerator: Type  :  Process

0(AMD Radeon 7900s0): GPU : flySmartProcess#18938

1(AMD Radeon 7900s1): GPU : ConvolutionPro#18873

2(Altera Terasic De5-Net): FPGA : Not in use

[09/13/2023_1130420UTC]___report sent

[09/13/2023_1130421UTC]__Instruction fulfilled, logging status
```

Screen Mockup: Error Handling

```
xilinx-zcu102-20221: Accelerator Manager Running...

[09/13/2023_1130410UTC]__Error occurred while running (flySmartOperator#18973) on accelerator
2(AMD Radeon 7900s0)

[09/13/2023_1130412UTC]___Logging error in smartSat

[09/13/2023_1130420UTC]____success

[09/13/2023_1130450UTC]__Instruction Received

[09/13/2023_1130452UTC]___Process 0(flySmartOperator#18973)

[09/13/2023_1130453UTC]____Preferred accelerator available, process loaded, starting process on
accelerator 2(AMD Radeon 7900s0)

[09/13/2023_1130455UTC]__Instruction fulfilled, logging status
```

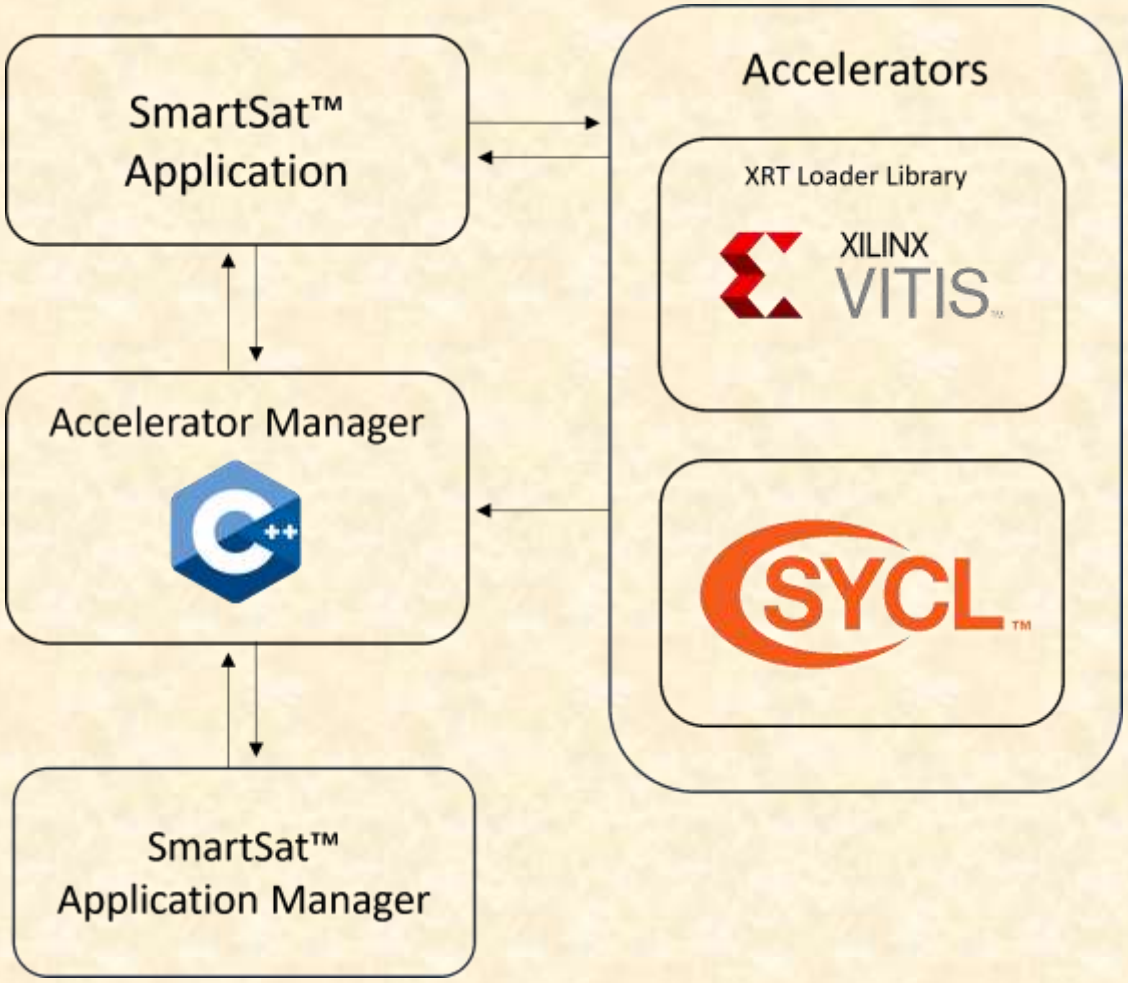
Screen Mockup: Managing Priority

```
xilinx-zcu102-20221: Accelerator Manager Running...

[09/13/2023_1130450UTC]__Instruction Received

[09/13/2023_1130452UTC]___Process 0(flySmartOperator#18973)

[09/13/2023_1130453UTC]____Preferred accelerator unavailable, requested process priority level 1,
checking priority on preferred targets

[09/13/2023_1130455UTC]_____process(convolutionPro#18973) running on preferred target with
priority level 2

[09/13/2023_1130458UTC]____stop process(convolutionPro#18973) on accelerator 1(AMD Radeon 7900s0)

[09/13/2023_1130462UTC]____loading process(flySmartOperator#18973) on accelerator 1(AMD Radeon
7900s0) load 0

[09/13/2023_1130467UTC]____load 0 successful, starting process 0(flySmartOperator#18973) on
accelerator 1(AMD Radeon 7900s0)

[09/13/2023_1130468UTC]__Instruction fulfilled, logging status
```

Project Technical Specifications

- Accelerator manager allows deployment of applications on compatible and available machines
- Xilinx Runtime loader library to help manager run algorithms
- Two common algorithms written with different programming techniques to begin creating system-agnostic applications

Project System Architecture



Project System Components

- Hardware Platforms
  - ZCU102 Evaluation Board
  - UDOO Bolt Gear
- Software Platforms / Technologies
  - PetaLinux
  - Vitis
  - SmartSat™ SDK
  - Xilinx Runtime Library
  - OpenSYCL

Project Risks

- Embedded System Development Workflow
  - No one on the group has experience with embedded systems
  - Xilinx forums and documentation to understand basics
- Frequent PetaLinux builds
  - PetaLinux requires a long time to build on target device
  - Create Linux server in CSE 498 lab to run build process and plan when a team member needs to rebuild
- Testing software
  - Setting up boards is tedious, testing code can be a hassle
  - Lockheed Martin Space is providing a testing environment
- OpenSYCL Framework
  - Parallel programming is new to every member of the team
  - Create simple programs that run across multiple accelerators to understand basics

Questions?