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Extension and Evaluation of a Python-based High-level Synthesis Tool Flows - Work Plan

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0.1 Motivation

- From Moore's law, we know that the number of components on an integrated circuit increases to almost double in approximately 18 to 24 months and so is the case for FPGA's. Today we see that a Xilinx Virtex UltraScale+ VU19P contains millions of system logic cells and thousands of I/O on a single chip [3] and also with the availability of full-fledged high-level synthesis tools that support programming languages such as c/c++ allow even non-native FPGA-developers to write software applications using such programming languages and achieve hardware acceleration.
- On the other hand, a massive amount of data is being generated by simple sensor nodes to IOT's every day and is drastically increasing. Machine learning and different branches of Artificial intelligence which are a statistical approach to cluster these data and creating knowledge bases are being used in almost all the fields to provide solutions by learning from data.
- In the past few decades, we have seen multiple programming languages coming to light and Python is one such programming language that gained popularity cause of its extensive libraries, documentation, training, easy and clear syntaxes [4]. Python contains NumPy, Pandas, sciKit-learn, matplotlib, these inbuilt libraries and third party developed modules simplifies implementing data-analytics and machine learning making python as a desirable programming language for data scientists and machine learning developers.
- At present, there are no full-fledged tools that support high-level synthesis for python and an effort to overcome this barrier was made by developers of Hot & spicy. Hot & spicy is a python-based HLS tool that uses annotated python syntax and translates it to abstract syntax trees with which a C code ready to run on HLS tools is generated. However, the tool is still naive and cannot be used for the development of extensive python applications.
- Hence with Hot & spicy as base work for this thesis and keeping machine learning and data-analytics as focus, I will extend the functionality of the tool to support much larger python syntax, semantics and data structures.

0.2 Work Plan

Based on the task list provided in the description document, I would like to divide the task into the following phases and explain my objective on each of the milestones.

1. `Research Phase:` In this phase, I would mainly focus on five subtasks
    - Conduct a literature survey based on the previous and current research of Python-based high-level synthesis that will assist me to decide on which methodologies and techniques can be inherited or avoided for extension of Hot Spicy tool. This will also be a starting step for the documentation.
    - To familiarize myself with Xilinx PYNQ board and understand completely how the hardware design and also the tools required such Xilinx Vivado works. For this, I will set up the PYNQ environment as per [1] and run given examples.
    - To familiarize myself with the internal working of the tool Hot & Spicy. This will involve a detailed analysis of the code of the said tool from [2] and also run the given examples in the tool in an already setup environment Which will also assist me to evaluate the tool.

- Research of the available libraries which support data analytics and machine learning in python. Discuss and come to a conclusion on which data structures and function sets can be implemented in the setup environment and also within the time frame of the master's thesis.
- Create and provide a proposal document on what and how the Hot & Spicy tool can be extended to support the data analytics and machine learning libraries in python. This document will contain the methods and techniques which will be used for implementation and discussion on existing challenges in the tool and solutions accordingly.

2. `Implementation Phase:` In this phase, I will focus on two sub-tasks

   - The discussed data structures and function sets for implementation will be categorized into focus and additional. The data structures and functions sets in focus will be implemented first and if time permits the additional will be implemented.
   - Though the syntactical errors can be fixed on the go while development, the semantics of each the implemented component will tested to check if they are working as desired and results are valid.
   - A demo application will be developed such as matrix multiplication to demonstrate the implementation, extension of Hot Spicy tool and results.

3. `Documentation:`

   - This phase will involve the complete documentation of the master's thesis which will be refined over multiple reviews.The structure of the documentation will be as below.
     - Abstract: Providing an overview.
     - Introduction: Explaining the technologies and terms.
     - Background: discussion and comparisons of similar works.
     - The Hot & spicy approach: explaining the details of Hotspicy and its drawbacks.
     - Implementation: providing my solution for the drawbacks and how the implementation is done.
     - Results: explaining the working of demo app with the extension of hot and spicy.
     - Conclusion and Future work: summarizing the paper with conclusion and discuss future work of Hot & Spicy.

4. `Presentation`

   - This will be the final presentation of the master's thesis with discussion on what was initially planned and what is achieved, challenges and learning's.

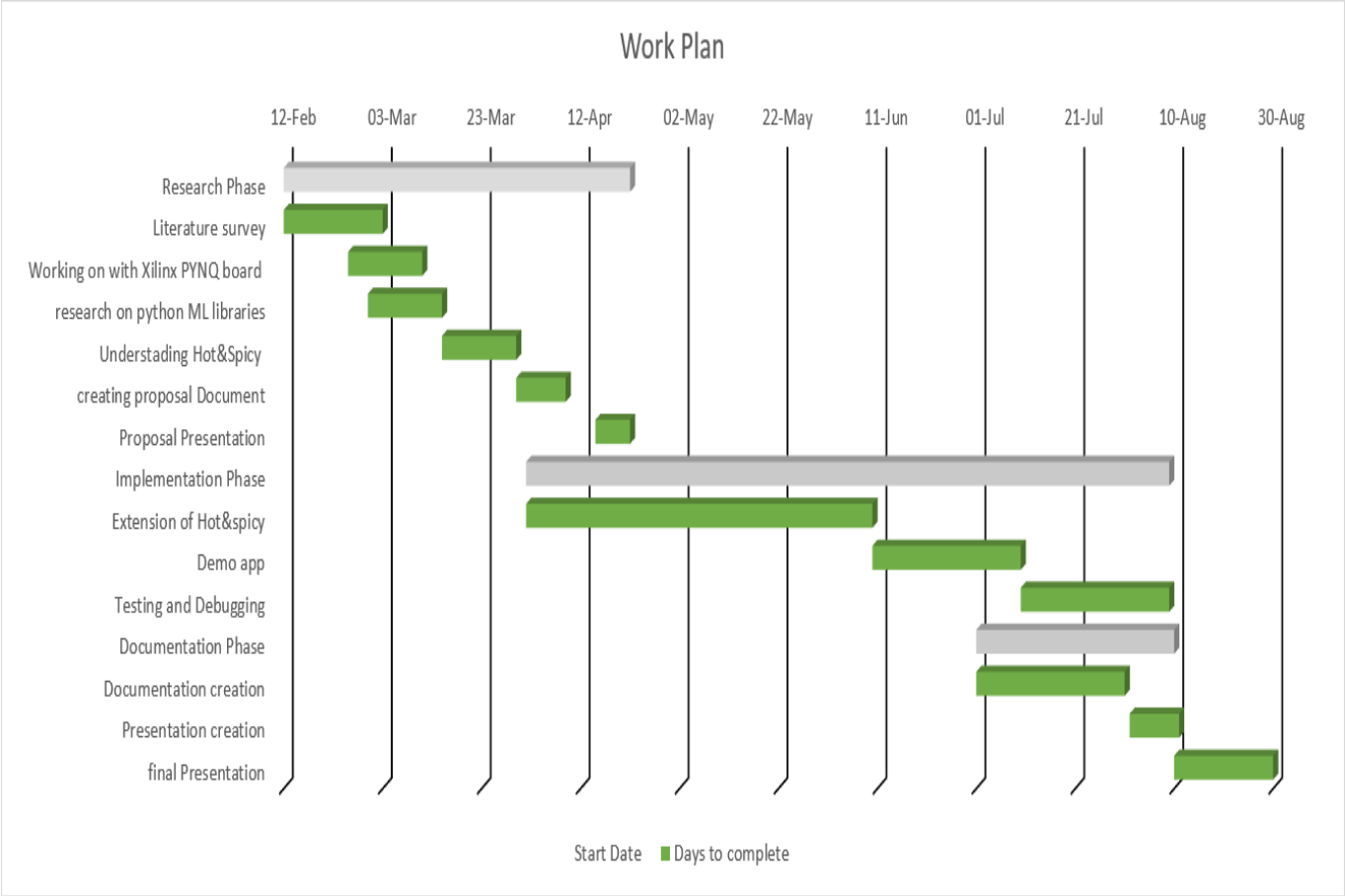

Figure 1: Gantt chart representing Work Plan

Bibliography

[1] Pynq: Python productivity for zynq. http://www.pynq.io/home.html.

[2] Hot spicy: Python tools for fpgas. https://www.isi.edu/projects/spicy/hot_spicy_improving_productivity_python_and_hls_fpgas.

[3] Virtex-ultrascale-plus-vu19p. https://www.xilinx.com/products/silicon-devices/fpga/virtex-ultrascale-plus-vu19p.html.

[4] Python. https://www.python.org/about/.