Weber State University

Master of Science in Computer Engineering

Academic Plan and Project Proposal

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**Supervisory Committee**

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**Academic Plan**

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| --- | --- | --- | --- | --- |
| Semester | Year | Course No. | Credits | Course Name |
| Fall | 2016 | ECE 3210 | 4 | Signals and Systems |
| Spring | 2017 | ECE 6210 | 3 | Digital Signal Processing |
| Fall | 2017 | CS 6610 | 3 | Computer Architecture |
| Fall | 2017 | CS 6840 | 3 | Formal System Design |
| Spring | 2018 | CS 6420 | 3 | Advanced Algorithms |
| Spring | 2018 | ECE 6410 | 3 | Communication Circuits and Systems |
| Summer | 2018 | SLCC EE 2280  (Substitute for ECE 3110) | 4 | Microelectronics I |
| Fall | 2018 | ECE 3610 | 4 | Digital Systems |
| Fall | 2018 | ECE 6420 | 3 | Digital Communication |
| Spring | 2019 | EE 6010 | 3 | Design Project I |
| Spring | 2019 | CS 6850 | 3 | Parallel Programming and Architecture |
| Fall | 2019 | ECE 6110 | 3 | Digital VLSI |
| Fall | 2019 | EE 6010 | 3 | Design Project |

**Project Proposal**

Project Title: A Comparative Analysis of GPU vs CPU Digital Signal Encoding and Decoding

Purpose

The primary purpose of this project is to utilize multiple SDR Receivers in parallel to receive and decode multiple bit encoded streams in parallel and decode them simultaneously. Encoding and decoding digital data for transmission through a Software Defined Radio (SDR) system can be a hardware intensive process; details of this complexity can be are explored by Haghighat [1].

In many cases FPGA’s are configured for this process. As a hardware-based system, the improvement in speed is offset by expense, but there can be other limitations in their flexibility and functionality depending on the complexity of the signal. Another alternative utilizes a CPU to process SDR bit encoded data; however, a conventional CPU can be overloaded quickly with the number of computations required [2]. An alternative to a CPU is to utilize a GPU, whose structure is designed for multiple parallel operations simultaneously which allows for performance increases [3].

The deliverables of this project include an evaluation and comparison of the DSP capabilities for CPU and GPU based algorithms processing parallel encoded bit streams. Computational load, throughput, and power consumption are examples of system characteristics for analytic comparison.

Approach

The initial steps of the project will be to generate a model using MATLAB’s Simulink to provide a basis for comparison, theoretical models, and limits for a system. In addition, the system models may provide simulation data that can be fed through the other software system for data comparisons and debugging at the various stages of the algorithms.

The second step is to utilize the GNU Software Defined Radio to implement a CPU-based system on hardware and evaluate the system outside of simulation. The open source modules that are provide by the GNU Software Defined Radio system provide will provide a realistic model to evaluate the GPU algorithms.

With theoretical simulations from MATLAB and realistic models from the GNU Software Defined Radio, the final step is to generate C++ code to perform the digital encoding and decoding on the CPU for evaluation, and then to generate the equivalent GPU algorithms.

With these various implementations, the final results can be captured for analysis. One of the major points to analyze will be the cutoff point where GPU’s become more effective than CPU’s, i.e. when the CPU becomes overloaded, and unable to process data at rate. This will be accomplished by utilizing multiple radios and data streams to push the system implementations to their limits.

Research

Multiple resources exist for integrating the various hardware components. As the RTL-SDR and Hack One RF radios are both open source there are multiple examples and open source software that can be utilized [4][5]. The Nvidia GPU processors will be programmed using CUDA, and there are various papers that have been written and developed using GPU programming techniques. Another paper describes a framework for utilizing multiple radios to develop a multi radio framework that can provide wide band scanning and allow for parallel searching for a specific signal. The GNU Radio website contains multiple resources for using their open source tool [6]. Aside from the broad base of resources, I personally have worked for multiple years in the field of RF Development and system design. I will be able to draw upon that experience, and the expertise of personal at L3 Technologies if needed.

Criteria

The Criteria for evaluation can be spread evenly between the following list of tasks:

1. MATLAB simulations of
   1. AM
   2. FM
   3. BPSK
   4. QPSK
2. GNU Radio Application of
   1. AM
   2. FM
   3. BPSK
   4. QPSK
3. CPU based Radio Applications of
   1. AM
   2. FM
   3. BPSK
   4. QPSK
4. GPU based Radio Applications
   1. AM
   2. FM
   3. BPSK
   4. QPSK
5. Evaluate the different applications based on the following Criteria
   1. Power Utilization
   2. Throughput
   3. Processor vs GPU utilization
6. Multi-Radio evaluation of parallel RF signals in Real Time to demo the effectiveness.

**Committee Signatures** (sign only after the project is approved by the faculty)

Chair Date   
Dr. Christian Hearn

Member Date   
Dr. Abdulmalek Al-Gahmi

Member Date   
Dr. Dhanya Nair

Bibliography

1. A. Haghighat, "A review on essentials and technical challenges of software defined radio," MILCOM 2002. Proceedings, Anaheim, CA, USA, 2002, pp. 377-382 vol.1.  
   doi: 10.1109/MILCOM.2002.1180471  
   URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1180471&isnumber=26509>
2. K. Vachhani and R. A. Mallari, "Experimental study on wide band FM receiver using GNURadio and RTL-SDR," 2015 International Conference on Advances in Computing, Communications and Informatics (ICACCI), Kochi, 2015, pp. 1810-1814.  
   doi: 10.1109/ICACCI.2015.7275878  
   URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7275878&isnumber=7275573>
3. W. Thomas and R. D. Daruwala, "Performance comparison of CPU and GPU on a discrete heterogeneous architecture," 2014 International Conference on Circuits, Systems, Communication and Information Technology Applications (CSCITA), Mumbai, 2014, pp. 271-276.  
   doi: 10.1109/CSCITA.2014.6839271  
   URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6839271&isnumber=6839219>
4. Software Defined Radio with HackRF, Lesson 1. (n.d.). Retrieved from https://greatscottgadgets.com/sdr/1/
5. Rtl-sdr.com. (n.d.). Retrieved from https://www.rtl-sdr.com/
6. GNU Radio. (n.d.). Home page. Retrieved from https://www.gnuradio.org/