Department of Electrical and Computer Engineering

On Demand Conversion Project

Submitted by:
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Andrew Hillocks
Montaque Jones
Jasmine Little

Senior Design – Spring 2012
Instructor: Dr. Charles Kim

April 25, 2012

SUBMISSION AND APPROVAL

This project report is submitted for partial fulfillment of the Senior Design course describing the design and implementation of our project.

Name	Signature	Date
Name	Signature	Date
Name	Signature	Date
Name	Signature	Date

I approve this project report

Advisor's Name	Signature	Date

Acknowledgments

We would like to take the time to acknowledge the following. They helped up tremendously during this project

- Department of Electrical and Computer Engineering, Howard University
- Howard Graduate Marlon Winder
- Ravindranath Jaglal & Gerard Spivey
- Dr. Charles Kim and the entire Senior Design I/II class

Executive Summary

Our goal was to design and create an on demand fiber to Ethernet converter. We were asked to design a system that would gather information coming in at high data rate, 6+ Gb/sec, convert it from fiber and send it over LAN at the press of a button. In other words we needed to build a test receiver system that could handle data at high rates but is more cost effective than the expensive MIL-SPEC hardware that is in used companies today. Unfortunately we were not able to successfully complete this design. From this experience, however, a lot was learned.

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Background

Northrop Grumman Corporation is an American global aerospace and defense technology company. It was formed in 1994 as a result of the purchase of Grumman by Northrop. The company was the fourth-largest defense contractor in the world as of 2010, and the largest builder of naval vessels. It has its headquarters in Falls Church, Virginia. Northrop Grumman Corporation is a leading global security company providing innovative systems, products and solutions in aerospace, electronics, information systems, and technical services to government and commercial customers worldwide.

Northrop Grumman's core competencies are in align with the current emerging global security challenges in key areas, such as unmanned systems, cybersecurity, C4ISR, and logistics that are critical to the defense of the nation and its allies. Northrop Grumman has four business sectors. These business sectors are aerospace systems in which unmanned and manned aircraft are provided; information systems in which advanced solutions are made for clientele; technical services in which life cycle solutions and long term technical services are provided; and electronic systems in which Northrop is a leader in airborne radar, navigation, etc systems. Northrop's electronic systems sector is most relevant to this to this project because this project is to work in line with the radars that Grumman creates in factory.

Radio detection and ranging (or Radar) is an object-detection system which uses radio waves to determine the range, altitude, direction, or speed of objects. It can be used for the detection of all types of objects (i.e. aircraft, spacecraft, guided missiles, motor vehicles, weather formations, and terrain). The radar would transmit radio waves or microwaves which bounce off any object in their path. The object returns a tiny part of the wave's energy to a dish or antenna which is usually located at the same site as the transmitter.

Radar was developed by several nations before and during World War II. The modern uses of radar are highly diverse, including air traffic control to track planes both on the ground and in the air; radar astronomy to track satellites and map the solar system; air-defense systems, antimissile systems; marine radars to locate landmarks and other ships; aircraft anti-collision systems; ocean surveillance systems, outer space surveillance and rendezvous systems; meteorological precipitation monitoring; police radar to detect the speed of passing motorists; guided missile target locating systems; and ground-penetrating radar for geological observations. High tech radar systems are associated with digital signal processing and are capable of extracting objects from very high noise levels.

When people use radar, they are usually trying to accomplish one of three things:

- Detect the presence of an object at a distance - Usually the "something" is moving, like an airplane, but radar can also be used to detect stationary objects buried underground. In some cases, radar can identify an object as well; for example, it can identify the type of aircraft it has detected.
- Detect the speed of an object - This is the reason why police use radar.
- Map something - The space shuttle and orbiting satellites use something called Synthetic Aperture Radar to create detailed topographic maps of the surface of planets and moons.
- All three of these activities can be accomplished using two things you may be familiar with from everyday life. Radar makes use of the same techniques using radio waves.

Problem Formulation and Current Status of Art

Ethernet-Fiber Converters enable connections of Ethernet equipment over a fiber optic link to take advantage of the benefits of fiber which include;

- Extending links over greater distances using fiber optic cable
- Protecting data from noise and interference
- Future proofing your network with additional bandwidth capacity
- Increasing the overall speed of the network

Ethernet connections are limited to a data transmission distance of only 100 meters when using unshielded twisted pair (UTP) cable. By using an Ethernet to fiber conversion solution, fiber optic cabling can now be used to expand the bandwidth capability. Optical signals can carry much more information than electrical ones. The most advanced copper cables can theoretically carry 1 Gigabit/second. Optical fibers, on the other hand, have a theoretical capacity of 350 Terabits/second or 350.000 Gigabits/second.

Currently there are no commercial products that have the ability to do on demand conversations.

The most common type of Ethernet-Fiber Converter is one that is a standalone device with its own power adapter.

Current devices on the market:

As stated earlier, there are no commercially available products that have to ability to perform an on demand conversion of high speed fiber to Ethernet data. Currently, the only products available are MIL-SPEC hardware. This hardware is very expensive and not readily available.

The only products available on the market are as follows; they will aid our team in understanding conversion process. These products cannot be used alone to accomplish the goal of our project. As stated above they will however, help us understand the conversion process.

1000 Mbps Gigabit Ethernet Single Mode Fiber Media Converter – about $330.00

This Gigabit Single Mode (SM) Ethernet Fiber Media Converter creates a cost-effective Gigabit Ethernet-fiber link, converting to/from 1000Base-T Ethernet signals and 1000Base-LX optical signals. The converter supports a maximum single mode fiber optic cable distance of 40km (25 miles), providing a simple solution for connecting 1000BaseT Ethernet networks to remote locations using SC terminated single mode fiber, while delivering ideal network

performance and scalability. Operating at full Gigabit speeds end-to-end; this media converter offers a cost-effective way to extend/bridge networks using fiber optic cabling.

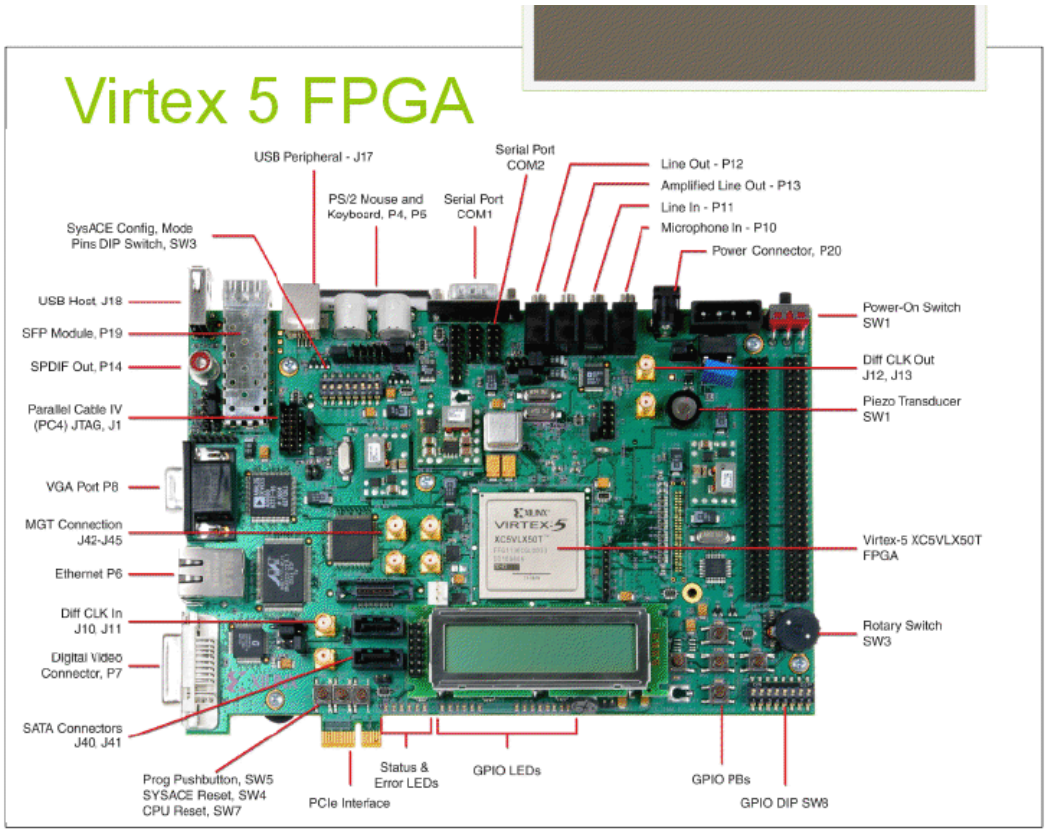
http://www.amazon.com/StarTech-com-Gigabit-Ethernet-Converter-ET91000SM40/dp/B000KDUSKY

Relationship:

In relation to this project, the current converters do not have the capacity to handle data at rates up to 6.2Gbps and convert as required for this project. One might ask why a commercially available high speed fiber optic to Ethernet interface does not exist, the answer is the market demand does not exist. Our converter will fulfill our sponsor's need and be available for a market demand if it materializes.

System Components

Used: Virtex 5 FPGA



The Virtex-5 LXT and the LX are FPGA boards designed for logic-intensive applications. Xilinx changed the fabric of logic with the Virtex-5, from four to six-input LUTs. With the complexity

of combinational logic functions performed by SoC increasing, the percentage of combinational paths requiring multiple four-input LUTs became a performance and routing bottleneck. The new six-input LUT represented a tradeoff between better handling of increasingly complex combinational functions, at the expense of a reduction in the absolute number of LUTs per device. The Virtex-5 series is a 65 nm design fabricated in 1.0 V, triple-oxide process technology

Pros:

- The Aurora protocol can be used
- Only component needed to implement design

Cons:

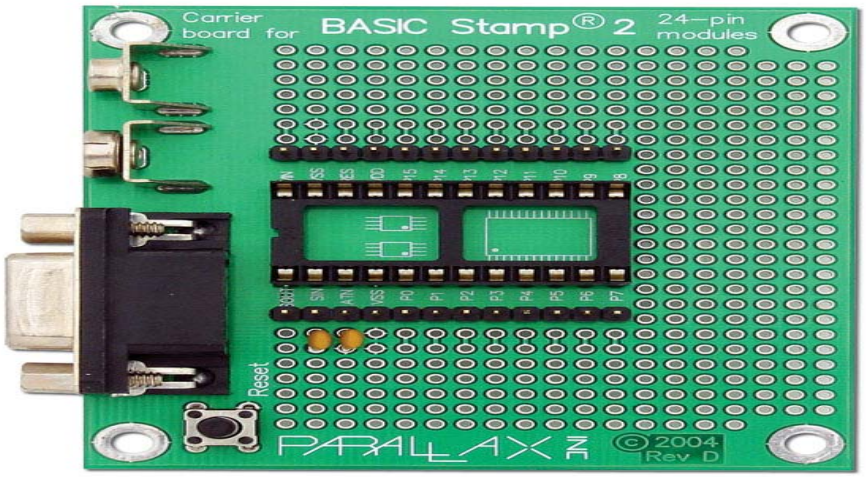
- Programming is a challenge due to lack of documentation
- High Cost
- System will run slower than one composed of several components

Sources

http://www.xilinx.com/support/documentation/virtex-5.htm

http://www.xilinx.com/support/documentation/data_sheets/ds100.pdf

Not Used: BASIC Stamp 2 Board



Pros:

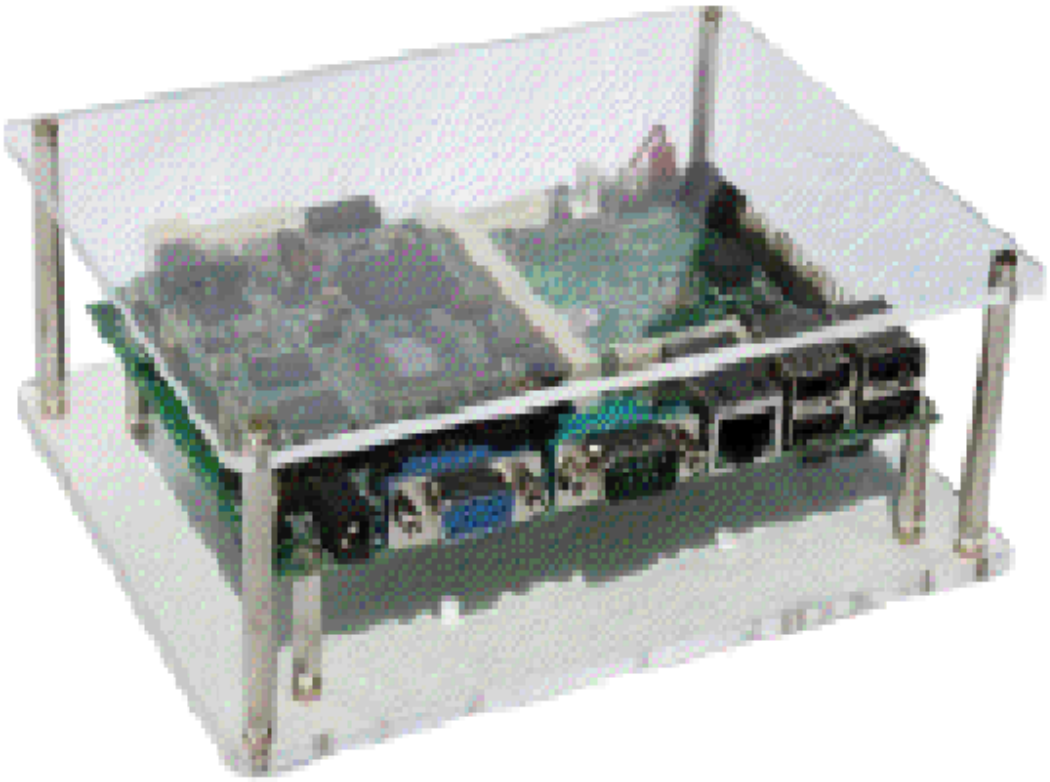
- Very easy to program

- Inexpensive
- Small in size

Cons:

- Aurora protocol cannot be used

Not Used: Atom Board



Pros:

- Faster system speed due to more components being utilized

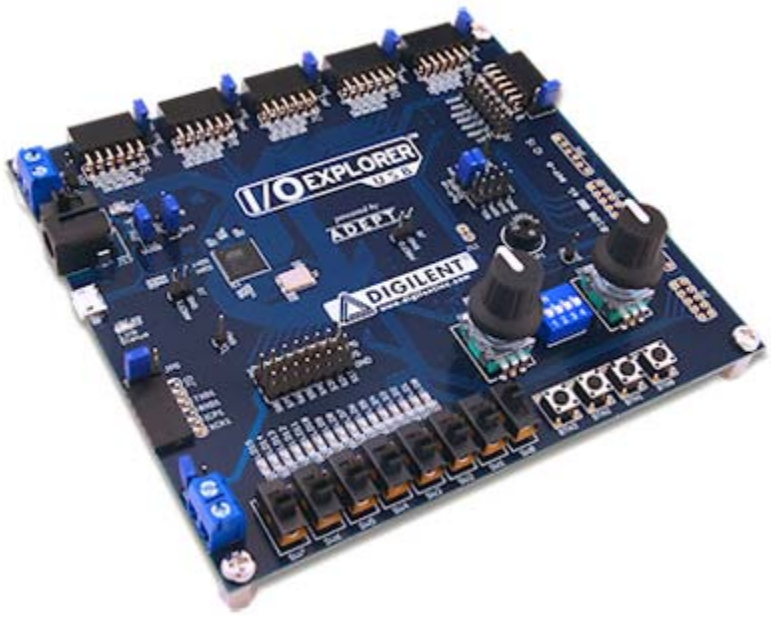
Cons:

- Cost of expense and complexity of system will grow due to added parts

Sources

http://boardswithbenefits.com/e6xx-tunnel-creek/

Not Used: I/O Explorer board



Pros:

- Faster system speed due to more components being utilized

Cons:

- Cost of expense and complexity of system will grow due to added parts

http://www.digilentinc.com/Products/Detail.cfm?NavPath=2,396,833&Prod=IOEXPLORER-USB

Constraints and Criteria of the Design Requirements

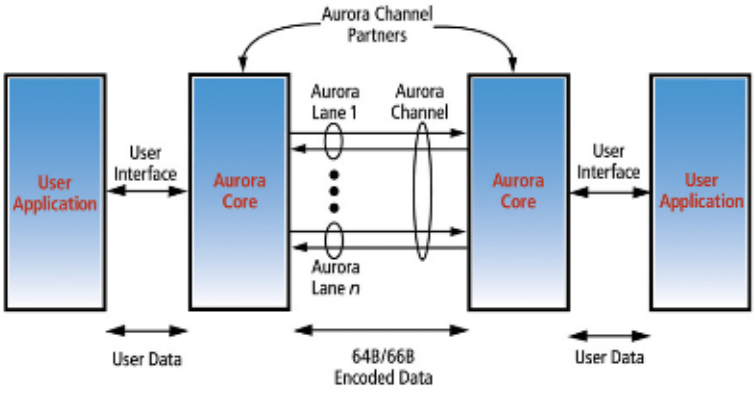
In general the system we are building is intended to acquire data on a fiber interface and buffer it in memory. The unit should receive data, convert it back into 32-Bit words, and buffer a large quantity of these words, and then upon request transfer the data block over a LAN interface to a requesting computer. A controller requests data acquired is transferred over LAN & our system then transfers the data and awaits next command. Real time conversion from fiber to LAN is not required & also the data comes in as serial data encoded in the Xilinx Aurora protocol. We show the completion of transfer of data through LED lights. In addition we were told to abide by the Aurora Protocol.

What is Aurora?

"Aurora is a scalable, lightweight, link-layer protocol that is used to move data across point-to-point serial links. It is an open protocol. It provides a transparent interface to the physical serial links, allowing upper layers of proprietary or industry-standard protocols to easily use these high-speed serial links."
(http://www.xilinx.com/products/design_resources/conn_central/grouping/aurora.htm)

We are using this protocol because its:

- Very efficient low-latency protocol that uses the least possible amount of logic
- Easily integrated
- Aurora increases bandwidth through bonded lanes.
- It is intended for use in high speed connections internally in a computer or in an embedded system.



Also we came across other benefits :

- High bandwidth transmission limited only by SERDES data rate capability
- Supports a large number of bonded lanes for high aggregate bandwidth
- Supports Full Duplex & Simplex channels
- Unlimited Frame size/flexible framing
- Small logic footprint
- Built-in Flow control

Solution Generation and Selection of Top Design

Our initial solution required our team to create an effective on demand fiber optic to Ethernet converter. This device needed to be both cost efficient and meet all of our design requirements. Key requirements created many challenges for our group. Since our system needed to transfer data at 6+ Gb/sec and use the Aurora protocol, we were truly stumped and could not determine what hardware would best fit this project. This is when all the brainstorming and research began.

We finally were able to come up with a solution that would satisfy those key requirements. We came to the conclusion that the Virtex was the best option to accommodate our requirements. As a group we decided that the Virtex-5 was a better option for our system. The Aurora protocol can be used with the Virtex and handle the 6+ Gb/sec data rates. Our first solution included using a RabbitCore as both our controller and buffer. The RabbitCore had enough memory for demonstration purposes and a stepping stone for us to get to our end result. This plan was short lived, however. From the little research we did on the board we did not find a reason why the RabbitCore couldn't do the job. So one might ask, why wasn't the RabbitCore used? Well we were giving the opportunity to work with the Intel Atom board (Tunnel Creek). This led us to our alternative solution. Below a diagram of how we believed the system could be put together.

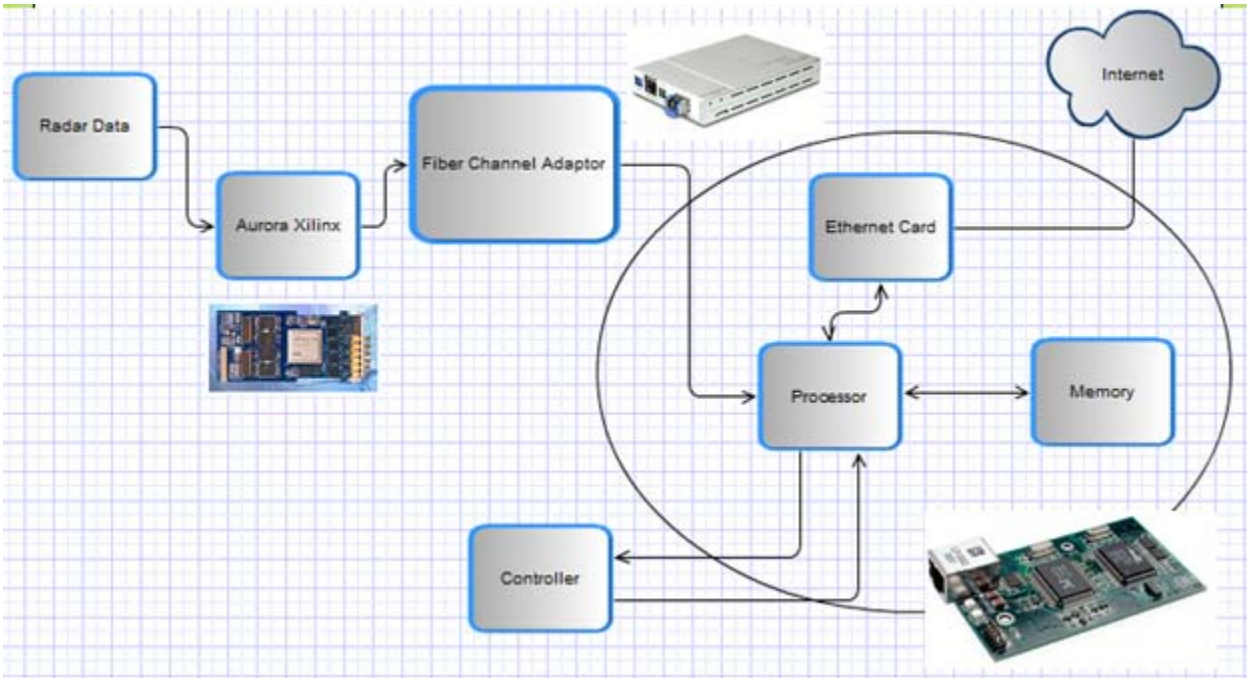


Figure 1 - Diagram of Initial Solution Using RabbitCore

Alternative Solution

Our next plan involved using the Intel Atom Board. This idea came about from two members (Jasmine and Damola) that also enrolled in an embedded design course. We felt that this was a better solution. There were more opportunities with our group getting help with any problems or questions we saw forthcoming. The Atom Board could be used as our processor. The atom board used Linux and our group used this before and felt confident using it for the project. It had enough memory for a demonstration and more could be added, if that was required. The board had an Ethernet port, so going with this approach eliminated the issue of adding an Ethernet port to our design. The board also had General Purpose Input/Output (GPIO) pins and 4 USB ports which could be used to connect our controller. The controller was the only component that we needed that was not already connected to the board. With that we needed to figure out what we could use as a controller. Below a diagram of how we believed the system could be put together.

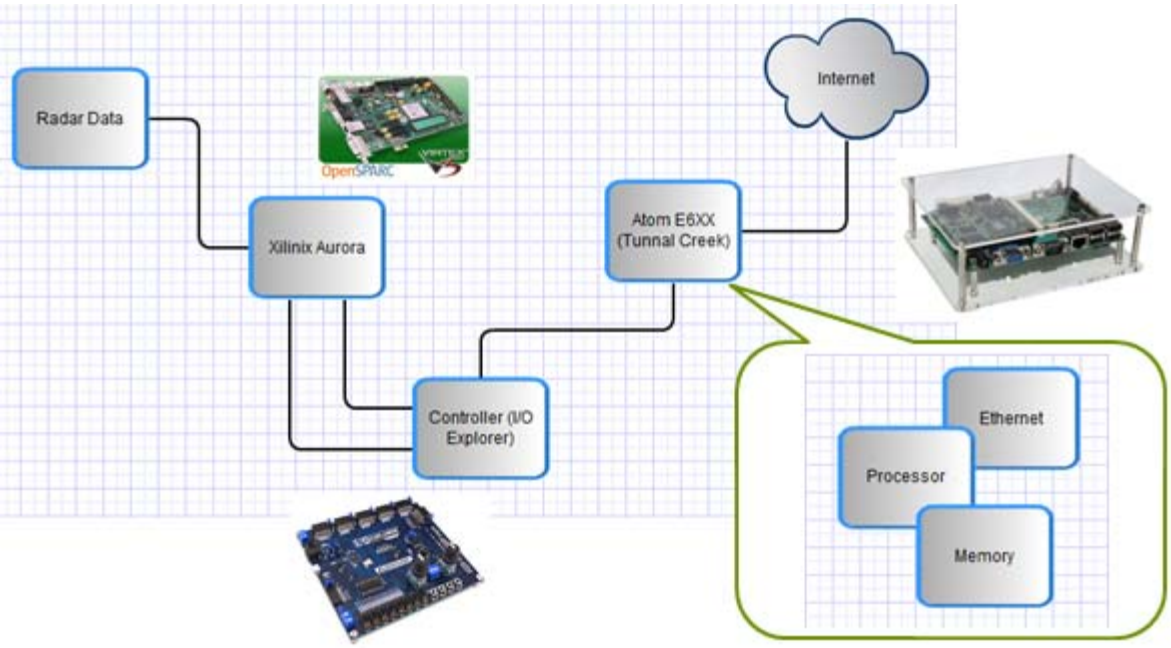


Figure 2 - Diagram of Alternative Solution Using Atom Board

Our next step was to let our advisor know what we decided. Emails were sent but there was no reply. We asked for funding to purchase the Virtex board and asked what type of test information we would receive. Time was rapidly decreasing and now we were faced with more challenges. Funding being the major issue we needed to produce contingency and produce them quickly. Virtex boards are very expensive and with no funding coming from our adviser we felt stuck. We continued to press on and came up with a few contingency plans. All of contingency plans had to make a huge assumption. We had to assume that our data from the radar had come through fiber, through the Aurora protocol, converted and now sitting in memory waiting for the command to be transferred.

Contingency Plan 1

Since we were having such a hard time getting a Virtex-5 board a new plan needed to be created. After conversations with our adviser we decided to use a BASIC Stamp 2 (BS2). With this plan we would store data in memory on the board. We would connect a button and LED

using GPIOs. The code used with the BS2 is called PBASIC. It was very easy coding language to learn and use. We predicted that the only problem we would face would be connecting the BS2 to the Atom Board.

Top Design Choice

After weeks of conversations from Dr. Charles Kim, Ravindranath Jaglal, Gerard Spivey and internally we came up with a final design solution. With the help from the department we were able to purchase on Virtex-5 board. So our final solution would only need the Virtex-5. When we received our board it was brought to our attention that with the development board we received everything could be done on the board. We had the Ethernet port, the LEDs, and the push buttons already connected to the board. The only issue was the programing of the board. As a group we had very little experience with programing Field-Programmable Gate Arrays (FPGA). Dr. Kim introduced us to a Howard graduate by the name of Marlon Winder to help with the programing of the FPGA. Below a chart of our design matrix can be found.

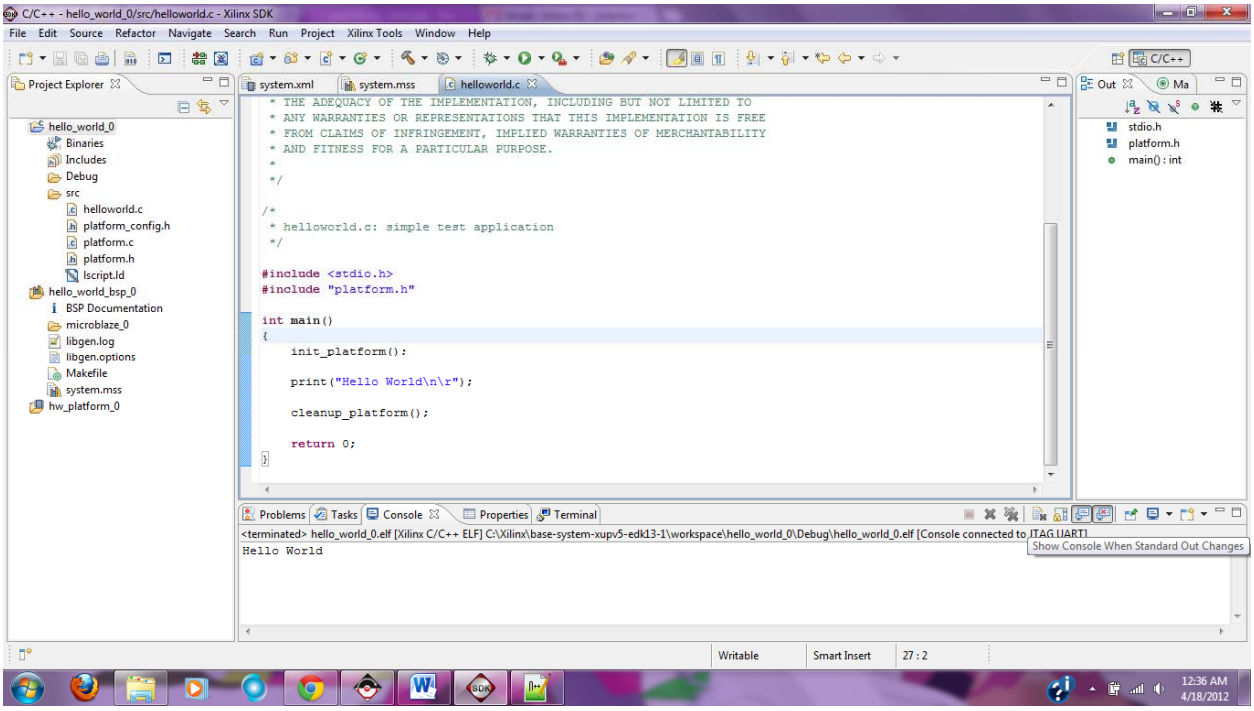
		BS2/Atom Board		**Atom Board/ I/O Explorer**		**Virtex-5**	
Criteria	Weight	Rating	Score	Rating	Score	Rating	Score
Aesthetics	10%	1	.1	2	.2	3	.3
Sustainability	15%	1	.15	2	.3	3	.45
Software (user-friendly)	15%	3	.45	1	.15	2	.3
Price	25%	2	.5	3	.75	1	.25
Memory	35%	1	.35	2	.7	3	1.05
Total		8	**1.55**	10	**2.1**	12	**2.35**

Figure 3 - Design Matrix

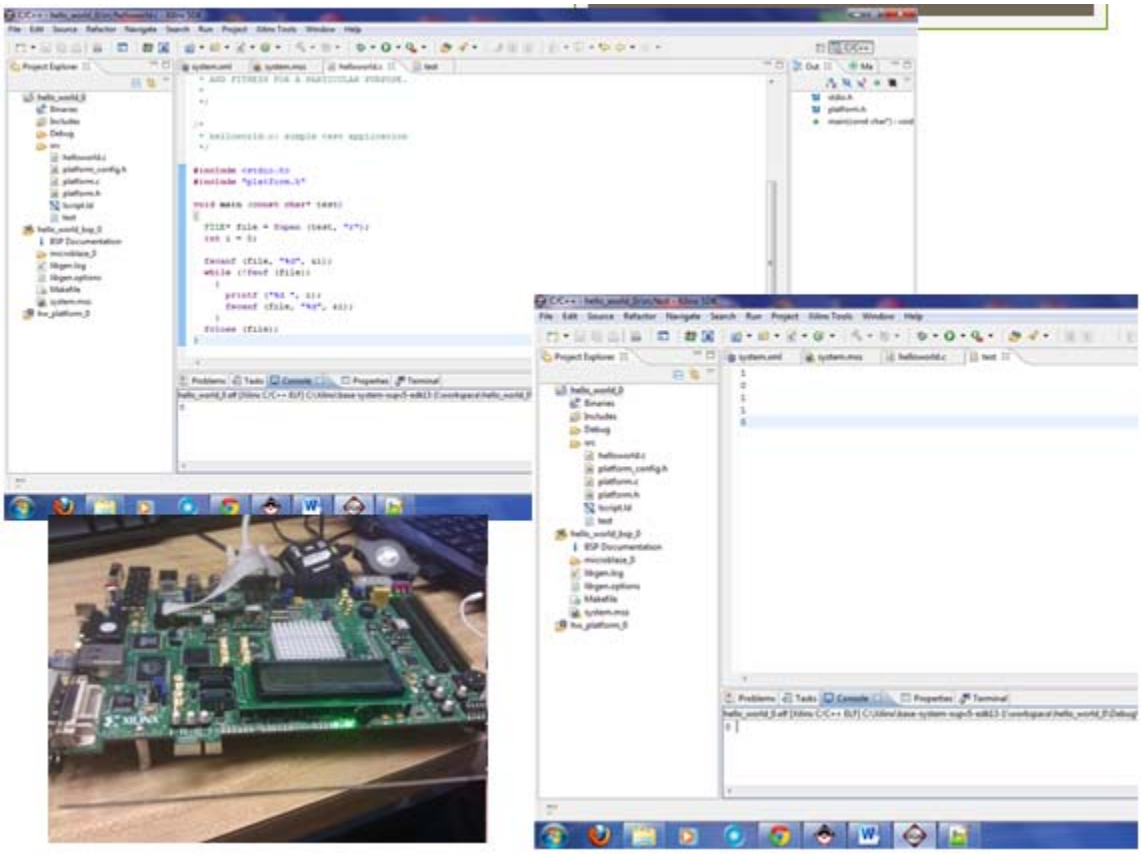
Implementation

When we finally received our board it was a mad dash to try and get it program. We Had to find a crash course on how to program our board because we received to board so late. Another pressing issue we ran into during the implementation phase was the fact that finding documentation on our board specifically was difficult. There was not much out there to help use. The documentation we were able to gather required different versions of Xilinx. Xilinx is what we were using to program the board. The problem with that is the Xilinx software takes a very long time to download and install. Slowly progress was being made but the sand in our hour glass was up. So the completion of this project was not a success. We encountered a lot of problems coding this FPGA and again it was due to lack of documentation. The first major issue we encountered was the fact that we had no way of enabling the components on the board. After research we decided to put together a soft core processor on the board. We found a very nice sample code online that included all the components of the board. We after a weekend of trial and error we were finally able to get a version of Xilinx that worked with the code that was found. Our next big issue was getting the C code to run on the board. We were able to get

something to output only with the print command. Below is a picture of this.



This was a huge break through for us because we were having such a hard time getting anything to run on the board. We feel a key reason to why is that we could not figure out the pin locations for our board. With the help from Marlon we were able to find a list of pin locations that were similar but they were not specifically for our board. Going back to the sample code we found for the soft core processor. It included an ucf that we used as a reference for the boards pin locations. With the pin location issue solved we had to return to the fact that the C code was still not running on the board. Think that our code was written incorrectly we ran the code on another complier and it ran with no errors. We just couldn't figure out why and time was up. Below is a figure of the results we continued to get.



We were able to get the file to open but it would only read one value and it wasn't even the first value. Our project really couldn't be evaluated because we did not have a finished product to test.

Conclusion

In conclusion, the Fiber to Ethernet team was able to learn a lot of Fiber to Ethernet conversion, radars, FPGA design and system design. Each component gave us insight on how it is to be a professional engineer and on what problems engineers are faced with in industry today. If given a project like this again in the future, the team would know how to handle it more efficiently and professionally for a more enhanced result. This could range from increasing our technical skills by either adding more to our repertoire or just increasing our skill level in the ones we have now. A great team fosters a great project so next time we will be on point with our teamwork skills.

Recommendations

In the future we would like to:

- Implement two Virtex-5 boards into the system
- Make real time conversion from fiber to LAN possible
- Incorporate the use of two buttons into our system

References

http://en.wikipedia.org/wiki/Aurora_(protocol)

http://www.quasarsystemsinc.com/aurora.htm

http://blogs.mcafee.com/mcafee-labs/an-insight-into-the-aurora-communication-protocol

(http://www.xilinx.com/products/design_resources/conn_central/grouping/aurora.htm)

http://www.xilinx.com/products/intellectual-property/aurora8b10b.htm

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(973) 485-0066 (Home)

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Newark, NJ 07104

OBJECTIVE

To use the skills that I have obtained as an engineer to solve the problems I am faced with at work.

EDUCATION

2008- Present Howard University **Washington, DC**

Bachelor of Science: Electrical Engineering
Classification: Senior

Expected Graduation Date: May 2012

TECHNICAL SKILLS

Word, PowerPoint, Microsoft Visual Studio 2008, PSPICE, Mobile Studio

RELEVANT COURSEWORK

Calculus I-III, Physics 1-2, Computer Science I, Digital Systems Design, Network Analysis I-II, Energy Conversion, Signals & Systems

ACTIVITIES AND ORGANIZATIONS

Fall 2009 - Present **Howard University Institute of Electrical & Electronic Engineers (IEEE) student chapter**

- Vice President (Fall 2010 – Spring 2011): Assist the president in his duties. Help put general body meetings together as well as lead E-Board meetings. Help everyone one else in the E-Board to complete their duties when I am done with mine.

Fall 2009 – Present **Association for Computing Machinery (ACM)**

- ACM is an educational and scientific society uniting the world's computing educators, researchers, students and professionals to inspire dialogue, share resources and address the field's challenges.
- Active member

Fall 2008 – Present **Howard University New Jersey Club**

- Represents New Jersey at Howard, hosts various activities to inform students from Washington DC and meet with those who are from or have a love for the great state of New Jersey.
- Weekend at the Mecca Co-chair: Help my co-chair plan a trip for a group of students from New Jersey to spend a weekend at Howard to get a real life view of our institution. (Fall 2010- Spring 2011)

Work Experience

09/09-Present **Computer Learning and Design Center (CLDC)**

- I am an Operator with responsibilities to manage the computer laboratory by helping users with problems ranging from internet connection to printer malfunctions and to work on projects that help maintain the lab's efficiency and also upgrade the lab's usefulness by adding functionality
- Nagios Project: Use a virtual machine to install Ubuntu. Set up Ubuntu so that Nagios (problem detection system) can be installed. Master Nagios and then implement the project on a real machine to work for the whole lab.
- Web Host Project: Use a virtual machine to install Ubuntu. Set up Ubuntu so that ISPConfig (web hosting application) can work on it. Master the application so it then can be installed on a real machine to work for the whole lab.

07/07 – 08/07 **North Star Academy**

- Inventory Assistant
- Duties were to make sure any newly delivered inventory was organized and set in the desired areas.

06/07-07/07 **Lehman Brothers**

- Interns were to explore the Investment Banking world with the help of an employee mentor

Interns were to choose a company and make a PowerPoint presentation telling why or why not buy stocks in the company

Andrew Hillocks

Permanent:

8860 Piney Branch rd # 903
Silver Spring, MD 20903
301 6752849
drewkeys88@gmail.com

Objective: To gain experience while working or doing research in a position related to software, electrical, or computer engineering.

EDUCATION:

Howard University (2007-present)

- Computer Engineering Undergraduate Program
- Experience with C++ data language
- Courses taken include: Chemistry, Physics, Calculus, Network Analysis, Electronics, and Digital Systems
- Familiar with VHDL
- Member of NSBE
- Member of DMV Club

EXPERIENCE:

U.S Census Bureau (April 2010-present)

- Conducted interviews with respondents and assisted the U.S government with the 2010 decennial census.

Vector Marketing (2007-2008)

- Scheduled presentations with clientele in order to sell merchandize and create customer volume.

Riderwood Village (2006-2007)

- Prepared food various dining areas for customer service such as salad bars, buffet lines, ect.

United Parcel Service (July 2009- January 2010)

- Handled packages from receiving trucks and organized them in order to be properly shipped out to the correct location.

232 Florida Ave. NW, Washington, DC 20001•773-710-5794•montyj88@gmail.com

Montaque Alan Jones

Objective

I am currently enrolled in the Electrical Engineering program to attain my Bachelor of Science Degree. I am seeking an opportunity with your company to be granted an internship that will provide me with additional experiences and skills to increase my marketability. Attaining employment within the company will train me further in the engineering industry.

Experience

Aug 2010-Apr 2011 Cramton Auditorium at Howard University Washington, DC

Production Assistant

- Organized promotional events for Howard University
- Performed preventive and minor equipment maintenance
- Maintained equipment inventory and records showing that required equipment maintenance is performed on schedule
- Responsible for formatting and managing production equipment

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May 2010-Aug 2010 Chicago State University Chicago, IL

Administrative Assistant

- Compiled and kept records of business transactions and office activities of the financial aid office
- Copied data and compiled records and reports
- Opened and routed incoming mail, answered multi-line phones, and prepared outgoing mail
- Directed students to appropriate personnel
- Responsible for inputting information into computer terminals

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Aug 2007- May 2009 L.G.I. Entertainment Washington, DC

Event Sales Representative

- Arranged private parties and club events in District of Columbia, Maryland and Virginia
- Followed up with clients on details and payment issues
- Negotiated agreements and assisted in planning logistics
- Handled any challenges and problems promptly to maintain the client's satisfaction
- Makes and/or takes potential customer calls, sells event space
- Assisted with the hosted events for purpose of networking and assuring customer satisfaction

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May 2006-Aug 2008 Phil Stefani Catering Chicago, IL

Caterer Helper

- Responsible for point of sale transactions
- Responsible for inventory inspections
- Assisted caterer by preparing and serving food at social events
- Arranged tables and decorations
- Washed and packed dishes and utensils for removal to catering establishment

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Jasmine Little

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Owings Mills, MD 21117
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E-mail: Jcherrial@gmail.com

OBJECTIVE: Obtain a full time position with a company where I can make a difference in the lives of people by contributing my skills and talents, while maximizing my experiences as computer engineer. I aspire to provide leading innovations and solutions for tomorrow.

STRENGTHS:

Proven ability to work independently
Attention to Detail
Leadership & Organizational Skills
Strong Interpersonal Skills
Experience handling sensitive information
Positive Attitude

EDUCATION:

Howard University
Major: Computer Engineering
Anticipated Graduation Date: December 2012
GPA: 2.57

SKILLS:

Proficient in Microsoft Office, Unix/Linux, Java, C++, VHDL programming, PSpice, Espresso and Fast Track

EXTRA CURRICULAR ACTIVITIES:

The Society of Women Engineers (SWE)
The National Society of Black Engineers (NSBE)
Institute of Electrical and Electronics Engineers (IEEE)
Historian of the College of Engineering Architecture and Computer Science (CEACS) Student Council

WORK EXPERIENCE:

March 2006 – Present **First Choice Transportation** **Owings Mills, MD**
Assistant Office Manager

Provide oversight and clerical support to the business to ensure the transportation needs of the clients are met.

- Dispatch and update transportation requests to the chauffeurs.
- Monitor and track driver location to ensure transportation needs are being handled effectively and efficiently.
- Provide office oversight during the absence of the office manager and owner.
- Answer incoming calls from clients, vendors, and employees.
- Maintain files and organize critical documents as assigned.

May 2011 – Aug 2011 **Intellect Solutions** **Falls Church, VA**
Summer Intern

Provided administrative and technical support to the Deputy Program Executive Officer to the Department of Defense on the Captain James A. Lovell Federal Health Care Center (JAL FHCC) Project.

- Managed information flow to appropriate individuals, maintained files and responded to routine matters.
- Compiled, created and maintained various reports, databases and charts using PC spreadsheets, word processing and graphical software packages.
- Assisted with all aspects of administrative management, directory maintenance, logistics, equipment inventory and storage
- Coordinated between departments and operating units in resolving day-to-day administrative and operational problems
- Scheduling and coordinating meetings and other similar activities
- Prepared business correspondence and powerpoint presentations

May 2010 – Aug 2010 **Axiom Resource Management** **Falls Church, VA**
Summer Intern

Provided administrative and technical support to the Deputy Program Executive Officer to the Department of Defense on the JAL FHCC Project. Duties included calendar maintenance, reporting, and other office duties as assigned.

Appendix B

Glossary

BS2 - BASIC Stamp 2: a microcontroller with a small, specialized BASIC interpreter (PBASIC) built into ROM.

FPGA - Field-Programmable Gate Array is an integrated circuit designed to be configured by the customer or designer after manufacturing—hence "field-programmable". The FPGA configuration is generally specified using a hardware description language (HDL).

GPIO - General Purpose Input/Output: a generic pin on a chip whose behavior (including whether it is an input or output pin) can be controlled (programmed) through software.

LED - Light-Emitting Diode: a semiconductor light source. LEDs are used as indicator lamps in many devices and are increasingly used for other lighting.

UCF – User Constraint File

USB - Universal Serial Bus: an industry standard developed in the mid-1990s that defines the cables, connectors and communications protocols used in a bus for connection, communication and power supply between computers and electronic devices.