Ethernet Interface for Hardware Data Routing

Project Proposal

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INTRODUCTION

Our project hopes to address the issue of multiple and varied device control from a single controller. Using our routing blocks, a range of useful devices like servos, motors, sensors, and LEDs can be controlled and turned on/off from one computer. This ability could prove useful in many robotics applications, providing a modular and compact method for distributive control of many parts and sensors. The advantages of the hardware routers are its modularity, power-management support, and device adaptability.

Existing Technology

Currently, a number of devices are required to use data acquisition units, which are either internal cards in a PC or a USB device, in order to interface them to computers. Some devices include built in USB or Ethernet functionality.

Benefits

- Control multiple devices of varying types from one computer
- Access done through the familiar TCP/IP protocol
- Device power control reduces power consumption
- Universal computer support – works with any Ethernet-capable computer

Features

- Analog and digital inputs
- Analog and digital outputs
- LED status indicator lights
- Fused power hub
- Interface with LabVIEW for verification of functionality

DESIGN

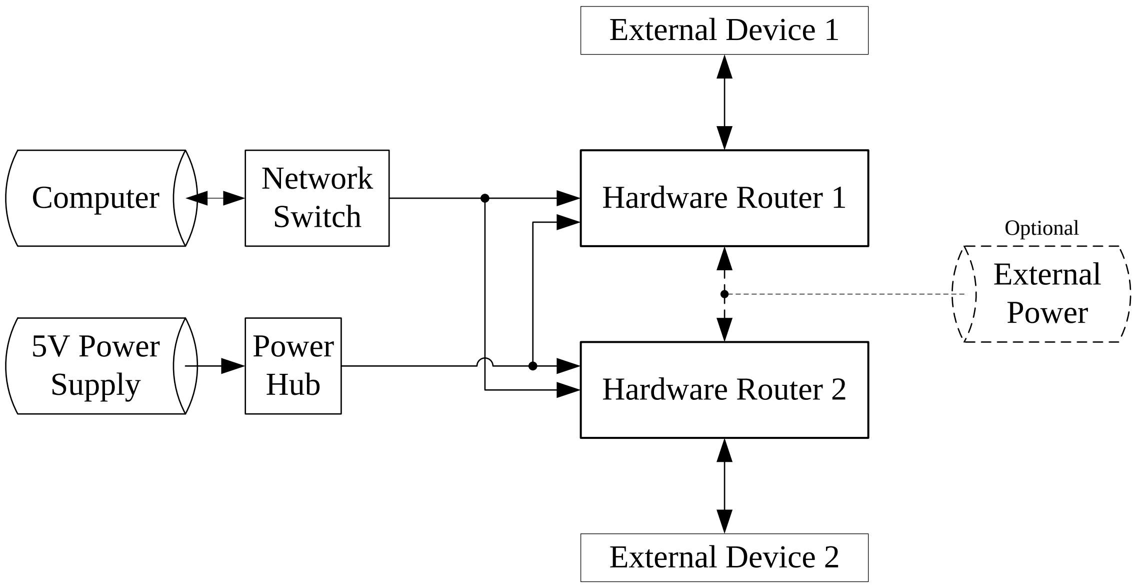

Figure 1: Network Overview

Computer: This represents any computer with Ethernet connectivity. The computer will generate commands, transmitted as TCP/IP packets sent to the router through Ethernet interface. The computer will process the data sent from the routers collected from the external devices.

Network Switch: A network switch connects multiple networked devices, transferring data between devices. It allows multiple hardware router devices to be connected to a single computer, each with their own MAC address, and thus assigned IP address.

5V Power Supply: This is a power source, either a 5V battery or wall plug, which supply power to the microcontroller through the Power Hub.

Power Hub: The power hub is the central location where the 5V logic power is distributed to the various routers, protecting the routers from over-current.

External Device: The external device is any device that does not already have a computer-ready interface, and is being connected to a computer. Examples include motor controllers, sensors, lighting and indicators. These devices can be near the computer, or as part of a distributed system.

External Power: Optional power to be supplied to the external device, for devices requiring more power than can be sourced by the 5V logic supply, or for higher voltage requirements.

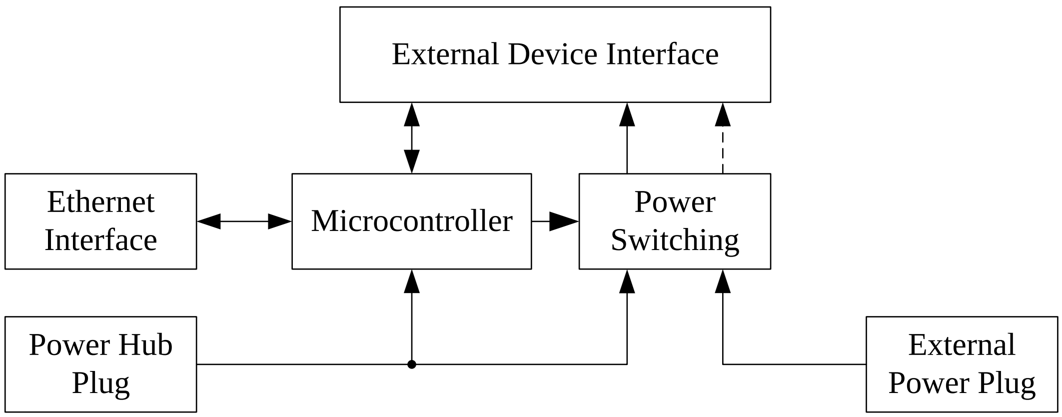

Figure 2: Hardware Router Internal Details

Ethernet Interface: The RJ-45 jack, galvanic isolation, TCP/IP stack implementation, and MAC address make up the Ethernet interface, connecting the microcontroller to the network.

Microcontroller: The microcontroller interprets the data from the Ethernet interface, as well as any data collected from the external device, and routes the data to the proper destination.

Power Switching: Solid-state switches that control the external power as well as the 5V logic power to the external device. The microcontroller sets these switches, disabling the external device initially until the device is initialized.

Power Plug: The power plugs are the physical jacks on each router to connect the various external power sources (from the external power and 5V logic power).

REQUIREMENTS AND VERIFICATION

Requirements	Verifications
A set instruction protocol controls the external power source switch from the computer	When the command is sent from the computer, the measured voltage should be observed to switch from 0 to the external source voltage or vice versa
Routed external power will observe the limitations of the power switch	The hardware router itself shall have a set, rated voltage maximum, but the switches shall be designed with a minimum safety factor of 25%
A/D sampling will be activated and automated in response to a set instruction protocol for sampling parameters	The input signal should be sampled at the rate a test instruction protocol dictates and should match a test input signal when the returned data is collected and plotted
A/D sampled data returns to the computer with a set data packet protocol	After sending a test instruction protocol, data should be returned to the computer and the plotted data should match the test input signal
Digital sampling will be activated and automated in response to a set instruction protocol for sampling parameters	The digital input signal should be sampled at the rate a test instruction protocol dictates and should match a test input signal when the returned data is collected and plotted
Digital input sampled data returns to the computer with a set data packet protocol	After sending a test instruction protocol, data should be returned to the computer and the plotted data should match the test input signal
The Ethernet controller and the microprocessor will communicate using the SPI specification	Both devices are SPI compatible, and a software library exists for use with the Ethernet controller on the microprocessor
D/A converted signals will be generated according to parameters carried by a set instruction protocol	Generated signals of varying amplitudes and frequencies will be commanded, and subsequently measured by a scope
A digital signal will be generated according to parameters carried by a set instruction protocol	An oscilloscope connected to the digital out pins should show a signal that matches one described by a sent test instruction
The power on routine will turn on necessary devices and then wait for instructions	When power is applied, external devices do not begin to function until commanded
Each routing device will respond to ping	A ping of the individual devices should prove successful
The hardware router will use the TCP/IP protocol to communicate with the network	The network interface will implement a TCP/IP stack
A LabVIEW interface that shows which routers are connected at all times	Add and remove routers and view shown LabVIEW connections
LabVIEW GUI or scripts for instruction formation and transmission	Analog out/in and Digital out/in instruction protocols should be sent correctly so that expected device implementation is observed
Acquired data presented in table, graphs, or	Test signals to Analog or Digital in should

scopes in LabVIEW during collection	provide appropriate graphs
Computer DHCP control assigns IP addresses according to MAC address	The routing devices should be visible and should be reachable by pinging their set IP addresses
Power hub supplies 5V ± 0.1V to each router	For a varying electronic load, the power hub is able to supply 5V consistently without an excessive drop along the wire
The power hub will not provide an excessive amount of current to the hardware routers	Each router output from the power hub will be fused, and the current will be monitored along the line, at the hub and the router itself, and going into the microcontroller, by a current probe

TOLERANCE ANALYSIS

The hardware router will need to receive 5V ± 0.1V in order for the circuits to function properly. Additionally, the regulated voltage to the microcontroller needs to be 3.3V ± 0.3V in order for the microcontroller to function. The external power source switch should be able to handle inputs of up to 75 volts of any polarity, and its fuses should cut off higher inputs.

COST

Table 1: Initial Parts Cost Estimate

Part	Price	Quantity	SubTotal
Microcontroller	$ 6.50	2	$ 13.00
External Power Interface	$ 0.50	2	$ 1.00
Network Switch	$ 15.00	1	$ 15.00
Power Plug	$ 3.00	5	$ 15.00
Enclosure	$ 10.00	3	$ 30.00
Ethernet Interface	$ 20.00	2	$ 40.00
Misc. Discrete Components	$ 0.20	30	$ 6.00
Shipping and handling	*20%*		*$ 24.00*
Total			**$ 144.00**

Table 2: Initial Labor Cost Estimate

Worker	Hourly Rate	Hours/Week	Weeks	Salary
John Alaimo	$ 35.00	20	12	$ 8,400
Hendrik Dewald	$ 35.00	20	12	$ 8,400
Satyam Shah	$ 35.00	20	12	$ 8,400
Subtotal				*$ 25,200*
Total	**2.5x overhead**			**$ 63,000**

Estimated project grand total: $63,144.00

SCHEDULE

Table 3: Schedule

Week	Description of Task	Group Member
9/24/2012	**Design Review Sign-up, Basic Software Flow**	**Group**
	Preliminary Hardware Layout, Preliminary Power Hub Design	John Alamo
	Set-up and Learn PIC MPLAB IDE	Hendrik Dewald
	Learn LabVIEW Usage	Satyam Shah
10/1/2012	**Design Review**	**Group**
	Detailed Hardware Layout	John Alamo
	Order Parts from Suppliers	Hendrik Dewald
	Develop Power-on Protocols	Satyam Shah
10/8/2012		**Group**
	PCB Schematic Design	John Alamo
	Create Skeleton code for PIC, Run Basic Simulation	Hendrik Dewald
	Develop Data Protocols	Satyam Shah
10/15/2012		**Group**
	Breadboard Verification of Layout	John Alamo
	Test Uploading to PIC, Run Simulation	Hendrik Dewald
	Run Protocols in Simulation	Satyam Shah
10/22/2012	**Individual Progress Report**	**Group**
	PCB Schematic Update	John Alamo
	Verify Data Transmission with Network Analyzer	Hendrik Dewald
	Develop LabVIEW Interface	Satyam Shah
10/29/2012	General Troubleshooting	**Group**
	PCB Layout Design	John Alamo
	Test and Refine Protocols	Hendrik Dewald
	Test and Refine Protocols	Satyam Shah
11/5/2012	**Mock Demos , Mock Presentation Sign-up,Test Protocols, Refine LabVIEW Interface**	**Group**
11/12/2012	**Mock-up Presentations, First Revision PCB Fabrication**	**Group**
	Revise PCB Design for Additional Router(s)	John Alamo
	Test Routers using Different Devices	Hendrik Dewald
	Test Routers using Different Devices	Satyam Shah
11/19/2012	**Final Revision PCB Fabrication**	**Group**
11/26/2012	**Demos and Presentation Sign-up, Fine-tune and Repair Testing Damages**	**Group**
12/3/2012	**Demos, Practice Presentation**	**Group**
12/10/2012	**Presentations, Final Paper, Lab Checkout, Lab Notebook**	**Group**