Internet Remote Control of Homebrew Projects

Inland Empire VHF Radio Amateurs Club

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Background

- * 1972 Novice License (WN6NDR), 1973 Advanced (WA6NDR), 2000 Extra (when 20 WPM code requirement dropped)
- * 1977-2009 Hewlett-Packard / Agilent Technologies (32 yrs)
 - * Radio & cell phone test equipment (28 yrs)
 - * Inkjet print/fax/copy/scan computer peripherals (4 yrs)
- * 6/2009 laid off from Agilent Technologies
- * 1/2010 to 6/2011 Eastern Washington University
 - * Masters of Science degree in Computer Science (MSCS)
 - * Masters Project: "Simple Network Management Protocol and Internet-Connected Embedded System Controllers" -- 220 hours; 245 emails; 26 online forum posts; 150 PC screen shots; 45 support files; 60 browser bookmarks; 44-page report; 33-slide presentation
- * This talk is derived from my EWU master's project.

Overview (1 of 2)

- * Hardware Platform 1: Modtronix SBC65EC
 - * Features; Photo; Web Server browser interface
 - * Customization Level 0: No Hardware/Firmware Changes
 - * Remote Access: Dynamic Domain Name System (DDNS) and Router Port Forwarding
 - * Remote Control: HTTP / browser or UDP / PC program
 - * Java program development using jGRASP IDE
 - * Demo (4 key abilities: digital/analog input/output)
 - * RS-232 Interface (system recovery if ethernet control is lost)
 - * Customization Level 1: User Web Pages
 - * Modtronix Network Bootloader software
 - * Customization Level 2: User Firmware
 - * Microchip TCP/IP Stack (open-source C code)
 - * Wireshark (an oscilloscope for Internet measurements)
 - * Microchip MPLAB Integrated Development Environment
 - * Modtronix Embedded Debugger

Overview (2 of 2)

- * Hardware Platform 2: Modtronix SBC66EC
 - * Features; Web Server; compare to SBC65EC (demo of mine online at home)
- * Hardware Platform 3: Microchip PIC32 Ethernet Starter Kit
 - * Features
- * Technology Extension: Cisco-Linksys WVC80N Home Monitoring Camera (demo of mine online at home)
- * Web Links to More Information

Hardware Platform #1: Modtronix SBC65EC



Modtronix SBC65EC Features

- * Remote Control from anywhere on the Internet
 - * By web browser (Hypertext Transfer Protocol, HTTP)
 - * By end-user programs (User Datagram Protocol, UDP)
- * Set and read digital signals (0 or 5V)
- * Set DC voltages using Pulse Width Modulation (PWM)
- * Read DC voltages using on-board Analog to Digital Converters (ADCs)
- * Based on a Microchip PIC18 Micro-Controller (8-bit, 40 MHz clock, inexpensive)
- * RS-232 system control / debug interface
- * Development uses free software tools and no additional hardware; only \$70; large user base; good documentation.
- * Based on the Microchip TCP/IP Stack version 3.75 (8/14/2006, > 15 releases old), plus Modtronix additions.
- * Add-on boards available: LCDs, keypads, relays, other I/O

SBC, Proto Board, Enclosure, LCD...



Modtronix SBC65EC Web Server (21 browser pages)

	Modtronix SBC65EC Web Server
Introduction	
Analog Inputs	Introduction
Port Values	This page is conved by the Medtropix SPC655C Web Server supping on a
LCD Display	<u>SBC65EC</u> Single Board Computer from Modtronix Engineering.
PWM Values	
Expansion Board	The default Username and Password is 'admin' and 'pw'.
Example 1	It has the following features:
System Configuration	
Serial Configuration	 Delivered with PIC18F6627 CPU, 24LC512 EEPROM and Modtronix
Contact	 Programmed with a bootloader for updating firmware over the network or internet
	 Has space for a 8 pin Ramtron SPI FRAM chip (32Kbyte FM25256 chip for example) to be assembled
	 Implements HTTP Compression for storing web pages 32 user programmable I/O pins. They can be monitored, configured and updated via web pages See <u>SBC65EC</u> product page for details 12 user programmable, 10 bit Analog to Digital converters. They can be monitored, configured and monitored via web pages
	 Red user LED Green LED for Link indication
	 Yellow LED to indicate transmit or receive activity RS232 interface via 3 pin connector or Frontend board Accepts a wide range of commands via HTTP GET method or UDP, <u>click</u> <u>here</u> for details

Remote Access: Dynamic Domain Name System (DDNS)

LINKSYS [®] A Division of Cisco Systems, Inc.						Firmwai	re Version : v4.20.7
					Wireless-G Broad	Iband Router	WRT54G
Setup	Setup	Wireless	Security	Access Restrictions	Applications & Gaming	Administration	Status
	Basic Setu	1þ	DDNS	ľ	MAC Address Clone	Advance	d Routing
DDNS	DDNS S User Na Passwo Host Na Internet Addres Status :	ervice: [[me:]] ne:]] me:]] s: 67	DynDNS.org	org ssfully		DDNS Service you to access y using domain na IP addresses. T manages chang and updates yo information dyn must sign up fo through TZO.cc DynDNS.org. More	: DDNS allows your network ames instead of he service ging IP address our domain amically. You r service om or
			Save	Settings	Cancel Changes		CISCO SYSTEMS IIIIIIIIII

Remote Access: Port Forwarding



jGRASP Integrated Development Environment (IDE), one option to create Java/C/C++... PC control programs



Modtronix SBC65EC Demonstration

- * Direct-connected to my laptop PC, so both the control program and device can be seen.
- * Control using a web browser (HTTP)
 - * Browse the web pages
 - * Set DC voltage using filtered Pulse Width Modulation (PWM)
 - * A 39 kHz variable-width (0 to 1/39000 s) pulse
 - * Filtered through an RC low-pass filter
 - * 1 kohm, 1 uF makes a 159 Hz corner frequency
 - * 39 kHz is attenuated 49 dB
 - * Measure voltage using an Analog to Digital Converter (ADC)
- * **Control using a PC program** (UDP, Java, jGRASP)
 - * Set LEDs and read 8 switches (digital I/O)
 - * Set and read a DC voltage (analog I/O, same as done above)

SBC65EC RS-232 Interface (system recovery if ethernet control is lost)

Modtronix SBC - HyperTerminal	×
File Edit View Call Transfer Help	
	~
5: Enable DHCP & IP Gleaning.	_
6: Disable DHCP & IP Gleaning.	
7: Download File System Image.	
8: Save & Quit.	
Enter a menu choice (1-8): 2	
Default IP Address (192.168.1.53): 192.168.1.53	
Modtronix Web Server	
1: Change Board serial number.	
2: Change default IP address.	
3: Change default gateway address.	
4: Change default Subhet mask.	
6. Disable DHCP & IP Gleaning.	
7: Download File System Image.	
8: Save & Quit.	
Enter a menu choice (1-8): 8	
Now running application	
Running Application, IP address: 192.168.1.53	
	~
Connected 0:01:41 Auto detect 57600 8-N-1 SCROLL CAPS NUM Capture Print echo	

Customization Level 1: User Web Pages

(the Modtronix Network Bootloader)

Firmware & Webpage Update Webpage Creation Firmware and Webpages Firmware and Webpages Firmware Hex File C:\MPLAB\SBC65EC\fw_v3.10\websrvr65_v310_hw211.hex Webpage Image File C:\MPLAB\SBC65EC\fw_v3.10\websrvr65_v310.img Settings Farget IP Address or NetBIOS name:	Browse Browse
Firmware and Webpages Firmware Hex File C:\MPLAB\SBC65EC\fw_v3.10\websrvr65_v310_hw211.hex Webpage Image File C:\MPLAB\SBC65EC\fw_v3.10\websrvr65_v310.img Settings Farget IP Address or NetBIOS name: 192.168.1.53	Browse Browse
Firmware Hex File C:\MPLAB\SBC65EC\fw_v3.10\websrvr65_v310_hw211.hex Webpage Image File C:\MPLAB\SBC65EC\fw_v3.10\websrvr65_v310.img Settings Farget IP Address or NetBIOS name: 192.168.1.53	Browse
Webpage Image File C::MPLAB:SBC65EC:tw_v3.10:websrvr65_v310_nw211.nex Webpage Image File C::MPLAB:SBC65EC:tfw_v3.10:websrvr65_v310.img Settings Image File Farget IP Address or NetBIOS name: 192.168.1.53	Browse
Webpage Image File C:\MPLAB\SBC65EC\fw_v3.10\websrvr65_v310.img Settings Farget IP Address or NetBIOS name: 192.168.1.53	Browse
Settings Target IP Address or NetBIOS name: 192.168.1.53	
Target IP Address or NetBIOS name: 192.168.1.53	
Target IP Address for Bootloader: 192.168.1.53	
Update EEPROM Configuration Data: 📃	
Reset Target Before Connecting: 🔽	
Upgrade Firmware Connect Upload Webpages Cancel	
17:58:19.372 - Trying to connect with Target	
I 7:58:21.916 - Found: SBC65EC, Hardware V3.01 (PIC18F6627) 17:59:21.926 - Rootloader V4.0	
17:58:21.926 - Successfully connected	
17:58:41.664 - Exited Bootloader Mode	
17:59:11.798 - Do not close program or switch target's power off!	
17:59:12:068 - Establishing FTP connection to Target 17:59:17:015 - Connected to FTP Server	
17:59:17.015 - Uploading file to FTP Server	
17:59:24.386 - File Successfully sent!	

Customization Level 2: User Firmware

- * Microchip MPLAB Integrated Development Environment (IDE)
- * Microchip TCP/IP Stack software
- * Modtronix Web Server software (code on top of the Microchip TCP/IP Stack; see link on last slide)
- * Wireshark (debugging tool)
- * Modtronix Embedded Debugger software (debugging tool)

Microchip MPLAB IDE

IntEEDATA.mcw			Heasembly I	Listing						
IntEEDATA.mcp			000182	S2R6	WOAE (Dzfeć, F, A	CCRSS	53: 🚥	vf P	
E Source F	AWain.c			9EA6	BCF Or	(fa6, 027,	Speci	al Function Registers	- 0	Ĩ
Main Da	unsigned sheet	Timestati	_	9882	BCE ON	ff2 0+7	CORD N	and T. Harry J.		Ť
Hender E 120	unsigned char	i imeout,	~				SFR N	an hex i	sinary	ļ
Object Fil 30	11			OESS	MAAN	0x55	INDF1			•
Library E 31				6EA7	MOWNE	Orfa7, ACC	INDF2			5
Construction Sec 132	void main 0			OEAA	NUATA	Ozaa	INTCOM	I AO	10100000	1
18/4/ 33	1			6EA7	MOWNE	Oxfa7, ACC	INTCOM	1Z 84	10000100	1
Other EL 34	Timeout = 0,			8246	BSE OF	fa6, 0x1,	INTCOM	13 CO	11000000	1
35	INTCON = 0x20	; //disable global	and enal	SEF2	BSE OF	112, 0x7, .	IPR1	rr	11111111	f.
36	INTCON2 = 0x8	4, //TMR0 high pr	iority	0003	SLEEP		1PRZ	15	00011111	5
37	RCONbits IPEN	 I; //enable priorit 	ty levels	8446	BSE OF	cfa6, 0x2,	LATA	00	00000000	Ľ
38	TMROH = 0;	//clear timer	21	0012	RETURN	0	Performance.	0.00		
39	TMROL Stor	watch				Watch				
40	INTCOL			Second Second Second	MOLICIT	ICTD] TOC		LUC 1 3 DODTOLS		i
G2	TRISE				NO	dSFRJ TUS	Y	vdd Symbol PUHT Bbits	*	L
43	TRISC=	Stope	watch Tota	al Simulated	BC	Address	_	Symbol Name	Value	1
44	EADR- SM	ch Instruction Cycles 2	1511894	21511894	BS	008B	in	dex	0x0078	Ē
45					0.00	OFC2	AD	COND	0x00	ŀ
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ine le 47		teres () and			D	OFFD	TO	ଟ	0x000126	ł
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24 00 50	white				-					
25 00 51	IT DO	ar Simulation Time On Reset			I W	atch 1 Watch	2 Watch	3 Watch 4		1
26 00 52				-	Hardw	are Stack				í
27 00 53	Timeout =	u, //clear.tim	eout indii			T		-	Links Co.	ŝ
28 00 54	EEWRITE/PC	RTC, EADR++);			TOS	Stack	Level	Return Address	Location	1
29 00 55	Nop();		~				0	Empty		
30 00 4	and a second sec		>				1	000044	_startup +	F
31 0055 .					-		2	000126	main + Ox4	ŝ
32 00E8 6	188D	CLRF Timeout, 1	BANKED				3	000198	.file	
33 00EA 0	0E20	MOVLW 0x20		R.			4	000000		
34 DOEC 6	EF2	NOVWF INTCON, J	ACCESS				5	000000		
35 OOEE C)E84	MOVLW 0x84		W			6	000000		
36 00F0 6	EF1	MOVWF INTCOM2,	ACCESS	-			7	000000		

Microchip MPLAB IDE

- * Manages Microchip and 3rd-party editors, compilers, assemblers, linkers, simulators and debugging hardware (programmers, debuggers, in-circuit emulators).
- * Source code revision control
- * Supports multiple "Workspaces" (windows, sizes, work-inprocess) and "Projects" (source file set, MCU, appropriate software tools...)
- * Features similar to Eclipse or jGRASP
- * 350-page User's Guide (good documentation)
- * Tutorials, debug features (step into/over, breakpoints, animate, trace, watch, stopwatch), macros...
- * 25 window types, 33 dialogs, command-line options...

Microchip TCP/IP Stack

source code: ~60 .c files, ~1000 pages

Dynamic Host Configuration Protocol; Simple Network Management Protocol; Hypertext Transfer Protocol; File Transfer Protocol; Trivial FTP; User Datagram Protocol; Transmission Control Protocol; Internet Control Message Protocol; Internet Protocol; Address Resolution Protocol; a few others not shown



Wireshark

- * Send a single UDP packet to the SBC65EC that requests a voltage reading ("%n20")
- * Receive the single UDP packet that gives the voltage ("2.44")
- * Lots is going on!
- * Each layer of the Transmission Control Protocol / Internet Protocol (TCP/IP) Stack is like a "nested doll" wrapping the information in the layer above. A 5-doll package goes out on the ethernet cable.
- * In this simple case there is about a 10 to 1 overhead cost in using the Internet instead of a simple RS-232 direct connection. (46 bytes carry 4 bytes of data. 60 bytes carry 5 bytes of data.)
- * This overhead value is a major network design consideration, and varies from protocol to protocol, application to application.

SBC65EC IO Demo.pcap [Wireshark 1.6.3 (SVN Rev 39702 from /trunk-1.6)]	
<u>Eile Edit View Go Capture Analyze Statistics Telephony Tools Internals H</u> elp	
	🔍 🖭 🔐 🗹 畅 % 😫
Filter: Expression Clear Apply	
No. Time Source Destination Protocol Length Info	
1 0.000000 192.168.1.115 192.168.1.122 UDP 46 Source port: fcip- 2 0.001931 192 168.1 122 192 168.1 115 UDP 60 Source port: 54123	port Destination port: 5412
	beschlacton porc. Terp por
⊕ Frame 1: 46 bytes on wire (368 bits), 46 bytes captured (368 bits)	
Ethernet II, Src: Intel_9a:cd:39 (00:0c:f1:9a:cd:39), Dst: Microchi_00:00:0	00 (00:04:a3:00:00:00)
E Destination: Microchi_00:00:00 (00:04:a3:00:00:00) E Sounco: Intol Deschi20 (00:0c:f1:0e:cd:20)	
Type: IP (0x0800)	
Internet Protocol Version 4, Src: 192.168.1.115 (192.168.1.115), Dst: 192.1	168.1.122 (192.168.1.122)
⊡ User Datagram Protocol, Src Port: fcip-port (3225), Dst Port: 54123 (54123))
Source port: fcip-port (3225)	
Destination port: 54123 (54123)	
⊞ Checksum: 0x43f5 [validation disabled]	
■ Data (4 bytes)	1
Data: 256e3230	
[Length: 4]	
0000 00 04 a3 00 00 00 00 0c f1 9a cd 39 08 00 45 00	
0010 00 20 56 59 00 00 80 11 57 06 c0 a8 01 75 c0 a8 \cdot ws	
Data (data), 4 bytes Packets: 2 Displayed: 2 Marked: 0 Load time: 0:00.500	Profile: Default

SBC65EC IO Demo.pcap [Wireshark 1.6.3 (SVN Rev 39702 from /trunk-1.6)]	
<u>Eile Edit View Go Capture Analyze Statistics Telephony Iools Internals H</u> elp	
	0, 🖸 🕁 🗹 畅 % 💢
Filter: Expression Clear Apply	
No. Time Source Destination Protocol Length Info	
1 0.000000 192.168.1.115 192.168.1.122 UDP 46 Source port: fcip-	port Destination port: 5412
2 0.001931 192.108.1.122 192.108.1.113 ODP 00 Source port. 34123	best matron port. Terp-por
⊞ Frame 2: 60 bytes on wire (480 bits), 60 bytes captured (480 bits)	
Ethernet II, Src: Microchi_00:00:00 (00:04:a3:00:00:00), Dst: Intel_9a:cd:	39 (00:0c:f1:9a:cd:39)
E Destination: Intel_9a:cd:39 (00:0c:f1:9a:cd:39) E Source: Microschi 00:00:00 (00:04:s2:00:00:00)	
Type: IP (0x0800)	
Trailer: 10040094aa0000020404007172	
Internet Protocol Version 4, Src: 192.168.1.122 (192.168.1.122), Dst: 192.1	168.1.115 (192.168.1.115)
User Datagram Protocol, Src Port: 54123 (54123), Dst Port: fcip-port (3225))
Destination port: fcip-port (3225)	
Length: 13	
⊡ Checksum: 0x0000 (none)	
■ Data (5 bytes)	
[length: 5]	
0010 00 21 05 9b 40 00 64 11 8c f3 c0 a8 01 7a c0 a8 .!@.dz.	
0020 01 73 d3 6b 0c 99 00 0d 00 00 <u>32 2e 34 34 00</u> 10 .s.k2.44.	
0030 04 00 94 aa 00 00 02 04 04 00 71 72	
Data (data), 5 bytes Packets: 2 Displayed: 2 Marked: 0 Load time: 0:00.500	Profile: Default

Modtronix Embedded Debugger

(configurable runtime "debug print" output)

🖋 Mo	dtroni	ix Embedde	d Debu	igger V1	.03							
<u>Eile</u>	<u>M</u> indo	w <u>H</u> elp										
	N -			e e e e e e e e e e e e e e e e e e e				á		a dila	anti arr	
FTP	FSE	E HTTP	IP	MAC	NBNS	STA	CKTSK	ТСР	Utils	FTFTPc	UDP	
Defa	ult	APPCFG	BUS	CMD	Gen	eral	НТТРХ	M	AIN	Announce	DHCP	DNS
15:00, 15:00, en-US 15:00, 15:00, 15:00, 15:00, 15:00, 15:00, 15:00, 15:00, 15:00, 15:00, 15:00, 15:00, 15:00,	39.674 39.704 39.704 39.704 39.714 39.724 39.724 39.724 39.744 39.744 39.744 39.744 39.744 39.744 39.744 39.744 39.744 39.744 39.744 39.744 39.744 39.744 39.744 39.744	4 - 5 - Receiv 4 - 5 - Receiv 4 - 5 - Receiv 4 - 5 - Receiv 5 - Receiv 5 - Receiv 5 - Receiv 5 - Receiv 5 - Receiv 5 - Sendin 5 - Sendin	ed follov ed follov o/20110 ed follov ed follov sed follov ed follov ed follov ed follov ed follov ed follov ed follov	wing HTT wing HTT 420 Firefo wing HTT oplication wing HTT wing HTT wing HTT wing HTT wing HTT command to be con to be con ent file ected	P Head P Head Dx/3.6.1 P Head P Head P Head P Head P Head d for 'IN I body tinued	er: 'Ho er: 'Us er: 'Acc er: 'Acc er: 'Acc er: 'Acc er: 'Acc er: 'Co DEX.H	st: m3.dyn er-Agent: I T CLR 3.5 ept: q=0.8' ept-Langu ept-Chars ept-Chars ap-Alive: 1 nnection: TM'	dns.or Mozilla .30729 Jage: (ding: g set: ISC 15' keep-a	rg' /5.0 (W 3; .N' zip,defl D-8859 ilive'	(indows; U; V late' -1,utf-8;q=0.	Vindows N 7,*;q=0.7'	T 5.1;
C:W	PLAB	SBC65EC/fw	_V3.10\	websrvr6	i5_V310	_rn1	COM1, 5	57600				

Hardware Platform #2: Modtronix SBC66EC



Modtronix SBC66EC + Microchip TCP/IP Stack + Microchip TCP/IP Demo App

		CP/IP Stack Demo Applica					
Overview Oynamic Variables	Welcome!	LEDs: (click to toggle)					
Form Processing	Build Date: Mar 29 2011 17:14:29	Buttons:					
Authentication	This site demonstrates the power, flexibility,	ΛΛΛΛ Potentiometer: 7					
Cookies	embedded web server. Everything you see is						
File Uploads	running the Microchip TCP/IP Stack.						
Send E-mail	On the right you'll see the current status of the demo board. For a quick						
Dynamic DNS	buttons (except MCLR!) or turn the potentione update immediately. This examples uses AJAX	eter and you'll see the status techniques to provide real-tim					
Network Configuration	feedback. This site is provided as a tutorial for the variou	is features of the HTTP web					
SNMP Configuration	 server, including: Dynamic Variable Substitution - displa Form Processing - handle input from the Authentication - require a user name an Cookies - store session state information 	ay real-time data ne client nd password n for richer applications					

Modtronix SBC66EC Features

- * Introduced March 2011.
- * Based on the Microchip PIC24 (16-bit) MCU.
- * Relative to the SBC65EC: more memory; faster; battery-backed up Real-Time Clock (RTC); same price (\$70); **based on the latest Microchip TCP/IP Stack v5.31 (10/19/2010) with only minor Modtronix modifications.**
- * But it is not a mature product yet. Early documentation and support were very poor: no user base; problems debugging; "early adopters beware"; not recommended by me for amateur radio operators.

Modtronix SBC66EC Demonstration

- * My SBC66EC is at home in my den.
- * DDNS equates <u>rn3.dyndns.org</u> to my house.
- * Port Forwarding routes HTTP to my house to the SBC66EC.
- * If you have Internet access with you, try <u>rn3.dyndns.org</u> now.
- * The Microchip web pages show off all the features of the **Microchip TCP/IP Stack software**, not the features of the **Modtronix SBC66EC hardware**. (Modtronix still needs to do for the SBC66EC what it did for the older SBC65EC.)

Hardware Platform #3: Microchip PIC32 Ethernet Starter Kit



Microchip PIC32 Ethernet Starter Kit + TCP/IP Stack + TCP/IP Demo App. Features

- * Two PIC32 (32-bit) MCUs, one dedicated to debug, and the latest Microchip TCP/IP Stack
- * Everything from one supplier: Better training, support, bug fixes, and feature additions.
- * \$72 (essentially the same as the 2 Modtronix boards)
- * What I ended up using for my EWU master's project, because is supports secure Simple Network Management Protocol version 3, with the iReasoning MIB Browser. I needed more security than the Modtronix boards provide.
- * Negative: The Modtronix Web Server software (web pages that make analog/digital I/O easy) does not work with this board. It is much harder to do simple control projects with the Microchip PIC32 ESK relative to the Modtronix SBC65EC.

Technology Extension: Cisco-Linksys WVC80N Home Monitoring Camera



Demo: Camera at home in my family room (cat for scale). Show live online audio/video.



Web Links to More Information

- * Modtronix (an Australian company) SBC65EC Single-Board Computer, \$70:
 - * http://www.modtronix.com/product_info.php?products_id=149
 - * http://www.modtronix.com/links/onlinemxws (live online board to play with)
 - * <u>http://www.modtronix.com/products/sbc65ec/websrvr65_v310/</u> (Web Server software developer's documentation)
- * Modtronix PT24E-ASM enclosure / prototyping board, with LEDs and switches, \$15:
 - * http://www.modtronix.com/product_info.php?products_id=230
- * Modtronix Add-On Boards (LCD \$40, I/O-Relays \$15 & \$60)
 - * http://www.modtronix.com/product info.php?manufacturers id=&products id=352
 - * http://www.modtronix.com/product info.php?manufacturers id=&products id=300
 - * http://www.modtronix.com/product_info.php?cPath=95&products_id=198
- * Microcontroller Pros Corporation (Modtronix distributor, Carson City, NV)
 - * http://www.ucpros.com/
- * Modtronix SBC66EC Single-Board Computer, \$70:
 - * http://www.modtronix.com/product_info.php?cPath=1_36&products_id=416
- * Microchip PIC32 Ethernet Starter Kit SBC, \$72:
 - * http://www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=1406&dDocName=en545713
- * Cisco-Linksys home monitoring camera with microphone, \$90 (eBay, refurbished):
 - * http://www.linksysbycisco.com/LATAM/en/products/WVC80N
- * Wireshark:
 - * http://www.wireshark.org/
- * jGRASP
 - * http://www.jgrasp.org