



MICROCHIP

Regional Training Centers

**TCP/IP: Designing a Web-Based
Monitor and Control Device**

COM4201

Objectives

- Describe the communication layers required in TCP/IP embedded designs
- Describe the Application layer components required of Web based embedded designs
- Capture and modify a simple HTML/CSS web page design
- Modify an existing HTML/CSS web page to include dynamic variables
- Integrate status and control requirements within the Microchip TCP/IP stack
- TCP/IP Apps
- WiFi vs Ethernet

Agenda

- **Crash Course in Networking**
 - Lab 1 – Join the Network
- **Introducing our Project**
 - Lab 2 – Web Page Design
- **The Microchip TCP/IP Stack**
- **Planning for Applications**
 - Lab 3 – Integrating the Stack
 - Lab 4 – Removing Blocking Code
- **Implementing Web Applications**
 - **Building with HTTP2**
 - ♦ Lab 5 – Web-Based Status Monitoring
 - ♦ Lab 6 – Web-Based Control
- **Base TCP/IP Programming**



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Crash Course in Networking

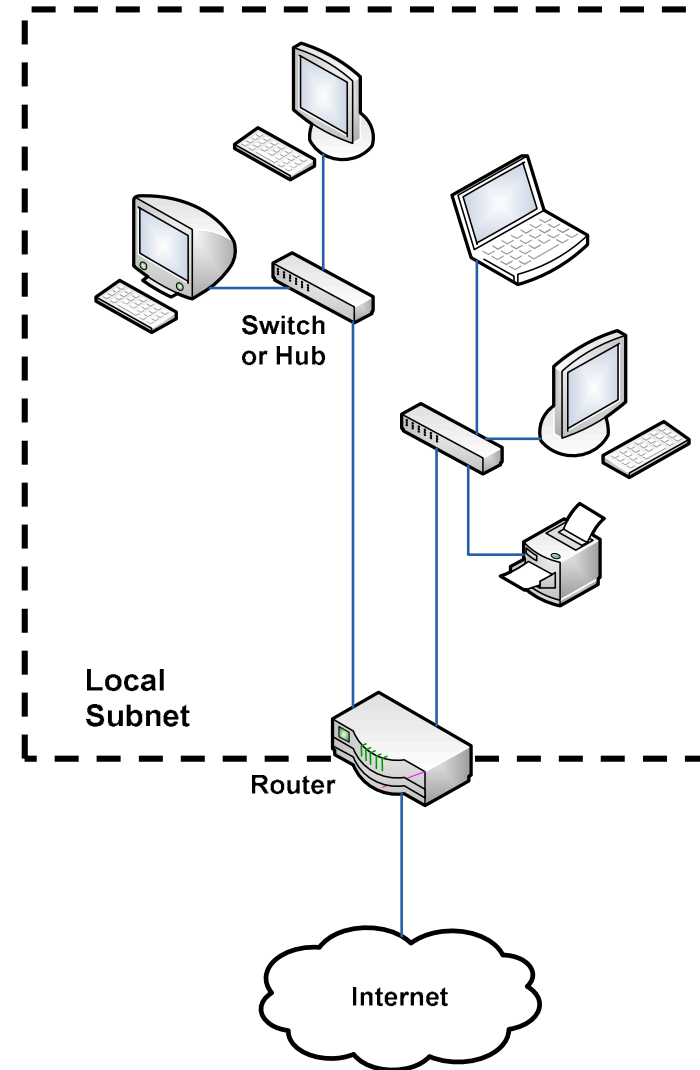
Crash Course in Networking

- **Basic Ethernet Topology**
- **MAC and IP Addresses**
- **Microchip Hardware**
- **Development Tools**

- **Lab 1: Join the Network**

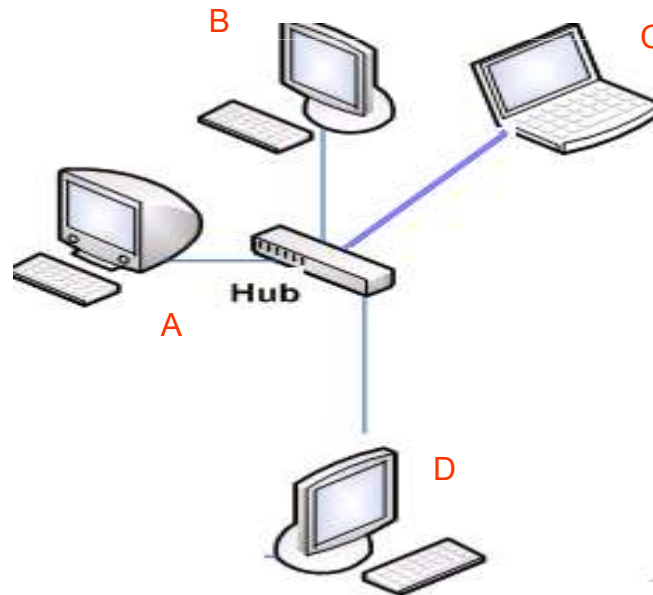
Basic Ethernet Topology

- Hub
- Switch
- Router



Hub Network

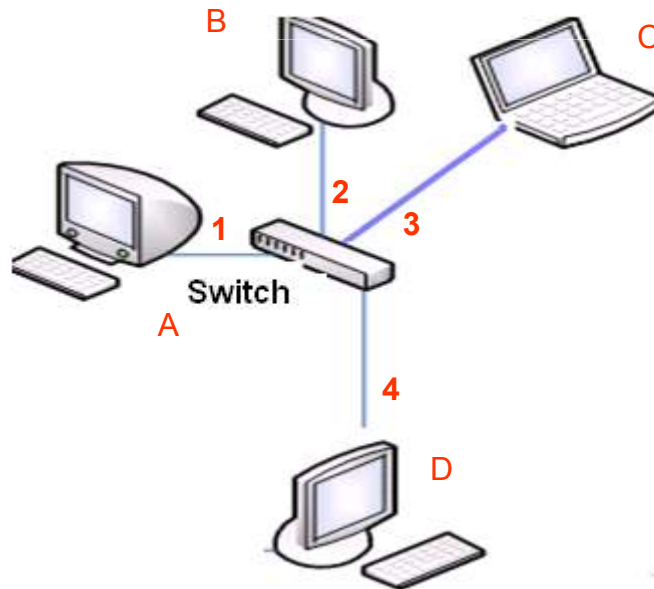
- **Hub**
 - Repeats all traffic
 - Mostly obsolete



Broadcast Network

Switch Network

- **Switch**
 - Directs traffic to specific destination
 - Common “in-room”



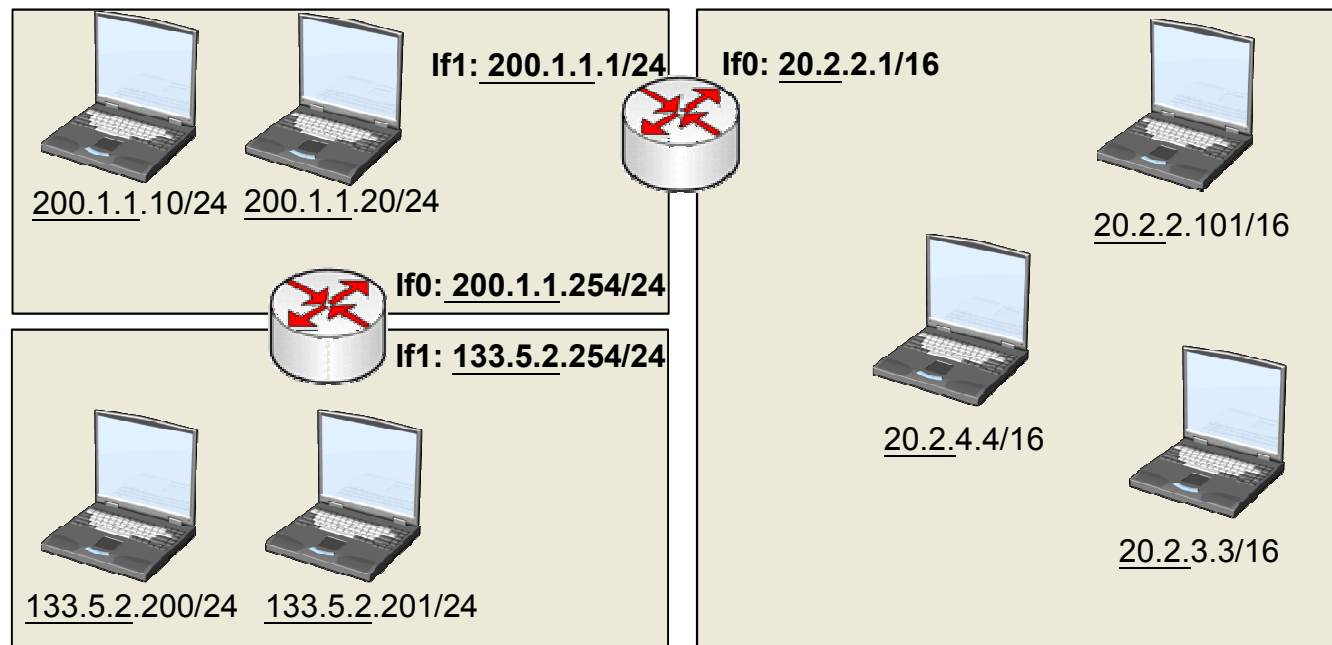
Address Table

Address	Port
AAAA	1
BBBB	2
CCCC	3
DDDD	\$

Broadcast Network

Router Network

- **Router**
 - Routes traffic
 - Acts as gateway
 - Other functionality



Basic Ethernet Topology

- **“Star Topology”**
 - More like a tree
 - Routers (at the root) serve as gateways to rest of the world
- Other configurations exist (obsolete)

Definitions

MAC: Media Access Control (Hardware) Address

IP: Internet Protocol (Software) Address

NAT: Network Address Translation

MAC and IP Addresses

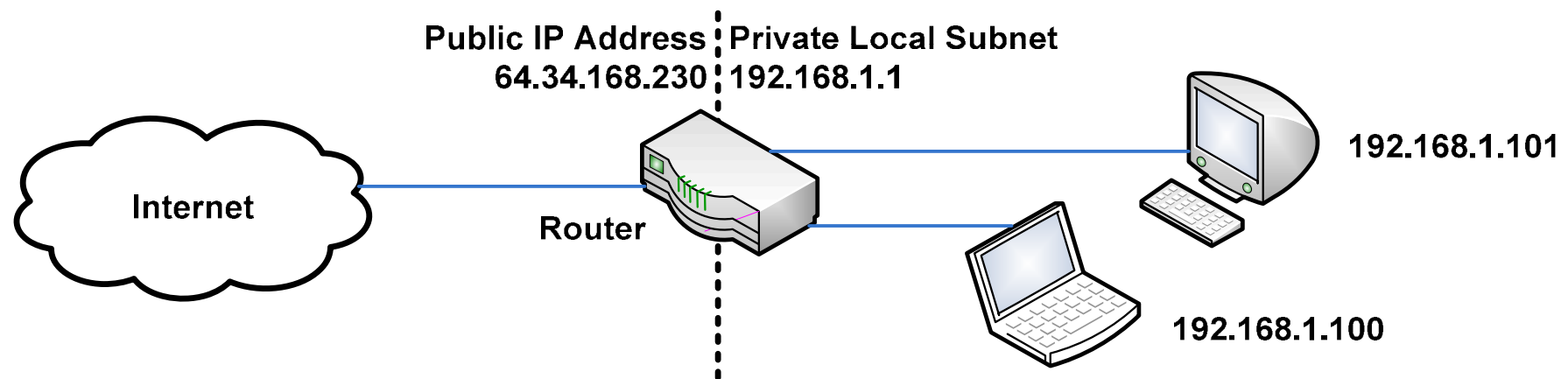
- **MAC Addresses**
 - **Associated with hardware**
 - **Six bytes: 00:04:A3:00:12:34**
 - **Specific to IEEE 802. networks**
 - ◆ **Ethernet, WiFi, etc**
 - ◆ **Only usable within the local network**
 - **Sold in blocks by the IEEE**
 - ◆ **Globally unique**
 - ◆ **US\$550 / 4096 pcs or US\$1650 / 16M pcs**

MAC and IP Addresses

- **Internet Protocol (IP) Addresses**
 - **Assigned by software (DHCP or manual)**
 - **Four bytes as dotted-quad: 192.168.1.100**
 - ◆ **New version (IPv6) will have 128 bits**
 - **Globally routable**
 - **Administered by regional authorities**
 - ◆ **Typically leased by your ISP**
 - **Some allocated for private networks**
 - ◆ **192.168.*, 10.*, 169.254.*, and 172.16.***
 - ◆ **Behind firewall and/or router**

Network Address Translation

- 32-bit address space insufficient
- NAT Provides one-to-many routing
 - Share one global IP among many machines
 - Router/gateway makes all outgoing connections
 - Can port-forward incoming connections
 - Also provides security



MAC and IP Addresses

- **Finding Nodes:**
 - **Start with host name**
 - ◆ www.microchip.com
 - ◆ Local name, e.g. MCHPBOARD
 - **Resolve host name to IP address**
 - ◆ DNS for global addresses
 - ◆ NBNS for local addresses
 - **Resolve IP address to MAC**
 - ◆ Use Address Resolution Protocol (ARP)
 - ◆ Router or gateway may respond



What is Ethernet Packet

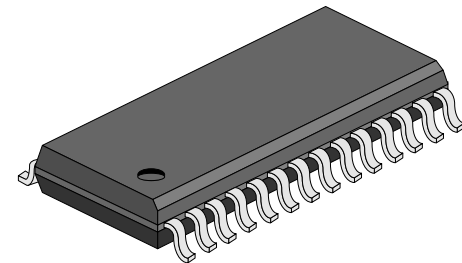
```

[-] Frame 124: 54 bytes on wire (432 bits), 54 bytes captured (432 bits)
    Arrival Time: Jun 17, 2010 21:33:21.655264000 [X][X]-[X][X][X][X]
    Epoch Time: 1276781601.655264000 seconds
    [Time delta from previous captured frame: 0.000080000 seconds]
    [Time delta from previous displayed frame: 0.000080000 seconds]
    [Time since reference or first frame: 9.757984000 seconds]
    Frame Number: 124
    Frame Length: 54 bytes (432 bits)
    Capture Length: 54 bytes (432 bits)
    [Frame is marked: False]
    [Frame is ignored: False]
    [Protocols in frame: eth:ip:tcp]
    [Coloring Rule Name: HTTP]
    [Coloring Rule String: http || tcp.port == 80]
[-] Ethernet II, Src: HonHaiPr_94:3b:df (00:1c:25:94:3b:df), Dst: Microchi_00:00:00 (00:04:a3:00:00:00)
    + Destination: Microchi_00:00:00 (00:04:a3:00:00:00)
    + Source: HonHaiPr_94:3b:df (00:1c:25:94:3b:df)
      Type: IP (0x0800)
[-] Internet Protocol, Src: 192.168.2.3 (192.168.2.3), Dst: 192.168.2.2 (192.168.2.2)
    Version: 4
    Header length: 20 bytes
    + Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00)
      Total Length: 40
      Identification: 0x36e4 (14052)
      Fragment offset: 0
      Time to live: 128
      Protocol: TCP (6)
    + Header checksum: 0x3e96 [correct]
      Source: 192.168.2.3 (192.168.2.3)
      Destination: 192.168.2.2 (192.168.2.2)
[-] Transmission Control Protocol, Src Port: tcim-control (2729), Dst Port: http (80), Seq: 448, Ack: 1508, Len: 0
    Source port: tcim-control (2729)
    Destination port: http (80)
    [Stream index: 6]

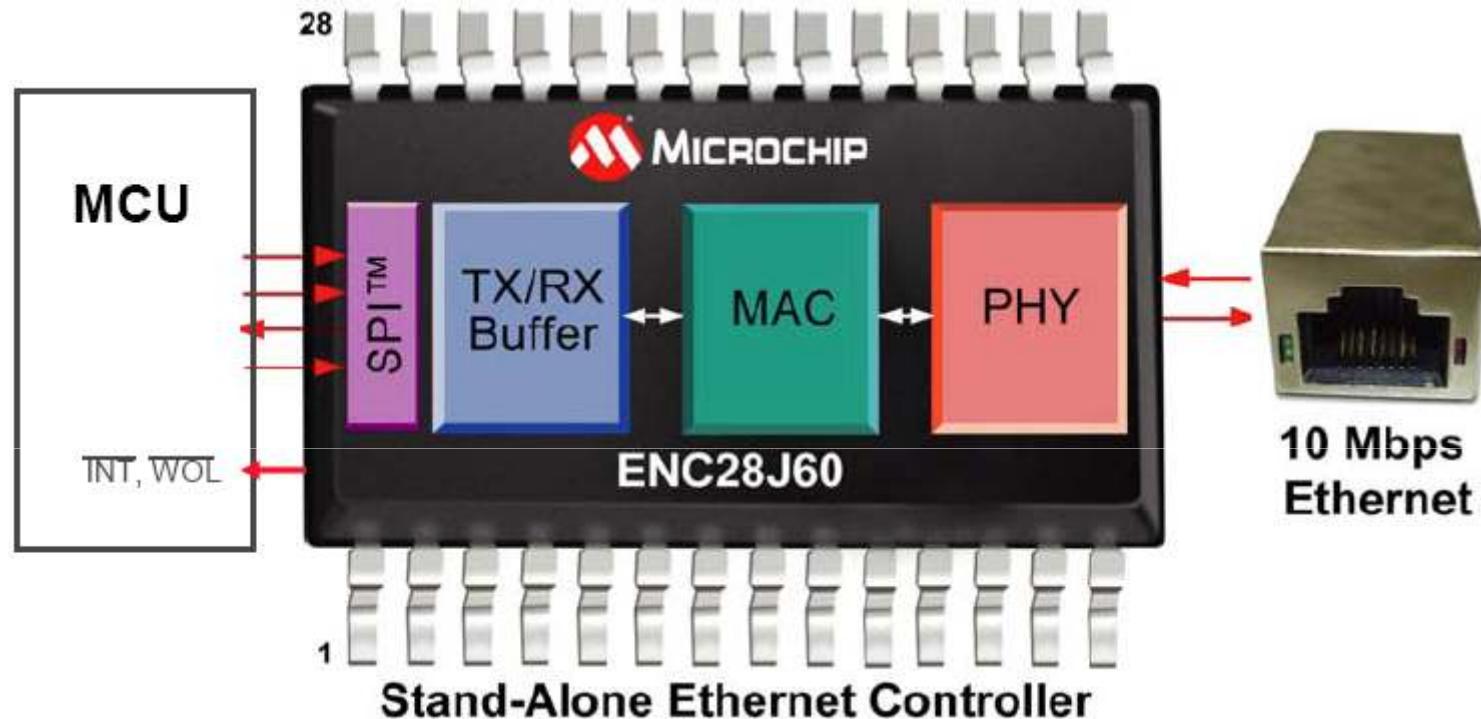
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Microchip Ethernet Hardware

- **ENC28J60 – In Production**
 - **Stand-alone 10Mbps Ethernet Controller**
 - **Integrated MAC + PHY + 8kB SRAM**
 - **3.3V, 20MHz SPI interface**
 - **28-pin SOIC, SSOP, QFN, SPDIP**



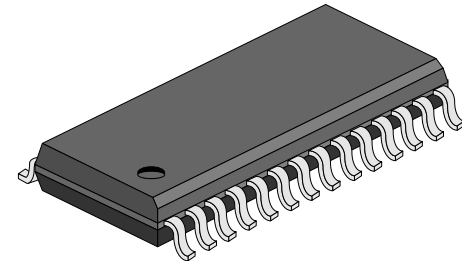
ENC28J60: World's Smallest Ethernet Controller!



Costt Efffeccttiive,, Easy tto Use iin 28--Piins

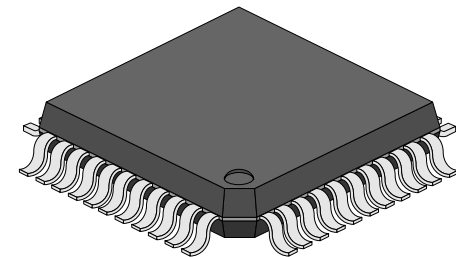
Microchip Ethernet Hardware

- **ENC624J600 – In Production**
 - **Stand-alone 10/100Mbps Controller**
 - **Integrated MAC + PHY + 24kB SRAM**
 - **3.3V, 20MHz SPI or 8/16 parallel interface**
 - **44-pin TQFP and QFN, 64-pin TQFP**
 - **Pre-programmed MAC Address**
 - **Hardware encryption acceleration for SSL**
 - ◆ **RSA, AES, MD5, SHA-1**



Microchip Ethernet Hardware

- **PIC18F97J60 Family – In Production**
 - **PIC18 with integrated 10Mbps MAC + PHY**
 - **3.3V, 64-128K Flash, 3.8kB + 8kB RAM**
 - **64, 80, or 100 pin TQFP**
 - **Extra 8kB is memory mapped**



Microchip WiFi Hardware

- **Complete focus on embedded markets**
 - Single chip, highly integrated design
 - Lowest total system BOM for Wi-Fi
 - Low power design
- **ZeroG architecture enables maximum flexibility**
 - Works with PIC18, PIC24, dsPIC, and PIC32
 - Very small system footprint
 - NO additional system resources required
- **Highly portable design results in fast time to market**
 - Easy to design in to existing or new products... a Wi-Fi I
 - Example solutions already in place in Microchip project
- **Compatible with standard b/g access points, Wi-Fi Certified**
- **Compatible with Microchip ENJ Ethernet solutions**
 - Simple to leverage designs using Ethernet or to incorporate dual mode support



Development Tools

- **PICDEM.net™ 2**

- PIC18F97J60
- ENC28J60



DM163024

- **Ethernet PICtail™**

- PICDEM HPC 2 Explorer



AC164121



- **Ethernet PICtail Plus**

- **Explorer 16**
 - PIC24, dsPIC, PIC32



AC164123



Adding WiFi to Microchip

- Start w/Microchip TCPIP Stack v5.25
- Comes with TCPIP WiFi Demo App
- Provides an out-of-box demo to help customer get started
- Add/Change Options for the application



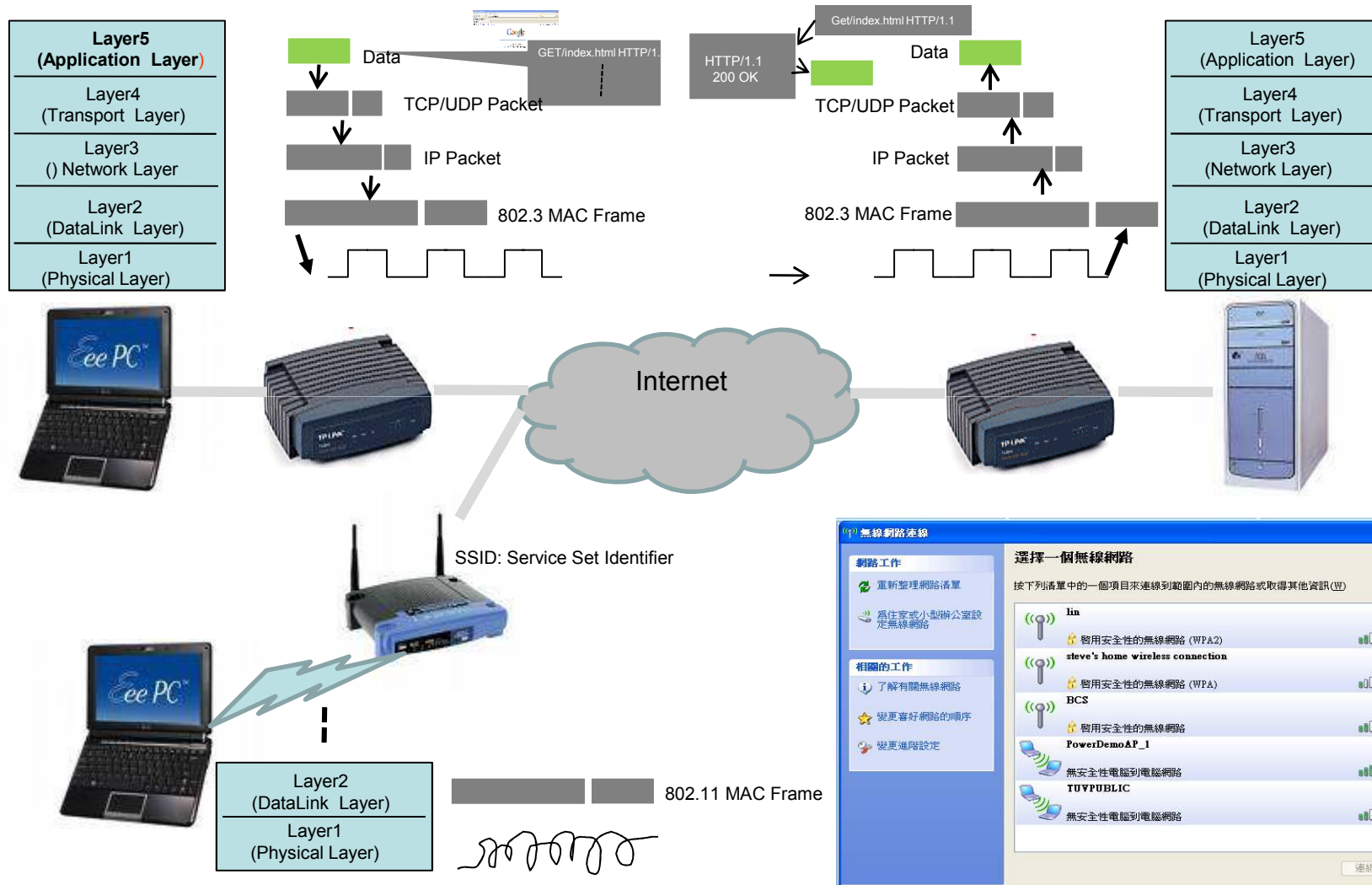
Silicon Solutions

Feature	ENC28J60	ENCX24J600	PIC18F97J60	MRF24WB0M	PIC32MX7XX/6XX
Technology	Wired Ethernet	Wired Ethernet	Wired Ethernet	802.11 Wireless	Wired Ethernet
MAC	Yes	Yes	Yes	Yes	Yes
PHY	Yes (10-Base-T)	Yes (10/100-Base-T)	Yes (10-Base-T)	Yes	No
RAM Buffer (bytes)	8,192	24,576	3,808	14,170	Internal RAM (128k)
Interface	SPI	SPI, 8 or 16 bit multiplexed or demultiplexed parallel interface	None (built-in Ethernet MAC/PHY)	SPI	None (built-in Ethernet MAC)
Pins	28	44, 64	64/80/100	36	64/100
Package	SOIC, SPDIP, SSOP, QFN (6x6 mm)	TQFP, QFN	TQFP	Surface Mount WiFi I/O module	TQFP, QFN (9x9 mm)
Cryptographic Engines	No	Yes	No	No	No
Pre-programmed MAC address	No	Yes	No	Yes	Yes

Stack Performance

Microcontroller	MIPS	Network Controller	Interface	LAN Transmit Throughput (Kbytes/sec)				Internet Transmit Throughput at 100ms ping (estimated Kbytes/sec) ⁽¹⁾				Compiler	Optimization
				TCP with 200 byte TX FIFO	TCP with 2000 byte TX FIFO	TCP with 8000 byte TX FIFO	UDP	TCP with 200 byte TX FIFO	TCP with 2000 byte TX FIFO	TCP with 8000 byte TX FIFO	UDP		
PIC18F97J60	10.4	Internal 10BaseT	-	33	72	N/A	114	2	20	N/A	114	C18	Debug
PIC18F8722	10	ENC28J60	SPI, 10 MHz	20	44	N/A	64	2	20	N/A	64	C18	Debug
PIC24FJ128GA010	16	ENC28J60	SPI, 8 MHz	49	119	N/A	195	2	20	N/A	195	C30	s (min size)
dsPIC33FJ256GP710 ⁽²⁾	40	ENC28J60	SPI, 8 MHz	68	176	N/A	249	2	20	N/A	249	C30	s (min size)
PIC32MX360F512L	80	ENC28J60	SPI, 20 MHz	109	287	N/A	428	2	20	N/A	428	C32	s (min size)
PIC32MX795F512L	80	ENC28J60	SPI, 20 MHz	120	300	N/A	435	2	20	N/A	435	C32	s (min size)
PIC18F8722	10	ENC624J600 ⁽³⁾	SPI, 10 MHz	28	75	80	115	2	20	80	115	C18	Debug
PIC24FJ128GA010	16	ENC624J600 ⁽³⁾	SPI, 8 MHz	56	161	175	368	2	20	80	368	C30	s (min size)
dsPIC33FJ256GP710 ⁽²⁾	40	ENC624J600 ⁽³⁾	SPI, 8 MHz	91	276	310	559	2	20	80	559	C30	s (min size)
PIC32MX360F512L	80	ENC624J600 ⁽³⁾	SPI, 13.33 MHz	139	356	412	687	2	20	80	687	C32	s (min size)
PIC32MX795F512L	80	ENC624J600 ⁽³⁾	SPI, 13.33 MHz	152	396	457	801	2	20	80	801	C32	s (min size)
PIC24FJ128GA010	16	ENC624J600 ⁽³⁾	PSP Mode 5, PMP	101	300	339	1043	2	20	80	1043	C30	s (min size)
dsPIC33FJ256GP710 ⁽²⁾	40	ENC624J600 ⁽³⁾	PSP Mode 5, Bitbang	196	659	813	2063	2	20	80	2063	C30	s (min size)
PIC32MX360F512L	80	ENC624J600 ⁽³⁾	PSP Mode 5, PMP	203	786	996	2115	2	20	80	2115	C32	s (min size)
PIC32MX795F512L ⁽³⁾	80	Internal 100BaseTX	-	434	1555	2562	8723	2	20	80	8723	C32	s (min size)
PIC18F97J60	10.4	MRF24WB0M	SPI, 10.4 MHz	5	24	30	45	2	20	30	45	C18	Debug
PIC24FJ128GA010	16	MRF24WB0M	SPI, 8 MHz	8	45	67	45	2	20	67	45	C30	s (min size)
dsPIC33FJ256GP710 ⁽²⁾	40	MRF24WB0M	SPI, 8 MHz	9	66	97	45	2	20	80	45	C30	s (min size)
PIC32MX360F512L	80	MRF24WB0M	SPI, 20 MHz	9	66	100	47	2	20	80	47	C32	s (min size)
PIC32MX795F512L	80	MRF24WB0M	SPI, 20 MHz	9	67	102	48	2	20	80	48	C32	s (min size)

Basic Networking



Lab 1: Join the Network

- **Goals:**
 - **Configure your development board**
 - ◆ MAC Address
 - ◆ Local host name
 - **Compile and load TCP/IP Stack**
 - **Upload demo web pages**
 - **Test connectivity**



Review:

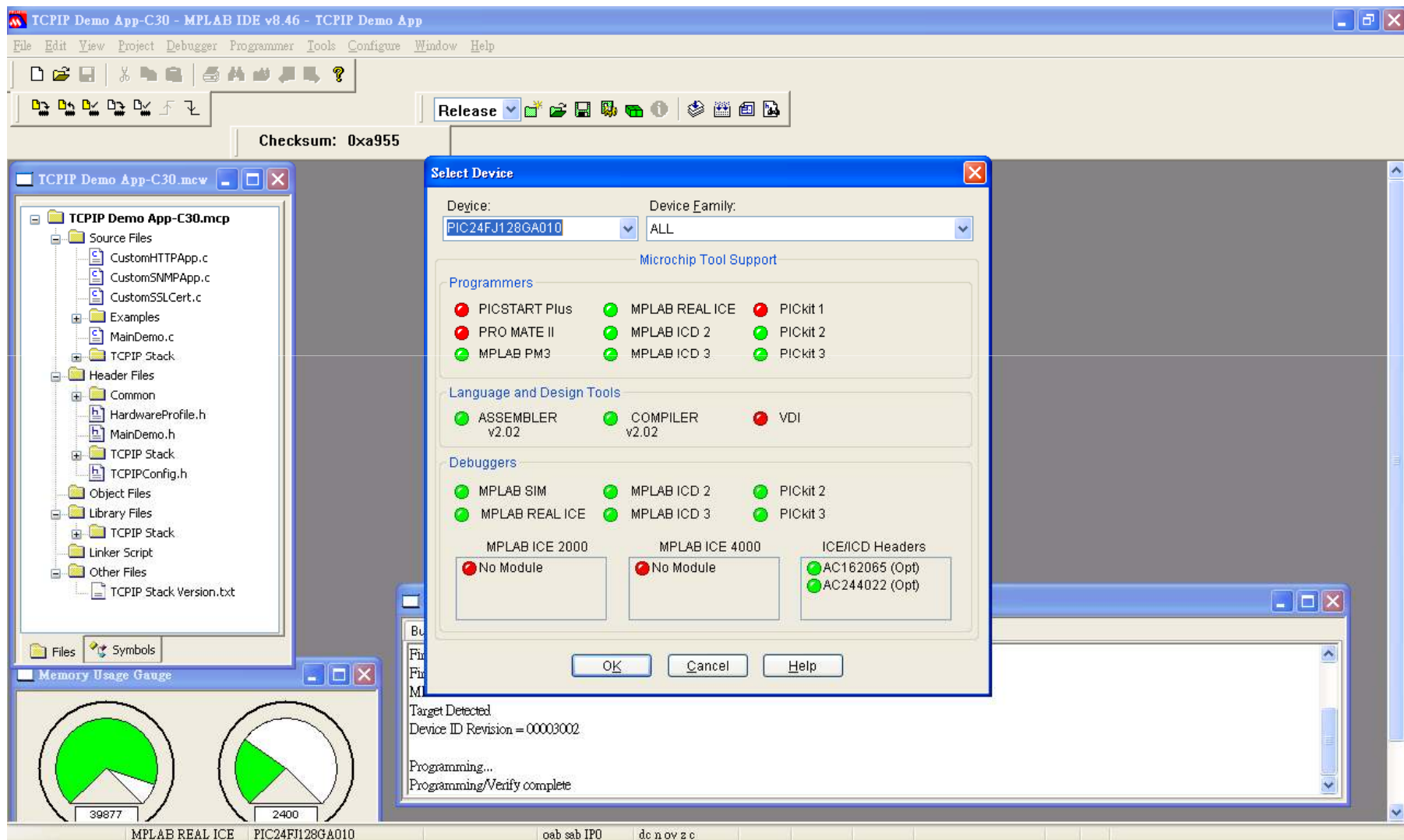
Crash Course in Networking

- **Basic Ethernet Topology**
 - Hubs, Routers, Switches
- **IP and MAC Addresses**
- **Microchip Hardware**
 - Stand-alone and integrated parts
- **Development Tools**
 - PICDEM.net™ 2
 - Ethernet PICtail™ Plus

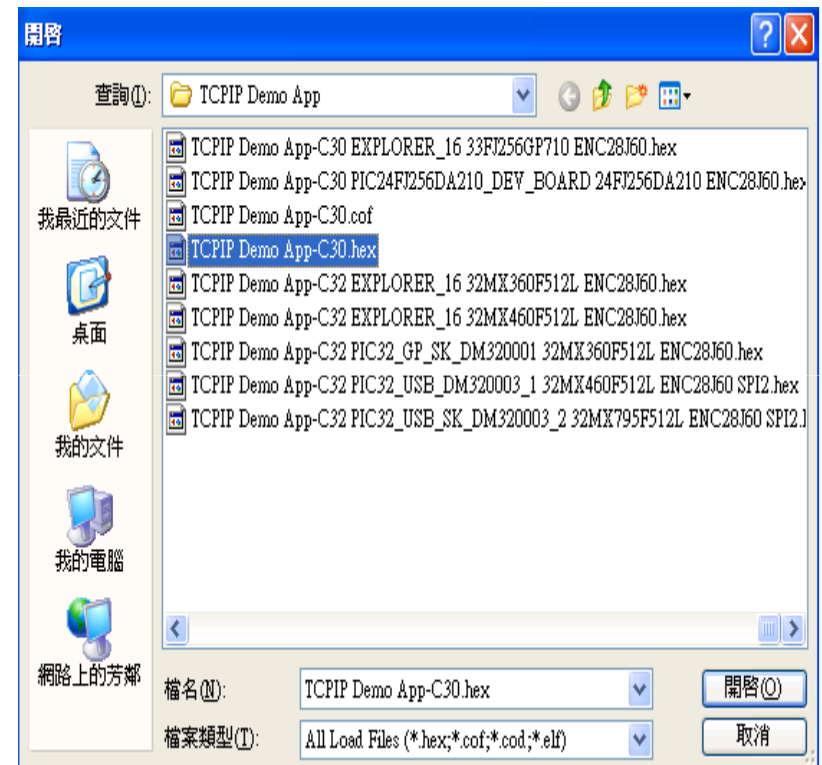
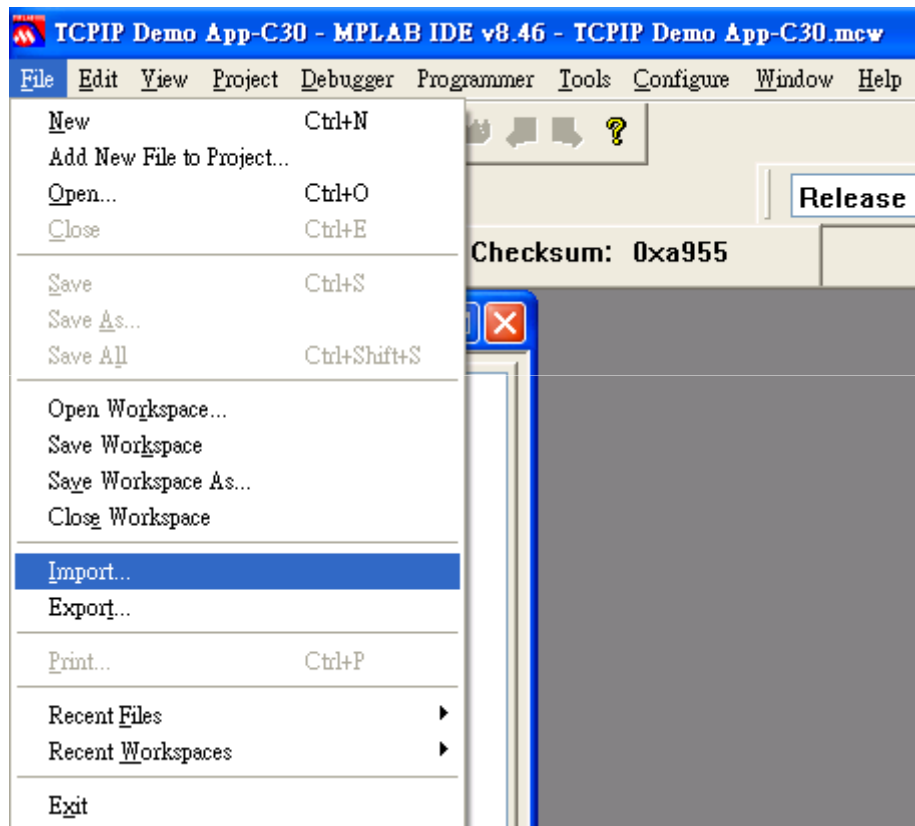


Experiment Environment

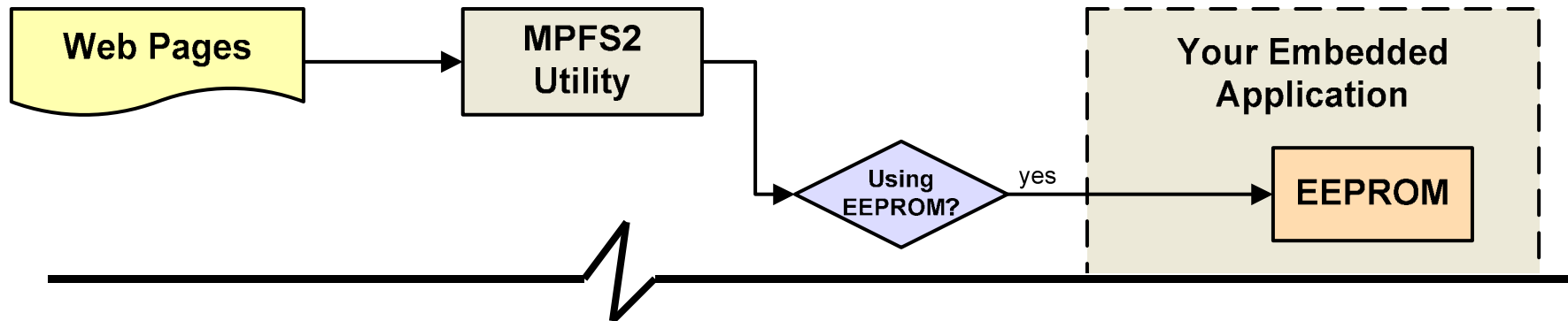
Open MPLab IDE



Open MPLab IDE



Packaging Web Pages



- **MPFS2 Utility**
 - File system for embedded devices
 - Creates file system image
 - Uploads image to running application
 - ◆ Application programs to EEPROM

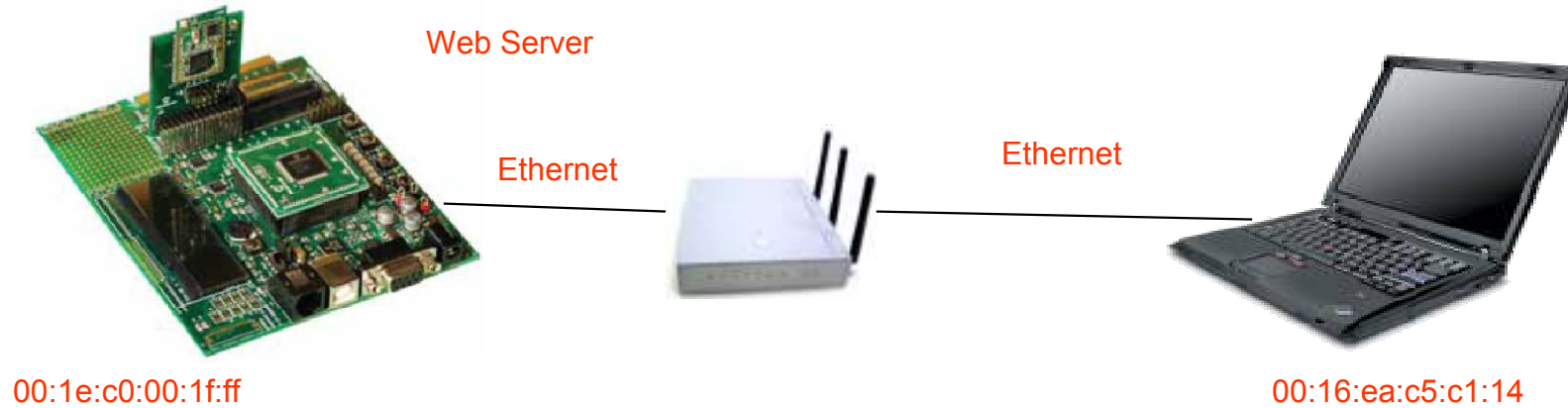
Clearing the EEPROM

- 1. Make sure the development board is programmed and not in debug mode**
- 2. Disconnect the MPLAB® ICD 2/3 or MPLAB REAL ICE™ from the board**
- 3. Press and hold BUTTON0 (RD13/S4 on Explorer 16 or RB3/S5 on PICDEM.net™ 2)**
- 4. Press and release the MCLR button**
- 5. Continue holding BUTTON0 until several LEDs flash indicating that EEPROM has been cleared. This takes about 4 seconds.**
- 6. Release BUTTON0**
- 7. Press and release MCLR again to reset the software**

Once you see LED0 (right-most LED) blinking, the software is running and ready for use.

Ethernet Experiment

Test Environment



The DHCP lease process



Explorer 16+PicTail
(00:BA:BE:22:00:00)



Wireless AP(00:13:F7:E9:01:44)

5. DHCP Server send ARP Packet (who use 192.168.2.100)

Packet	Source Physical	Dest. Physical	Size Bar	Absolute Time	Protocol	Summary
97	00:13:F7:E9:01:44	FF:FF:FF:FF:FF:FF	802.11 Beacon	22:39:02.015901	802.11 Beacon	FC=.....,SN=3205,FN= 0,BI=0,BI=
98	00:13:F7:E9:01:42	FF:FF:FF:FF:FF:FF	IP BOOTP	22:39:02.073055	DHCP	R ACK

Packet: 98

Packet Info

Packet Number=98 Flags=0x00000000 Status=0x00000000 Packet Length=368 Timestamp=22:39:02.073055000 02/26/2009 Data Rate=2 1 .0 Mbps Chan=1 2412

802.11 MAC Header

Version=0 Type=10 Data Subtype=0000 Data Only Duration=0 Microseconds Destination=Ethernet Broadcast BSSID=00:13:F7:E9:01:44 Source=00:13:F7:E9:01:42

802.2:

D=0xAA SNAP S=0xAA SNAP C=0x03 Unnumbered Information

IP:

S=192.168.2.1 D=IP Broadcast

UDP:

Src=bootps Dst=bootpc

BOOTP:

Operation=2 Boot Reply Hardware Address Type=1 Hardware Address Length=6bytes Hops=0 Transaction ID=2917012003 Seconds Since Boot Start=0 BootP 1=0 Boot

DHCP - Dynamic Host Configuration Protocol

DHCP Magic Cookie:

0x63825363

Message Type Option Code=53 Message Type Option Length=1 Message Type=5 ACK

Server Identifier Option Code=54 Server Identifier Option Length=4 Address=192.168.2.1

IP Address Lease Time Option Code=51 IP Address Lease Time Option Length=4 Value=86400

Subnet Mask Option Code=1 Subnet Mask Option Length=4 Address=255.255.255.0

Routers Option Code=3 Routers Option Length=4 Address=192.168.2.1

Domain Name Servers Option Code=6 Domain Name Servers Option Length=4 Address=192.168.2.1

DHCP Option End Option Code=255

Data Area:

(26 bytes)

Extra bytes (Padding):

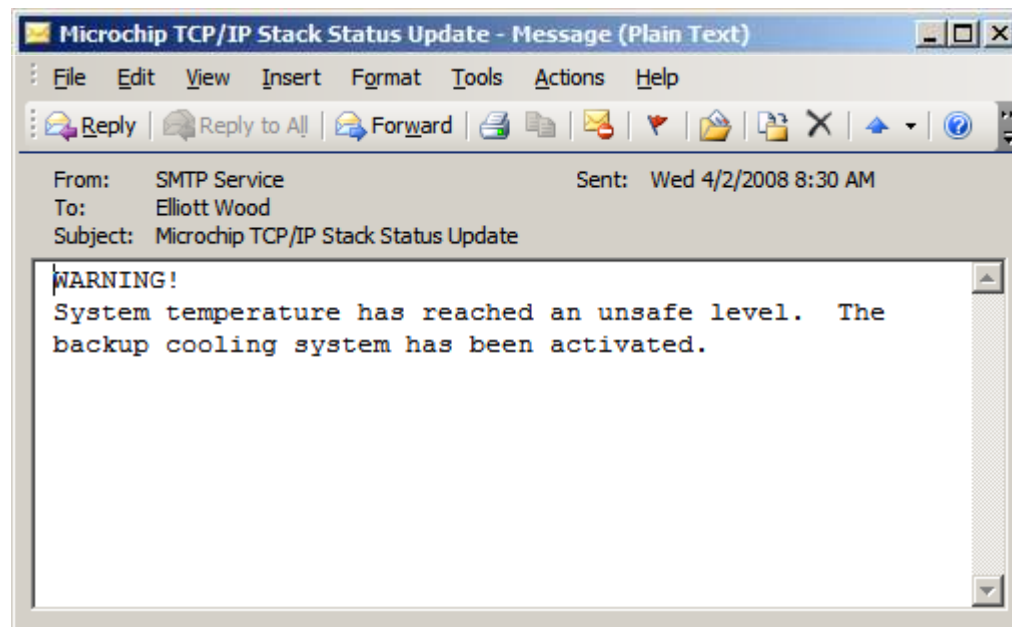
(4 bytes)

FCS:

FCS=0x1CDF4421 Calculated

Send e-mail Demo

- Send e-mail alerts
 - Attachments work too
- SMS gateways to cell phones





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Thank You

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