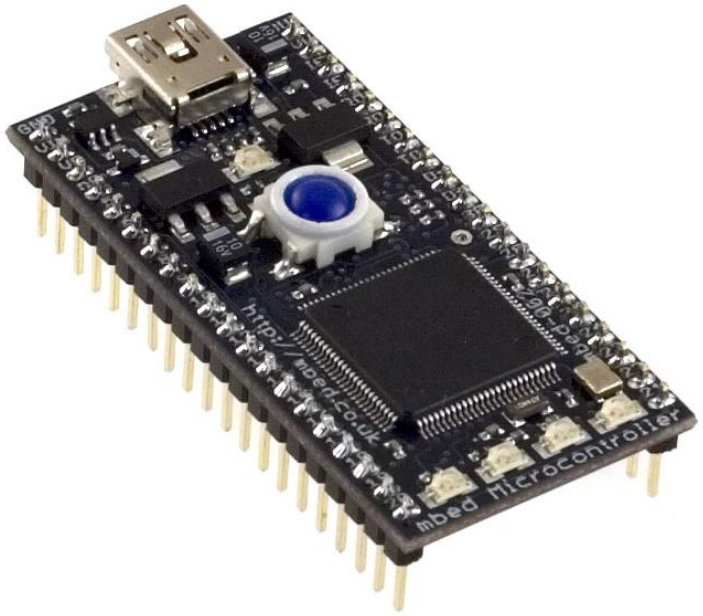
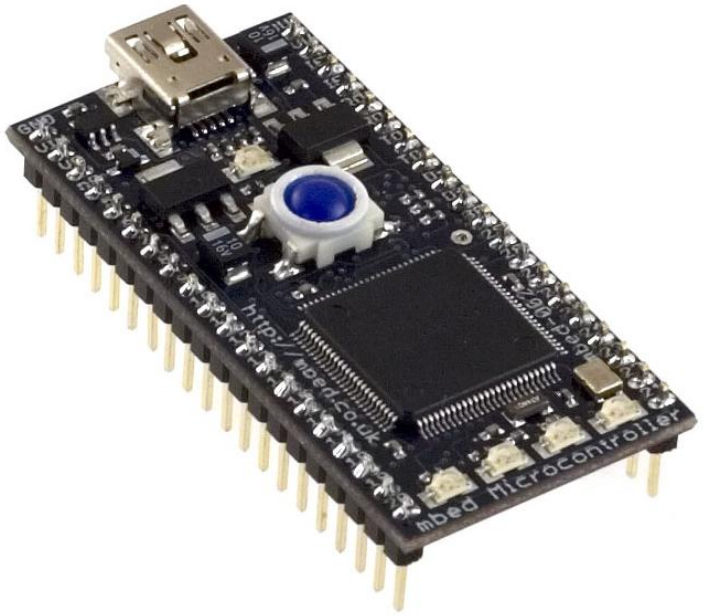


mbed + Sprint
Hello World!

Agenda

- mbed
  - Introduction to mbed
  - Lab 1: mbed registration and Hello World demo
  - Lab 2: Other IO
  - Lab 3: Interfacing with sensors
  - Lab 4: Output devices, a TextLCD
  - Lab 5: SMS Alerts
  - Lab 6 : Mobile data with websockets

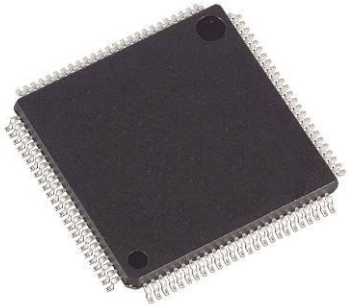


mbed + Sprint Hello World!

Introduction to mbed

What's happening in Microcontrollers?

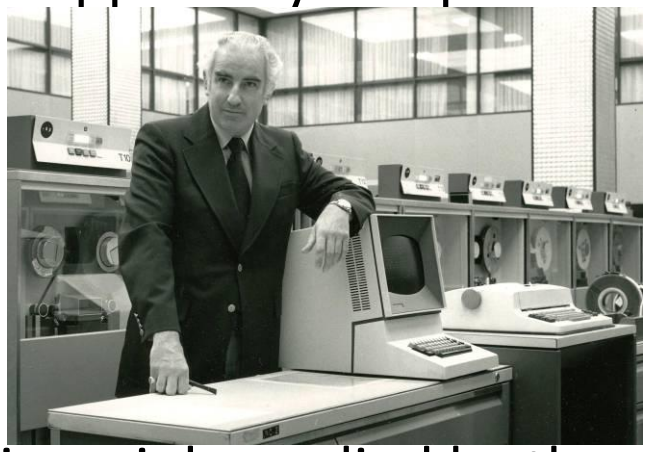
- Microcontrollers are getting cheap
  - 32-bit ARM Cortex-M3 Microcontrollers @ $1
  - 32-bit ARM Cortex-M0+ Microcontrollers @ $0.50
- Microcontrollers are getting powerful
  - Lots of processing, memory, I/O in one package
- Microcontrollers are getting interactive
  - Internet connectivity, new sensors and actuators



- Creates new opportunities for microcontrollers

Opportunities for Microcontrollers

- Before 1980 computers were used and applied by computer scientists
- now they are:
  - Applied across all industries
  - Widely used in the home
  - Used by almost anybody



- Currently microcontroller technology is mainly applied by the embedded professional
- Microcontrollers interact with “the real world”
  - Sensors, actuators and communication, define their application
  - Their potential is greater than the home computer

Barriers for Microcontrollers

- What prevents microcontrollers from being designed in?
- Conceptually simple things can be hard to prototype
  - I want to send an SMS when my cat comes through the cat flap
- Repetition of choices to make:
  - Microcontroller
  - Tool chain
  - Dev board
  - Sensors
  - It's not difficult, but can be tedious and time consuming
- Overhead for starting a new project
  - Fine for a long complex projects
  - A deterrent for quick experiments and tests

Rapid Prototyping

- Rapid Prototyping helps industries create new products
  - Control, communication and interaction increasingly define products
  - Development cycles for microelectronics have not kept pace

3D Moulding

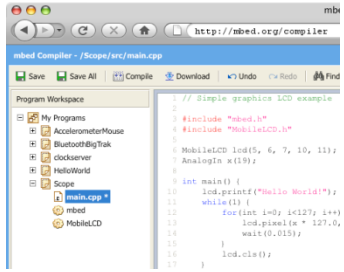
3D Printing

2D/3D Design

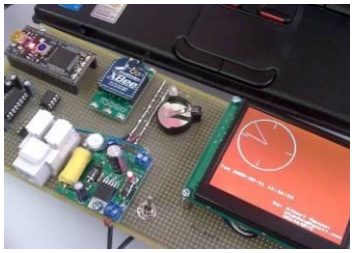
Web Frameworks

mbed.org - Rapid Prototyping for MCUs

- Fastest way to get started with ARM microcontrollers
  - Plug ‘n’ Play Hardware, Online Compiler
  - Get setup and run “Hello World!” in 60 seconds
  - Removes entry barriers to MCU technology



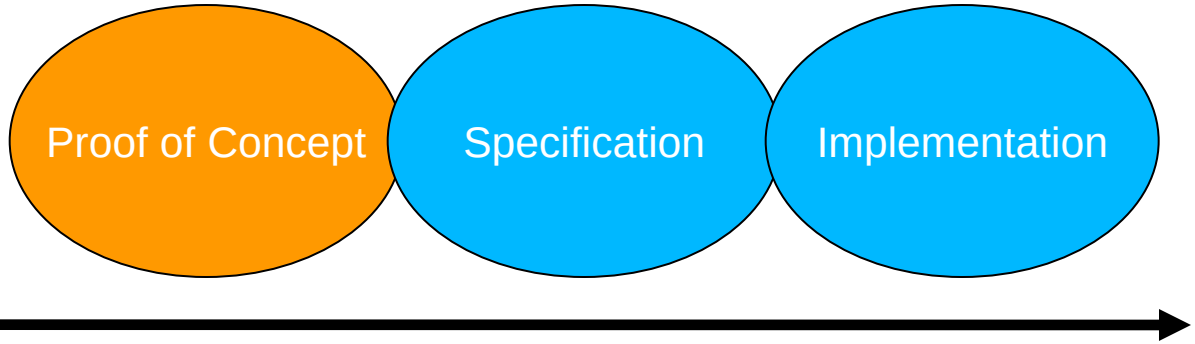
- Focused on rapid prototyping for a diverse audience
  - DIP form-factor, High-level APIs, Developer website
  - Technology and tradeoffs to enable fast experiments
  - Creates new applications for MCU technology



- Launched at ESC Boston with live demo
  - Internet-enabled “Twittering Billy” read out tweets
  - An embedded internet device, prototyped in ½ day
  - Over ¼ million video views in first week!

mbed Approach

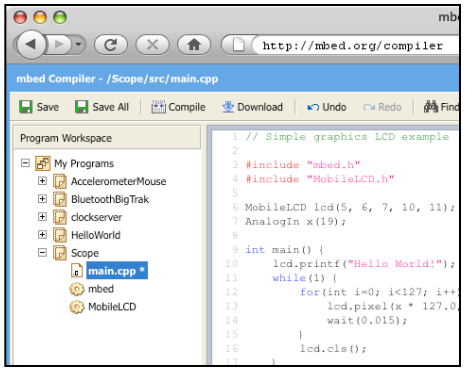
- Focus on tools supporting the earliest stage of design
  - Point of entry and Getting Started
  - Experimentation and Rapid Prototyping



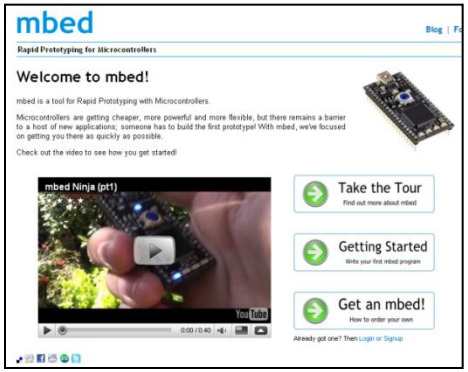
- Apply technology and trade-offs that support this goal
- What mbed is not trying to do:
  - Replace existing professional tools
  - Replace development or evaluation boards

mbed Rapid Prototyping Platform

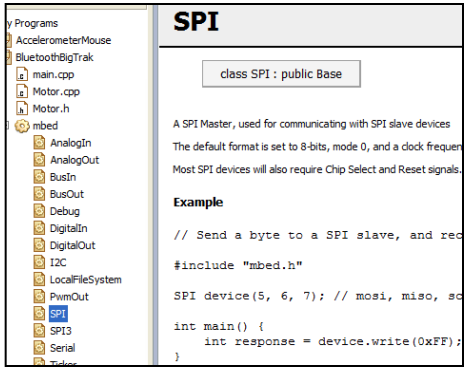
- Complete Hardware, Software and Web 2.0 Solution



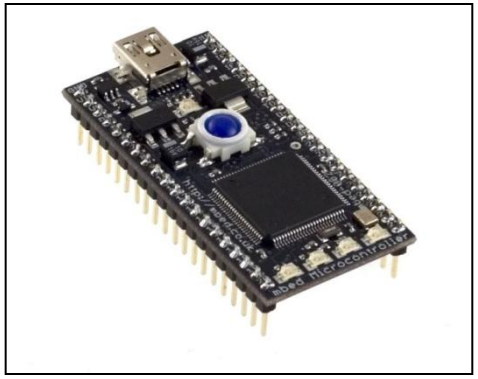
Dedicated Developer Website



Lightweight Online Compiler



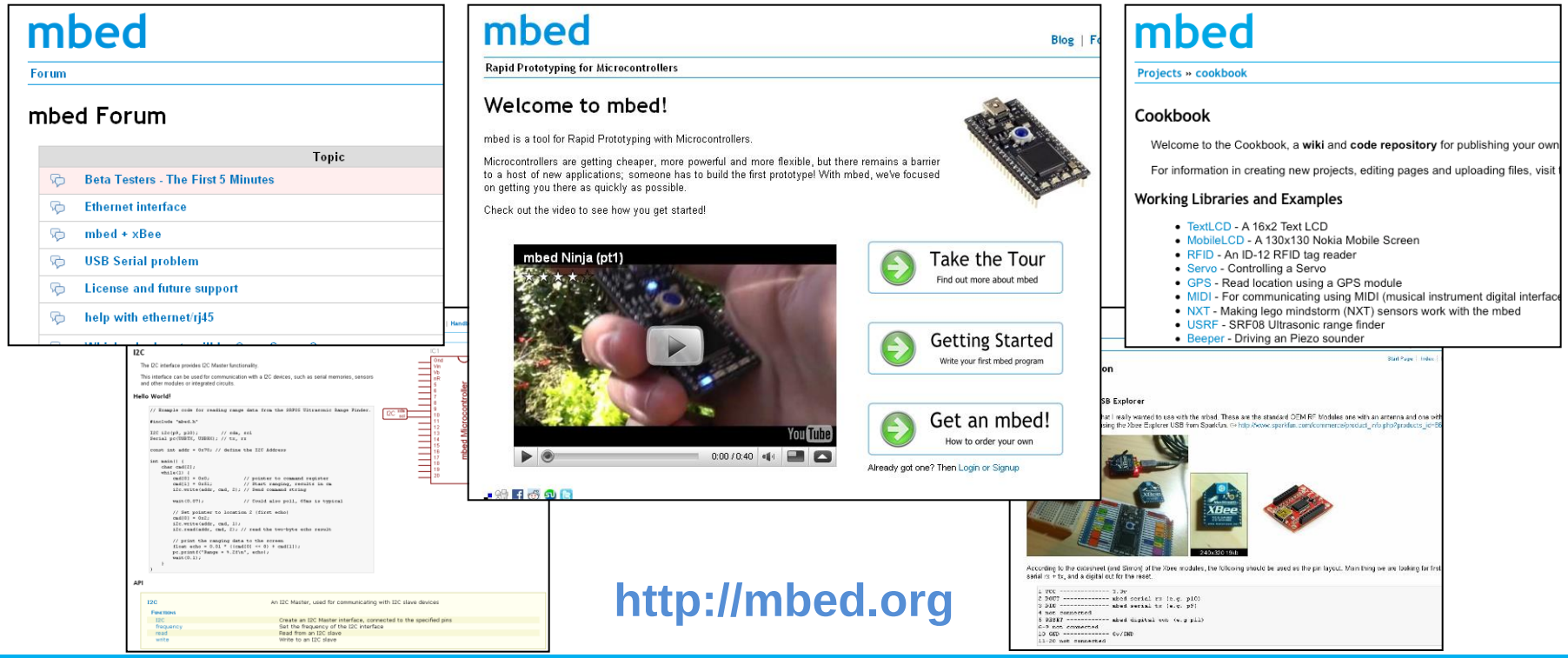
High-level Peripheral APIs



Prototyping Form-Factor

mbed Website

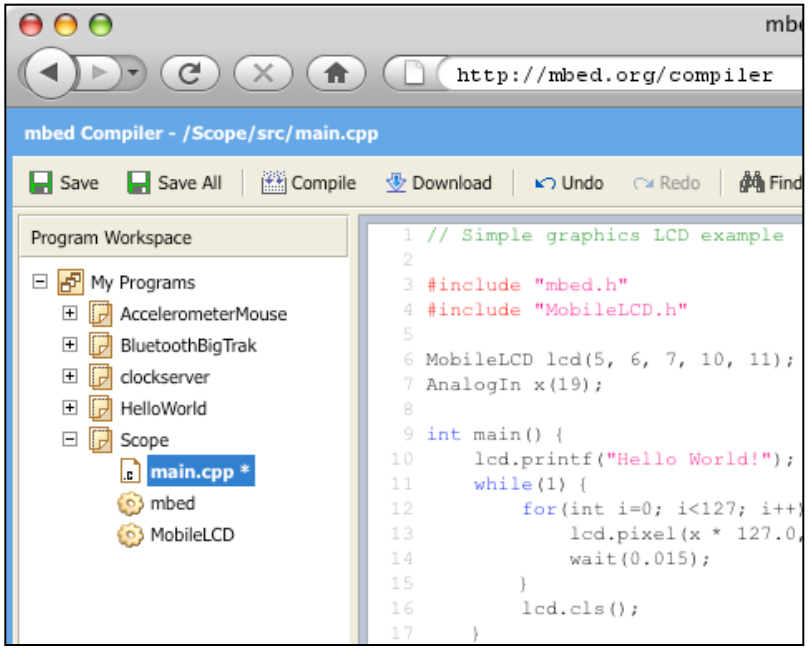
- Dedicated Developer Web Platform
  - Custom Web 2.0 tools and environment focused on developers
  - Simple route to get started, comprehensive resources and support



http://mbed.org

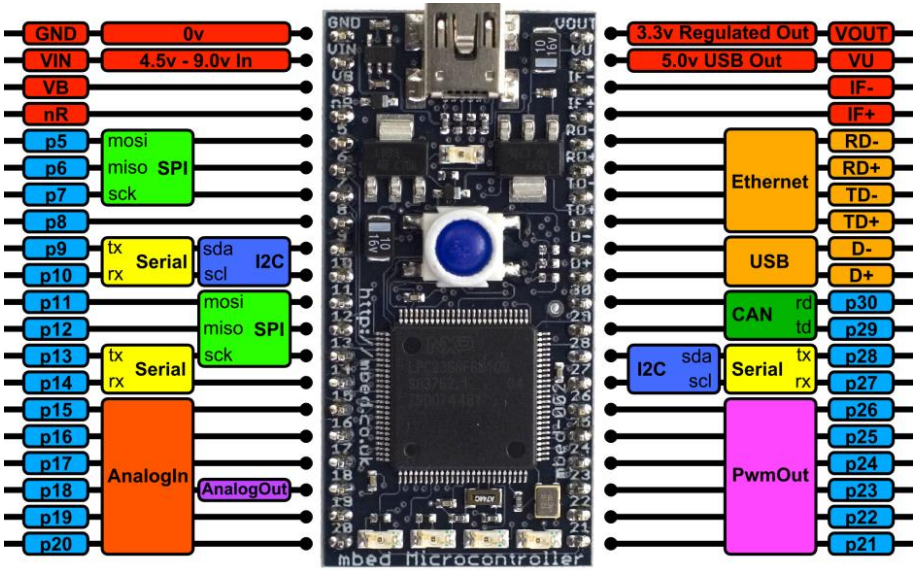
mbed Compiler

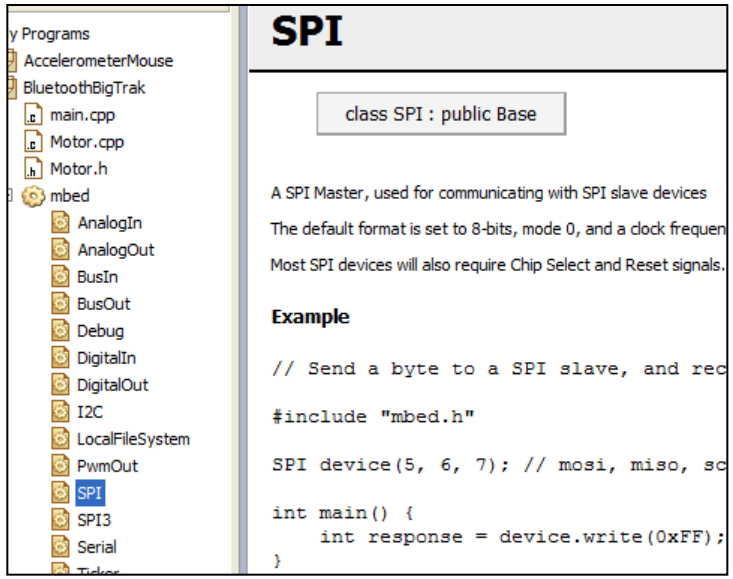
- Lightweight Online Compiler
  - Web 2.0 browser-based IDE with personal workspace “in the cloud”
  - Nothing to install or configure, login from anywhere
  - Industry leading RVCT 4.1 back end. It is a real tool!



mbed Library

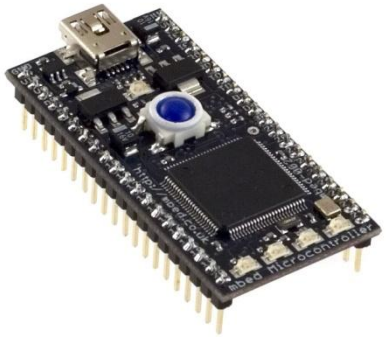
- High-level Peripheral APIs
  - Trading memory and CPU performance for ease of use
  - Abstract software interfaces for controlling microcontroller hardware
  - Intuitive peripheral access, encapsulation of implementation details
  - Treat hardware and software the same

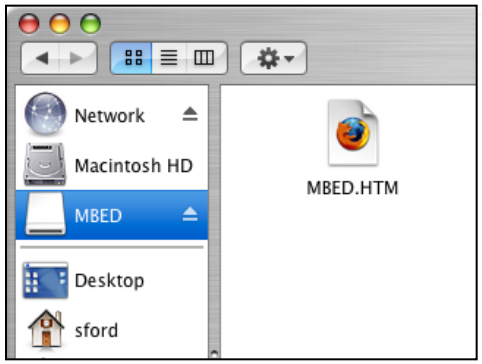


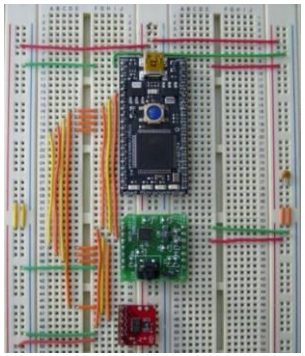


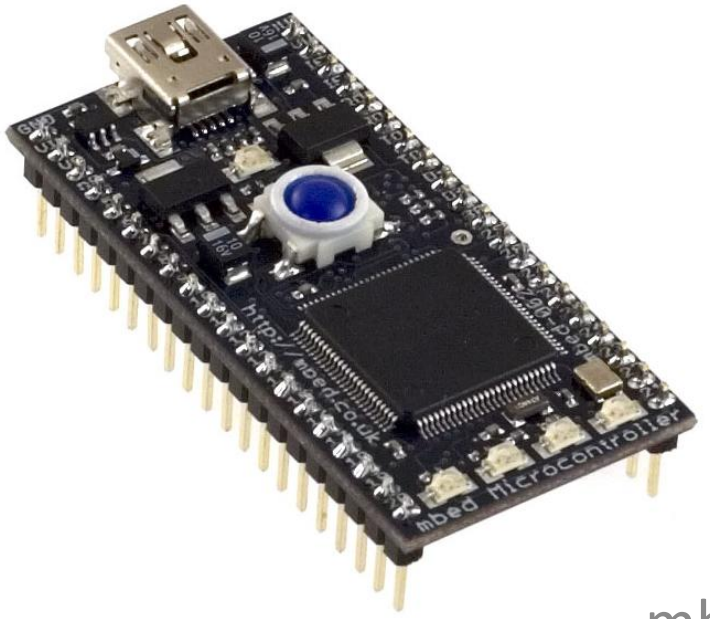
mbed Microcontroller

- Cortex-M3 MCU in a Prototyping Form-Factor
  - 0.1” pitch DIP with “USB Disk” interface and support components
  - Nothing to install or configure, practical for breadboard and PCBs









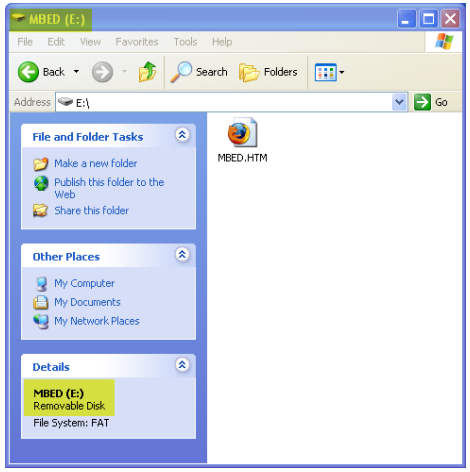
mbed + Sprint Hello World

Lab 1

mbed registration and hello world!

Registration

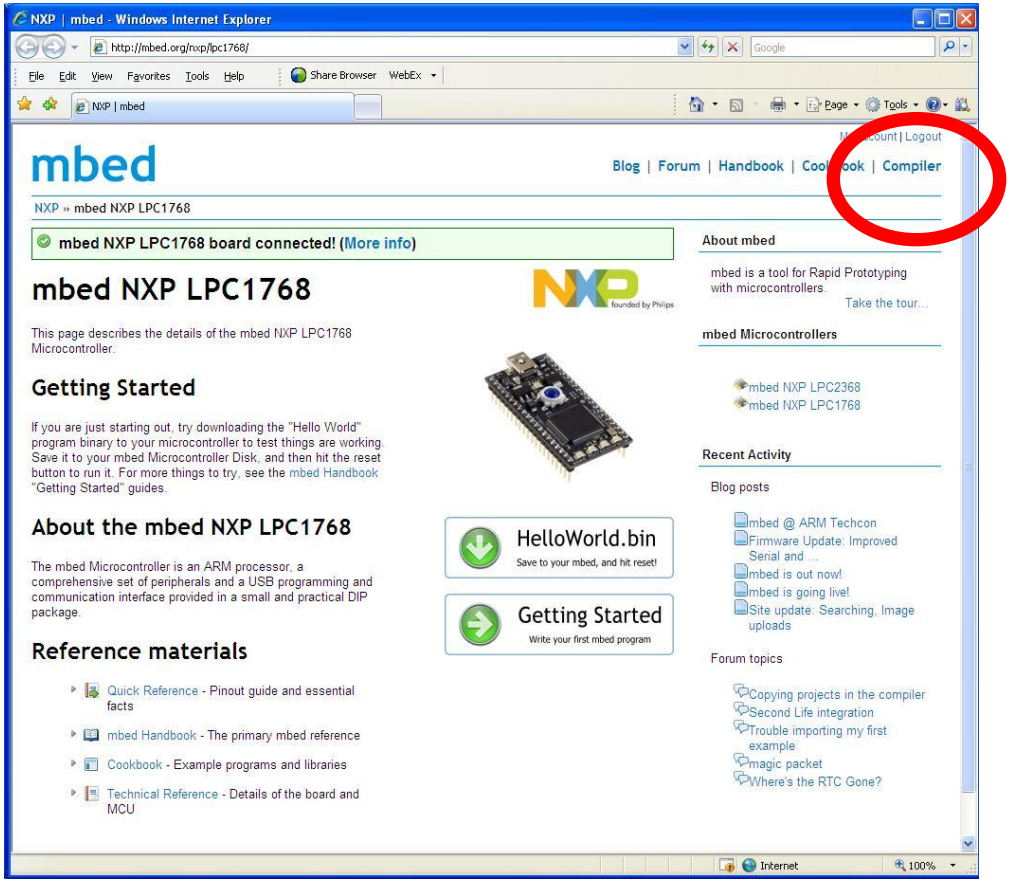
- mbed microcontroller enumerates as a Mass Storage Device (USB disk)
- Double-click the mbed.htm file on the mbed USB disk



- Log in or sign up for a new account
- The mbed microcontroller contains your license to the compiler

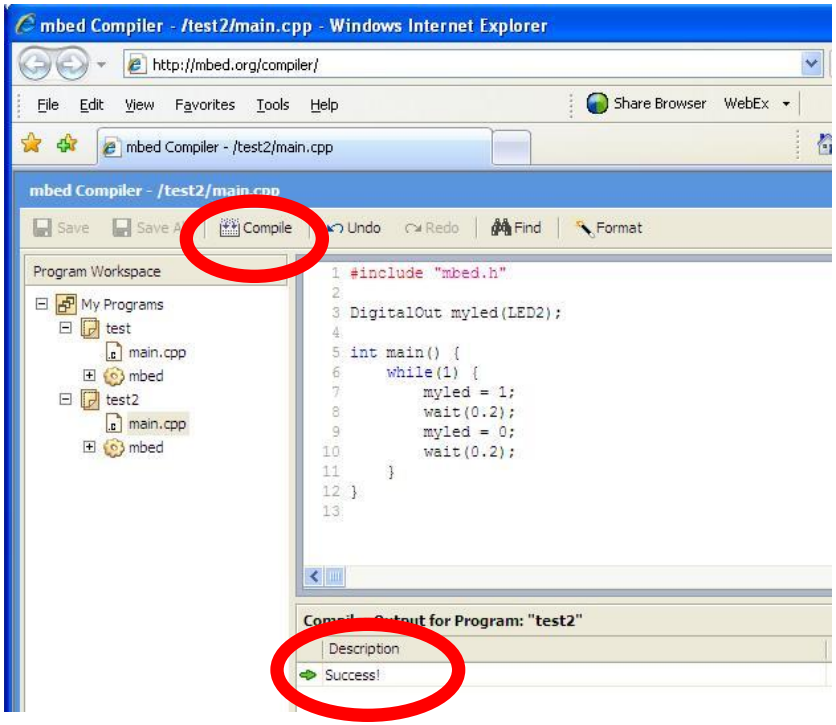
Getting Started

- Useful resources linked from the first page, including very clear links to “Hello World” and the Getting Started guide
- Compiler linked from front page



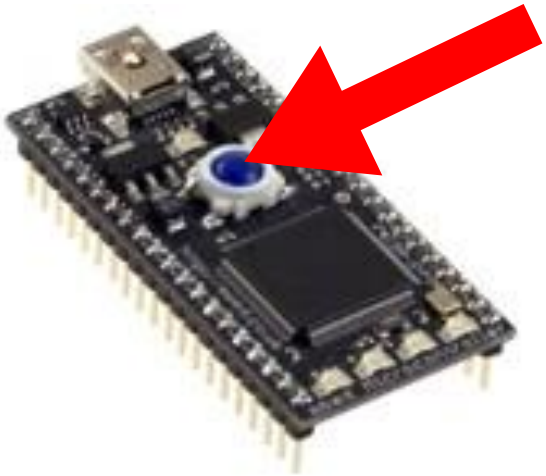
Getting Started

- Create or open a project in the Program Workspace
- Develop code in the text editor
- Save and compile
- Compiler outputs
  - Errors and warnings
  - -or-
  - A downloadable binary
- Save to the USB flash disk



Getting Started

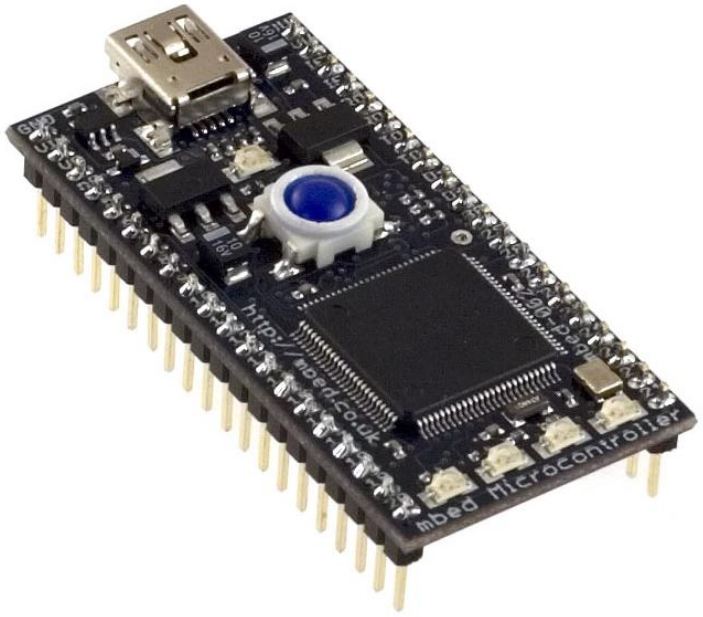
- Once the file has saved to the flash disk, it needs to be programmed into the microcontroller
- Press the button on the mbed module
- Your code will start running!



Over to you...

http://mbed.org/cookbook/SprintUSBModem

This presentation and the rest of the notes are published as a PDF



mbed + Sprint Hello World

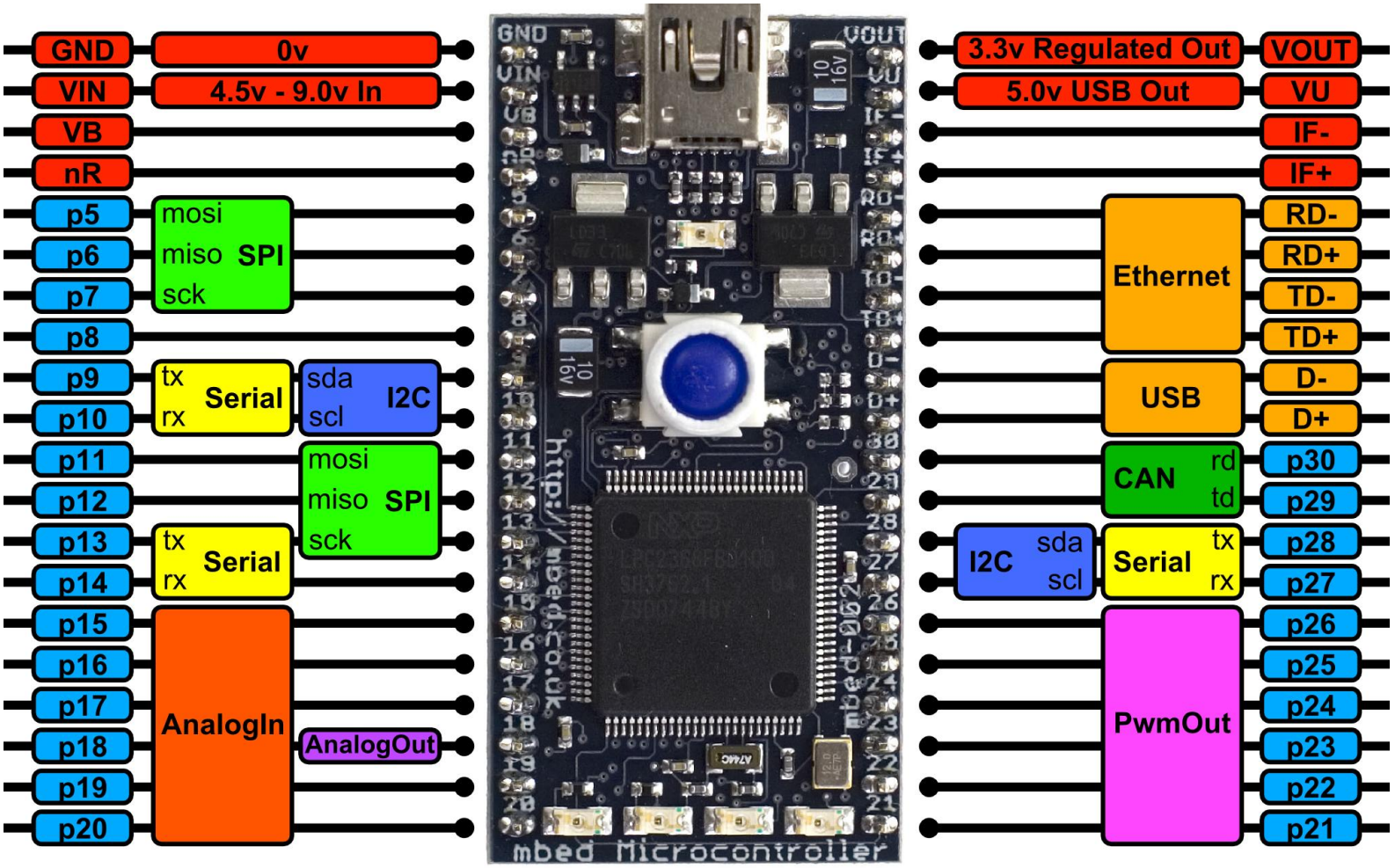
Lab 2

Rapid Prototyping: Other IO

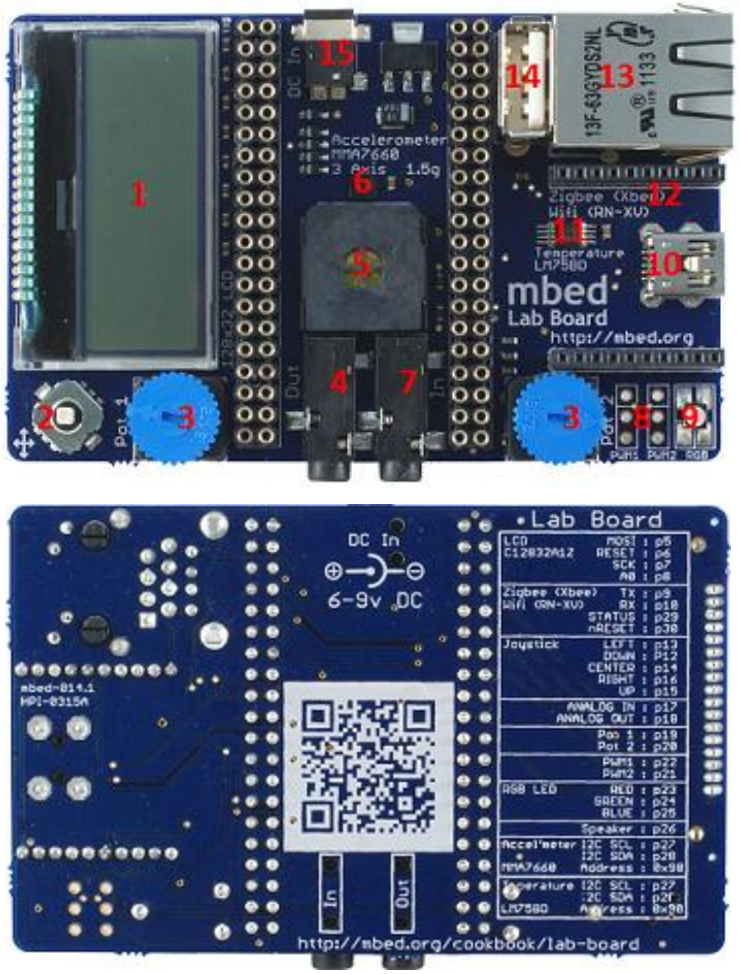
DigitalOut and Analog Input

- In the hello world session, we simply compiled the default program – blinky, but we didnt take too much notice of the code
- It was simple, it set up a digital output (DigitalOut) called “myled” and run a loop forever turning it on and off.
- Lets see if we can begin to influence this using and Analog input

What IO is there?



mbed application board



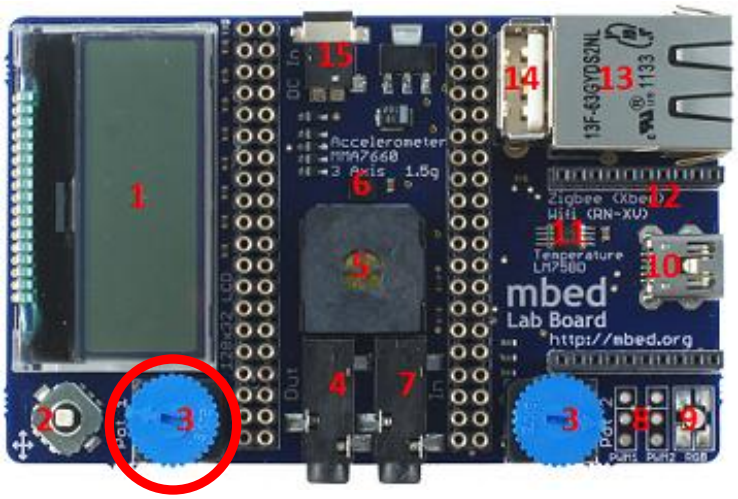
1. 128x32 Graphics LCD
2. 5 way joystick
3. 2 x Potentiometers
4. 3.5mm Audio jack (Analog Out)
5. Speaker, PWM Conencted
6. 3 Axis +/1 1.5g Accelerometer
7. 3.5mm Audio jack (Analog In)
8. 2 x Servo motor headers
9. RGB LED, PWM connected
10. USB-B Connector
11. Temperature sensor
12. Socket for for Xbee (Zigbee) or RN-XV (Wifi)
13. USB-A Connector
14. RJ45 Ethernet conenctor
15. 1.3mm DC Jack input

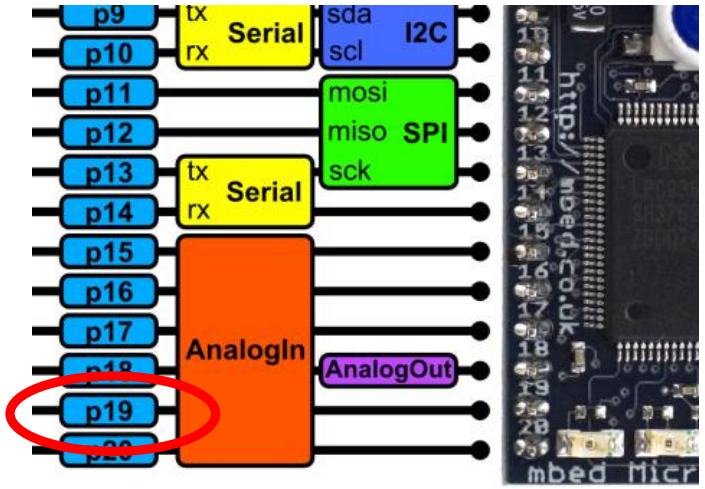
http://mbed.org/cookbook/mbed-application-board

DigitalOut and Analog Input

- The AnalogIn object returns a normalised float between 0.0 (0.0v) and 1.0 (3.3v)

- Pot1 is wired between GND (0v) and Vout (3.3v), and is connected to pin “p19” – an AnalogIn





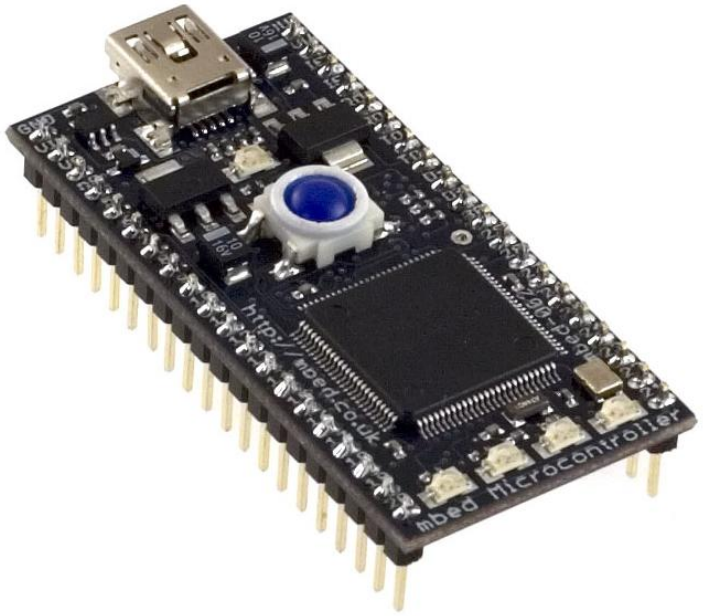
Challenge: DigitalOut and Analog Input

- Write a program to give the LED in the first blinky program a delay of 0.1-1.1 seconds.

main.cpp x

```
1  #include "mbed.h"
2
3  DigitalOut myled(LED1);
4  AnalogIn pot(p19);
5
6  int main() {
7      while(1) {
8          myled = !myled;
9          wait(0.1 + pot.read());
10     }
11 }
12
```

- Write a program that turns LED1 on at 0.66v, LED2 on at 1.32v, LED3 on at 1.98v and LED4 at 2.64v
- Hint : Look at BusOut in the mbed Handbook!



mbed + Sprint Hello World

Lab 3

Rapid Prototyping: Interfacing a sensor

Interfacing with sensors

- A good deal of microcontroller applications require some form of sensors to detect events or conditions in the immediate environment.
- This experiment show how to implement a simple temperature sensor.
- The sensor in question is the LM75B which has a digital interface using the I2C bus.

Conencting a Sensor

- mbed keeps I2C simple, and a library and example exists
  - I2C handbook page - http://mbed.org/handbook/I2C
  - Cookbook - http://mbed.org/cookbook/LM75B-Temperature-Sensor
  - Hello World - http://mbed.org/users/chris/code/app-board-LM75B/

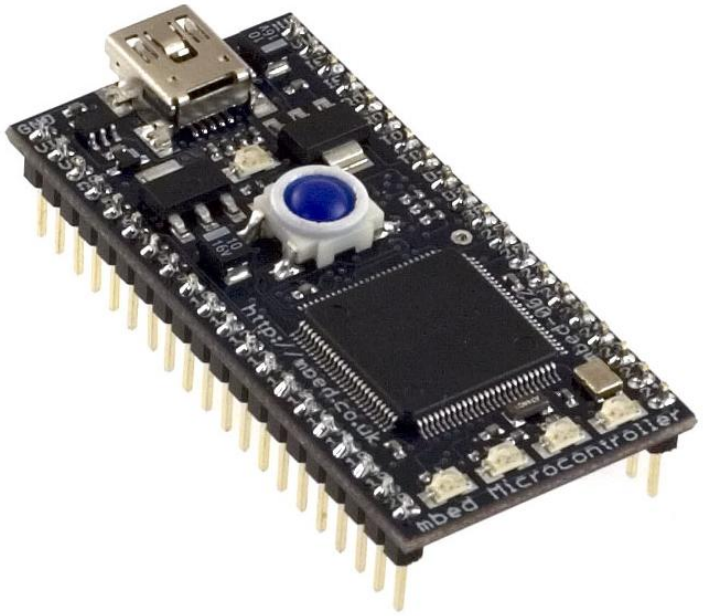
main.cpp x

```
1  #include "mbed.h"
2  #include "LM75B.h"
3
4  LM75B temp(p28,p27,0x90);
5
6  int main() {
7      while(1) {
8          printf("Temperature : %f\n",temp.read());
9          wait(5);
10     }
11 }
```

Challenge : Interfacing with sensors

- Write a program that turns LED1 on at 26°C, LED2 at 27°C, LED3 and 28°C and LED4 at 29°C.

- As an extended challenge, add Min/Max recordings to the program



mbed + Sprint
Hello World

Lab 4

Rapid Prototyping: Output device, Text LCD

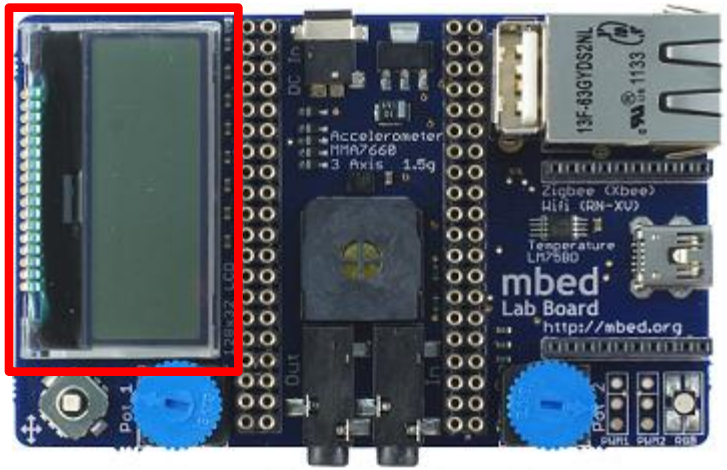
Output device, LCD

- It is not uncommon for devices that are embedded to have some for of user interface, or display output.

- This example shows an LCD connected to mbed and be driven simply from software.

Connecting up the TextLCD

- The LCD module has an SPI interface and a few digital outputs for reset, chips select and so on



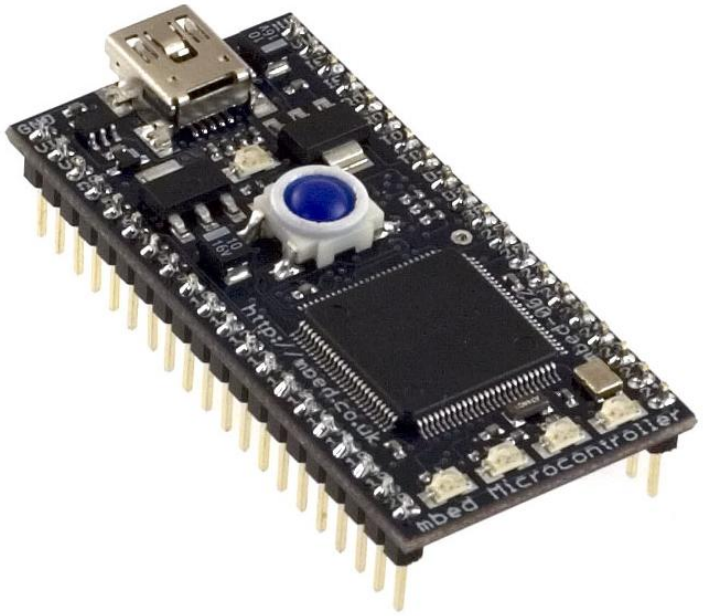
main.cpp x

```
1  #include "mbed.h"
2  #include "C12832_lcd.h"
3
4  C12832_LCD lcd;
5
6  int main()
7  {
8      lcd.cls();
9      lcd.locate(0,3);
10     lcd.printf("mbed application board!");
11 }
12
```

- mbed keeps it simple
  - Standard C/C++ interface via printf
  - Hello World : http://mbed.org/users/chris/code/app-board-LCD

Challenge: Digital Thermometer

- Make a digital thermometer that displays the current temperature.
- If you have time, you could also add Min/Max to the display too
- http://mbed.org/users/chris/code/app-board-LM75B/



mbed + Sprint Hello World

Lab 5

Rapid Prototyping: SMS alerts

SMS Alerts

- Some applications need to include and element of communication
- Taking the previous example of registering Min/Max temperatures, its might be desirable to communicate it limits are exceeded
- This example shows how the SprintUSBModem can be used to achieve mobile communication,

Hardware

- Simple hardware :
  - mbed NXP LPC1768 microcontroller
  - mbed application board
  - Sprint Mobile Broadband
  - DC adaptor

Example Program : SMS Send

- An example program of how to send SMS messages using the USB Modem can be found here

http://mbed.org/users/donatien/code/SprintUSBModemSMSTest/

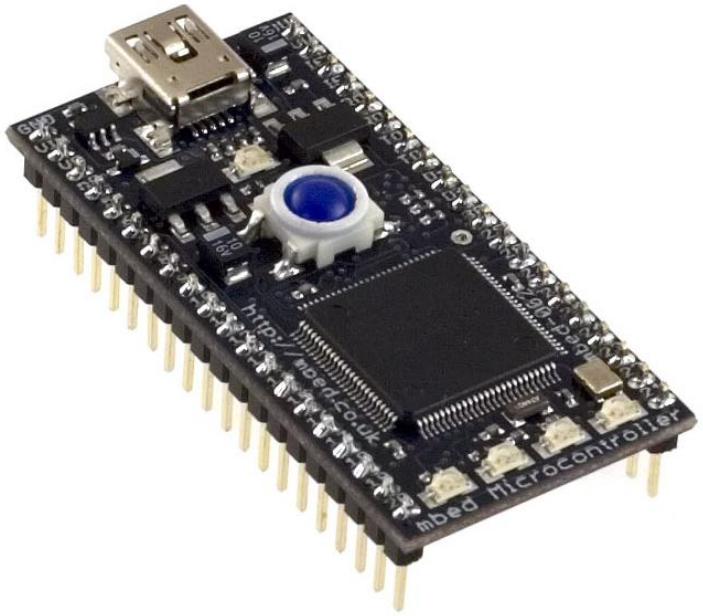
- Experiments :
  - Use the example program to send your self a message
  - Using “ssprintf” send yourself a over temperature alert message

Challenge: SMS Receive

- Once you have successfully sent SMS messages to your cell, try this :

Challenge

  - Set the minimum and maximum alert points by SMS
    - Receive a reply message from your cell back to the mbed
    - Use “sscanf” to retrieve the new minimum and maximum values for your thermometer
    - Trigger alert SMS messages when these new limits are exceeded
    - Include the temperature reading in the alert message



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Lab 6

Rapid Prototyping: Mobile data logging

Mobile data logging

- This example shows how the Sprint Mobile Broadband can be used to achieve remote data logging, where the data is sent live to online storage

- The driver is now providing a socket interface over which various protocol APIs and. For this example, we are using HTML5 web sockets

- Take 5 minutes to familiarise yourself with web sockets :
  - http://mbed.org/cookbook/Websockets
  - http://mbed.org/cookbook/WebSocket-Mbed-Server

Websocket server channels

The mbed.org websocket uses “channels”, with “demo” as the default. To avoid conflict during a workshop, create your own channel by substituting “demo” with your own channel name

In mbed code :

Websocket ws("ws://sockets.mbed.org:443/ws/demo/rw");

Becomes

Websocket ws("ws://sockets.mbed.org:443/ws/<your_channel>/rw");

In broswer URLS :

http://sockets.mbed.org/demo/viewer

becomes

http://sockets.mbed.org/<your_channel>/viewer

Hardware

- Simple hardware :
  - mbed NXP LPC1768 microcontroller
  - mbed application board
  - Consumer USB Modem
  - DC adaptor

HTML5 and Websockets

- New feature of HTML5 (RFC 6455) providing:
  - Full-duplex communication
  - Over a single TCP socket
  - Standard and secure connections (ws:// and wss://)

- Motivation:
  - Replace existing polling techniques (AJAX) used in modern websites
  - Provide a two-way communication without multiple HTTP connections
  - Enable new classes of application

- Other notable HTML5 features:
  - HTML5 Canvas Element – For dynamic, scriptable 2D rendering

Example Program : Web sockets

- An example program of how to send the current temperature as a web socket message to the mbed web socket server using the Sprint USB Modem can be found here

http://mbed.org/users/chris/code/SprintUSBModemWebsocketTest-Temp/

See the output here :

http://sockets.mbed.org/demo/viewer

Experiments :

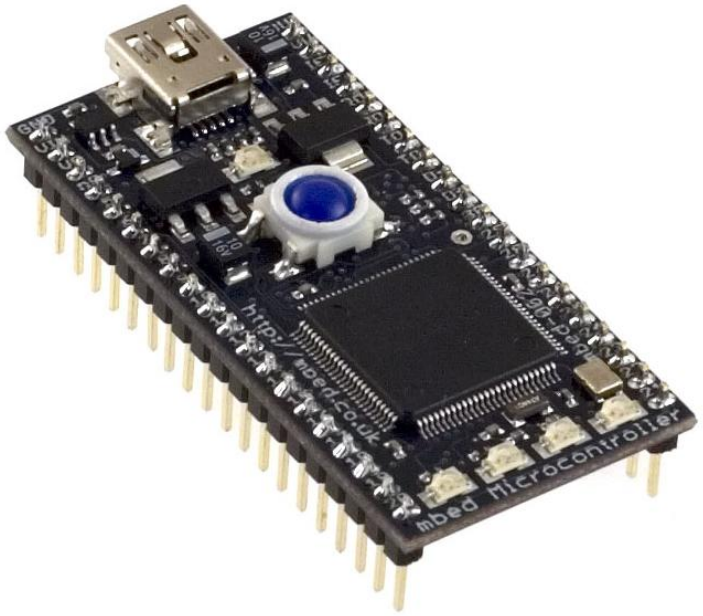
- Trigger a web socket message using navigation switch

Challenge : Web sockets

- The previous example was write-only (“wo”) and sent data to the socket server

- Try making a connection that is read-only “ro”
  - To see how to receive web socket messages refer to : http://mbed.org/users/donatien/code/SprintUSBModemWebsocketTest/
  - Display received messages on the LCD, for examples see : http://mbed.org/cookbook/mbed-application-board
  - To send messages, use the “sender” http://sockets.mbed.org/demo/sender
- If you get stuck... But try to do it yourself first !

  http://mbed.org/users/chris/code/SprintUSBModemWebsocketTest-LCD-RO/



mbed + Sprint Hello World

Summary

Summary

- There is huge opportunity for microcontroller applications
  - A major barrier to adoption is simple experimentation
- mbed helps with getting started and rapid prototyping
  - Fast turnaround of experiments and prototyping new ideas
  - Try out new technology and new ideas
- Makes the technology very accessible
  - Demo showed a start to finish prototyping example
  - From getting a user started to enabling an application experiment
- Use at as a tool when you need to experiment!

Summary

- A solution focused on prototyping has a broad appeal
- Engineers new to embedded applications
  - Enables experimentation and testing product ideas for the first time
  - Create designs where electronics and MCUs are not the focus
- Experienced engineers
  - Provides a way to be more productive in the proof-of-concept stages
  - Introduce 32 bit microcontroller technology to existing designs
- Marketing, distributors and application engineers
  - Provides a consistent platform for demonstration, evaluation, support
  - Make promotion of MCUs more effective and efficient

Q&A