The BBC micro:bit - from the UK to the World

[Extended Abstract]

Lancaster University | Micro:bit Educational Foundation | Microsoft Research

ABSTRACT

The micro:bit rocks!

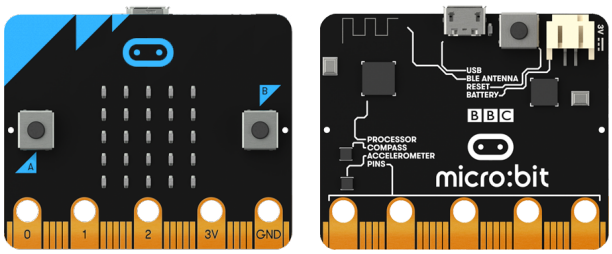
1. INTRODUCTION

The micro:bit is a small programmable and embeddable computer designed, developed and deployed by the BBC and partners (including Microsoft, and Lancaster University) to approximately 800,000 UK middle school students in 2015-2016. Part of the BBC's Make it Digital Campaign, the BBC described the micro:bit as its "most ambitious education initiative in 30 years, with an ambition to inspire digital creativity and develop a new generation of tech pioneers." [**?**]

Figure 1 shows (a) the front and (b) the back of the micro:bit, which measures 4cm x 5cm. Like the Arduino Uno (which measures 5.34cm x 6.86cm) and its precursor Wiring, the micro:bit is a single-board microcontroller that can be programmed via a host computer (usually a laptop or desktop) and then embedded in projects where it runs on battery power. In contrast to the Uno, which has no built-in sensors, the micro:bit board hosts a variety of sensors (temperature, accelerometer, magnetometer, light level), a 5x5 LED matrix, two user-defined buttons, as well as Bluetooth Low Energy (BLE) communications.[1].

The design of the micro:bit hardware was driven by the first two objectives of the micro:bit project: (1) to provide a simple creative experience for physical computing, wearable and Internet of Things (IoT) projects; (2) to supply a device that can continue to provide learning opportunities as the user's expertise grows.

On the hardware side, the micro:bit's built-in sensors, buttons and LED display allow many projects to be completed with no additional hardware or wiring. The holes on micro:bit's edge connector allows additional external sensors and actuators to be connected via crocodile clips. The micro:bit's BLE capabilities introduces networking to the picture, and enables streaming of data and command/control operations among the micro:bit, smartphones, laptops, as well as other micro:bits. As with Arduino, an ecosytem of micro:bit shields (that accommodate the micro:bit's edge connector) expand its capabilities greatly.



(a) (b)

Figure 1: The micro:bit: (a) front, with two buttons, 5x5 LED display, and edge connector (bottom); (b) back, with processor, accelerometer, compass, Bluetooth, USB and battery ports.

The design of the micro:bit coding tools also was oriented towards a simple starting experience with room for progression. In particular, the coding objectives of the project were: (3) to give students an exciting, engaging introduction to coding; (4) to stimulate curiosity about how computing technologies can be utilized to solve problems that students identify.

Based on user trials with a micro:bit prototype at Years 5 and 7 (3rd and 5th grade in the US, respectively), the BBC focused on delivering a web app based on the popular Blockly framework [**?**] to permit Year 7 students to create scripts via drag-and-drop operations in a web browser. Text-based coding also was identified as an important feature. The text of a user's program (whether derived from Blockly or produced directly by the user) would be submitted to a compiler service in the cloud that would return a final executable to be copied onto a micro:bit (connected to the host computer by USB) via a specialized loader application. As the micro:bit would be incorporated into standalone projects, it was essential for the user's program to be installed in non-volatile storage on the micro:bit where it could be run via battery battery power.

The solution delivered by the BBC's partners evolved to include:

- support for Blockly, JavaScript, Python, and C/C++;
- a web app with Blockly and JavaScript editors, micro:bit simulator, and compiler to machine code, then linked against a pre-compiled C++ runtime (see `http://makecode.microbit.org`), obviating the need for a

[1]The micro:bit has a whopping 16kB of RAM and 256kB of Flash memory, compared to the Uno's 2kB of RAM and 32kB of Flash

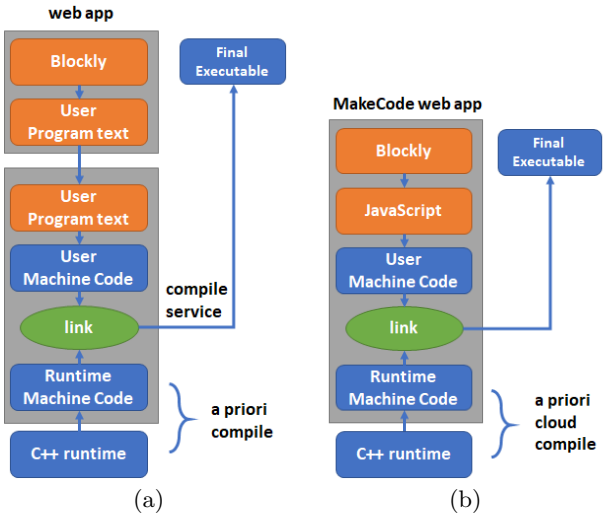


Figure 2: Web and compiler designs: (a) initial BBC design; (b) final design as implemented in MakeCode.

compiler service for user code;

- an on-device compiler and REPL for Python (via `https://micropython.org/`, an implementation of Python for microcontrollers);
- DAPlink firmware on micro:bit for USB pen drive (cross platform)
- open sourcing of platform;

What happened in terms of deployment and experience:

- first full school year was 2016-2017, during which micro:bit Education Foundation got started;
- two full school years complete with experience in more countries
- approximately two million micro:bits in market;
- lots of partners participating (ICSTE and CSTA 2018)!!

2. CONTEXT: PHYSICAL COMPUTING

Physical computing: computing interacting with our physical environment (as opposed to just living on a screen, like a computer game); "cyberphysical systems", "embedded (reactive) systems". Physical computing lives in the spaces between computing and many other disciplines: art, industrial design, health, environmental monitoring, etc.

Physical computing benefits:

- broad reach because of diverse applications of physical computing – leverage fine arts, music, design, etc. in projects;
- increased motivation and connections because of tangible visible outcome (rather than virtual on screen);
- learning by doing: many ways to achieve goal (no single correct solution)
- natural division of labor for more complex projects (design, hardware, software, ...)
- full system view of computing: hardware and software working together.

2.1 Wiring and Arduino

To help explain the BBC micro:bit design, it's very instructive to understand Hernando Barragan's 2003 Master's thesis, "Wiring: Prototyping Physical Interaction Design", the inspiration for the Arduino system [**?**]. His objective was to make it easier for non-technical creators, such as artists and designers, to leverage electronics in their their work by simplifying the hardware and programming experience. In particular, he said of existing work: "Current prototyping tools for electronics and programming are mostly targeted to engineering, robotics and technical audiences." Of Wiring's design, he identified the following key concepts:

- a simple cross-platform integrated development environment (IDE) to create so-called "sketches";
- simplified application programming interfaces (APIs) to access a microcontroller's resources;
- leverage open source compiler/linker toolchain, transparent to the end user;
- a bootloader to make it easy to upload a compiled sketch to the microcontroller;

Also make Wiring (hardware and software) open source.

But, still some issues:

- reliance on the C language and C compiler (needs to be installed)
- very poor experience in IDE
- USB bootloader requires device drivers on some systems

2.2 The BBC micro:bit

BBC micro:bit inherits the raw PCB nature of Arduino (everything is visible to the end user).

First key idea of the BBC micro:bit: NO WIRING REQUIRED!

3. ACKNOWLEDGMENTS

4. REFERENCES