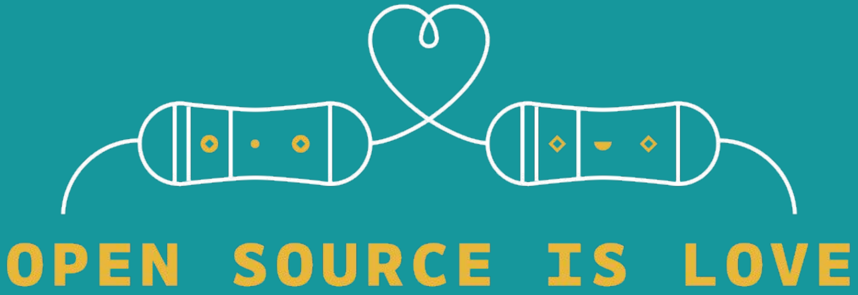
Arduino
Open Source Report 2023

Another busy year has passed in the Arduino world, and it’s about time to publish our annual retrospective on the Arduino open source ecosystem.
In this report you’ll learn about the activities of the **Arduino team** from the past year, as well as the contributions from our passionate and vibrant **community**.

This report is a snapshot of the ecosystem as of December 31st, 2023.



Introduction

One more busy year

The Arduino name designates a company, an open source project, a community.

We're **tens of millions of people** sharing a passion for embedded electronics. But we're also thousands of **companies** who manufacture boards, shields and accessories, and develop software for them. We're educators, students, hackers, consultants, engineers, designers, entrepreneurs. In these 18 years we have all been collaborating every day to share knowledge and solutions, building an incredibly vast amount of resources around which an **entire industry** has grown.
As Arduino company, we believe in the values that make this community great: **openness**, **transparency**, **collaboration**, **sharing**.
This yearly report documents our **efforts and investments** to support the growth of the ecosystem. As you will see in the document, **2023** has been an incredibly busy year in terms of open source development.

To comment on this report, join us in the Arduino Forum.

How to support the Arduino project

There are several ways to support the Arduino team:

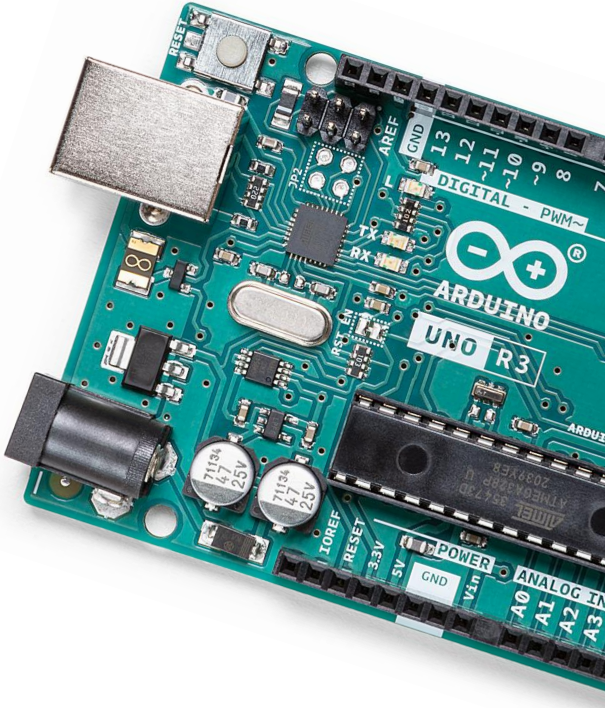
- **Buy original Arduino boards** (their cost funds our investment in open source development for the benefit of the entire ecosystem, including other hardware manufacturers)

- **Subscribe to an Arduino Cloud plan** (for a few $/month you can fund our open source development and also get web dashboards, smartphone app as a remote control for your projects, remote firmware upload, variable synchronization across devices, mobile push notifications and more)

- **Make a donation**

- Join the development and **become a contributor!**

But in addition to the Arduino team, do not forget to **support the authors of your favorite libraries**. Many of them accept donations through GitHub or other means, and all of them appreciate your gratitude in any form.



Activities carried out by the Arduino team

In this section we’ll go through the main projects delivered directly by the Arduino team.

Big news: Arduino joins the Zephyr® Project

In 2023 we joined the Zephyr® Project as Silver members.

Zephyr is an open source project at the Linux Foundation that builds a secure, connected and flexible RTOS for future-proof and resource-constrained devices, is easy to deploy and manage. It is a proven RTOS ecosystem created by developers for developers. Zephyr RTOS has a growing set of software libraries that can be used across various applications and industry sectors such as Industrial IoT, wearables, machine learning and more. It is built with an emphasis on broad chipset support, security, dependability, long-term support releases and a growing open source ecosystem.

Funding and supporting Zephyr is important for us because it helps keeping embedded development open, collaborative and accessible while investing in security and robustness.

Open-Source Hardware boards NEW

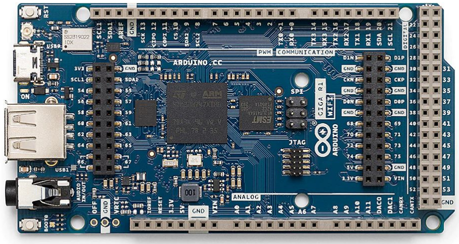
During this year we released **FIVE new open-source hardware products**:

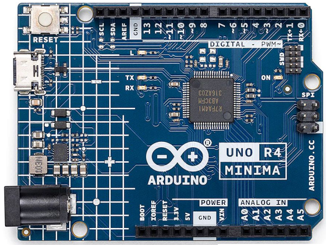
- GIGA R1 WiFi
- GIGA Display Shield
- UNO R4 Minima
- UNO R4 WiFi
- Nano ESP32

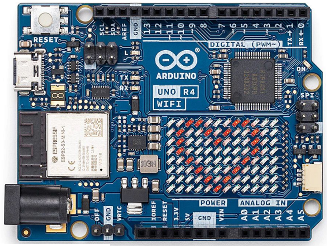
For each of them, the full schematics and CAD files are available on the docs.arduino.cc website along with **web-based interactive viewers** that let users see the 3D models and click on individual components to browse the BoM interactively and see part numbers and other details.

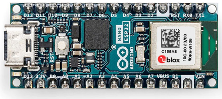
HOW TO GET INVOLVED:

- **Remix these boards, innovate and share your builds!**





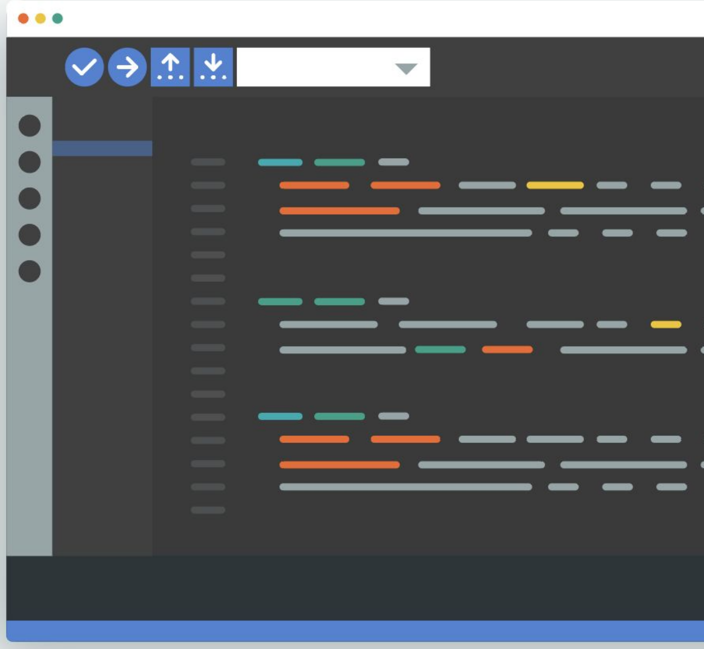




Arduino IDE 2

In 2022 we released the Arduino IDE 2, marking a big milestone in Arduino history. Since then, we never stopped working in it: the Arduino Tooling Team works on the IDE full time interacting with the community to make sure the IDE is robust, maintained, easy to use.

In 2023, 5 new versions were released with many improvements to UX and reliability, as well as new features such as a big revamp of the debugging framework.



HOW TO GET INVOLVED:

- **Test the IDE 2 to spot issues and bugs**
- **Contribute the translation in your language**
- **Join the development and help testing bugs, fixing them and developing new features!**

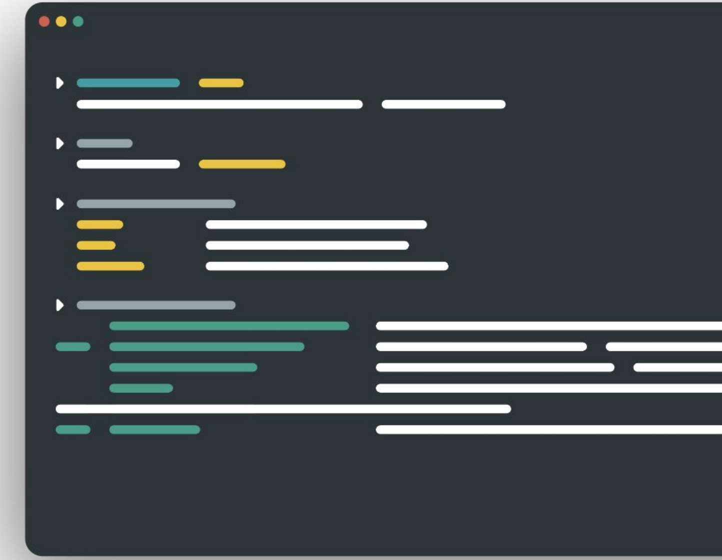
Arduino CLI

The open-source Arduino CLI command line tool provides access to all the features of the IDE, including compilation, upload to boards, library management and more. This tool allows you to manage your Arduino sketches without leaving your editor of choice, as well as integrate it in your scripts and custom applications.

We have been working on this tool on a daily basis to add new features, and during this year we released 6 new versions!
Thanks to the contribution of the community we're getting close to the release of the 1.0 stable version.

HOW TO GET INVOLVED:

- **Contribute the translation in your language**
- **Jump into the development and help testing bugs, fixing them and developing new features!**



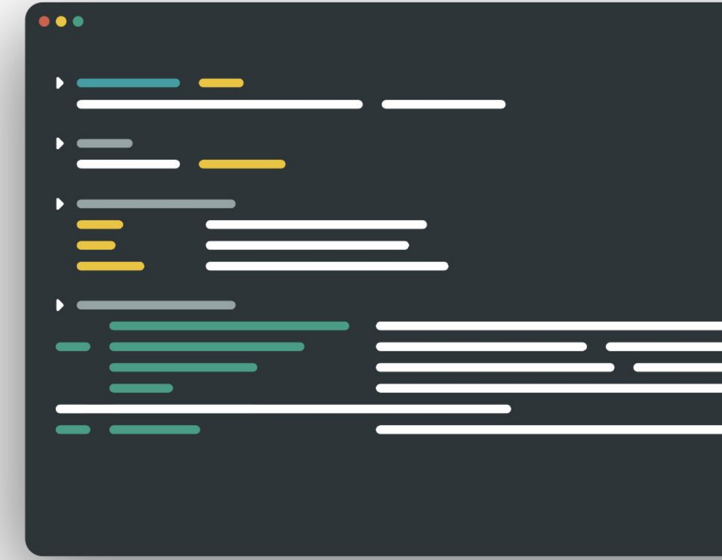
Arduino Firmware Uploader

Security in IoT is often neglected but for us it is very important to make sure there’s a robust and versatile toolchain to keep devices up-to-date. The open-source Arduino Firmware Uploader tool provides a simple way to update the firmware and/or add SSL certificates for any Arduino board equipped with ESP32-S3 or NINA Wi-Fi module.

During 2023, we released 3 new versions of the tool!

HOW TO GET INVOLVED:

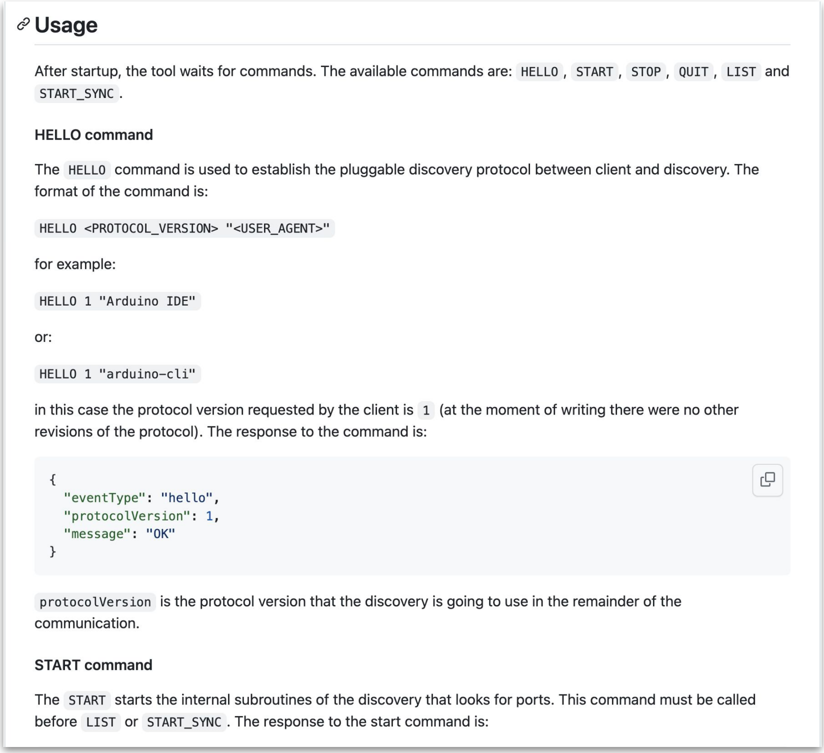
- **Jump into the development and help testing bugs, fixing them and developing new features!**



Pluggable discovery for DFU devices NEW

This one is very technical, but it’s an important contribution. We care a lot about making sure the Arduino ecosystem is open and supports any board on the market, not just ours. We feel the responsibility to make sure our industry is healthy and collaborative and this is why we believe in open standards.

In the past few years we worked hard to implement a modular way to have the CLI and IDE seamlessly communicate with a board using many different protocols. We call this framework “pluggable discovery”. Among the various protocols available, we now developed full support for DFU upload. DFU is part of the USB standard.
Thanks to this contribution, any vendor can now design boards leveraging DFU and provide a smooth user experience to their users.



Usage

After startup, the tool waits for commands. The available commands are: `HELLO`, `START`, `STOP`, `QUIT`, `LIST` and `START_SYNC`.

HELLO command

The `HELLO` command is used to establish the pluggable discovery protocol between client and discovery. The format of the command is:

`HELLO <PROTOCOL_VERSION> "<USER_AGENT>"`

for example:

`HELLO 1 "Arduino IDE"`

or:

`HELLO 1 "arduino-cli"`

in this case the protocol version requested by the client is `1` (at the moment of writing there were no other revisions of the protocol). The response to the command is:

```
{
  "eventType": "hello",
  "protocolVersion": 1,
  "message": "OK"
}
```

`protocolVersion` is the protocol version that the discovery is going to use in the remainder of the communication.

START command

The `START` starts the internal subroutines of the discovery that looks for ports. This command must be called before `LIST` or `START_SYNC`. The response to the start command is:

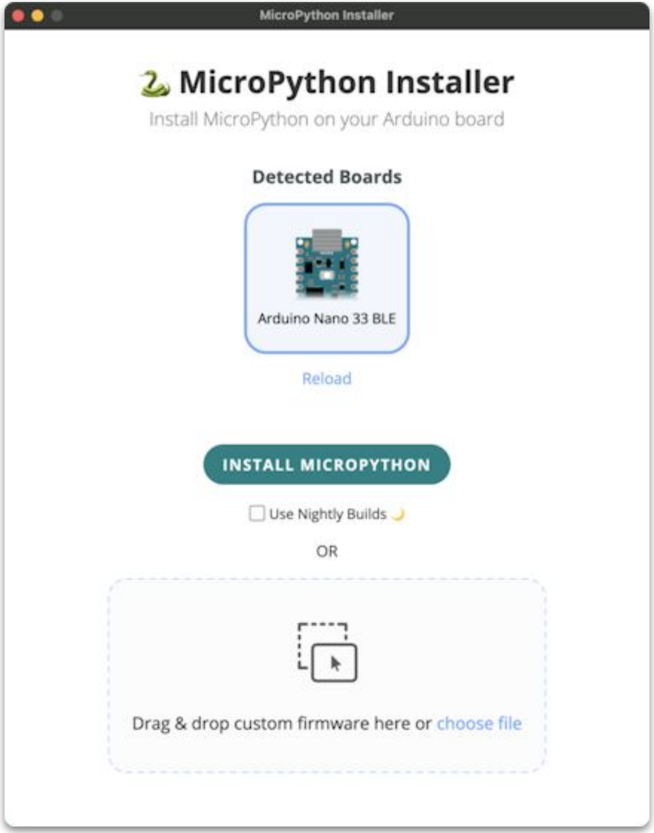
MicroPython installer for Arduino NEW

Following our mission to democratize embedded development, we keep investing on new technologies to empower the community.

This year we released the MicroPython Installer for Arduino which is a cross-platform tool that streamlines the process of downloading and installing MicroPython firmware on compatible Arduino boards. It runs on macOS, Linux, and Windows and is built using the Electron framework.

HOW TO GET INVOLVED:

- **Test the installer and report feedback**
- **Join the development and roadmap discussion on GitHub**



Install MicroPython on your Arduino board

Drag & drop custom firmware here or choose file

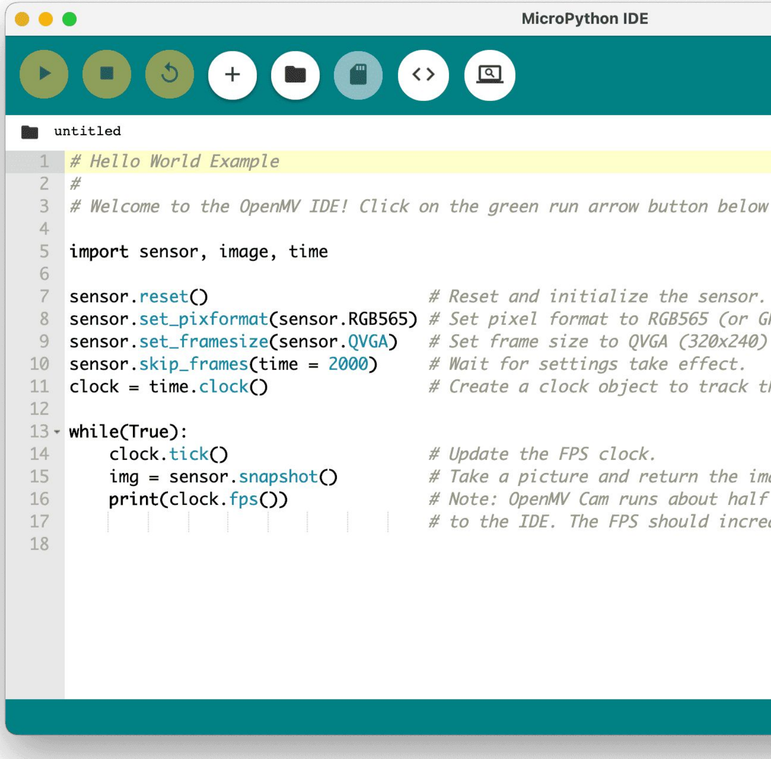
Arduino Lab for MicroPython

In 2022 we had released a new IDE for MicroPython was released as an experimental project. Since then we have received very good feedback from the community so we have been improving it to add new features and improve reliability.

In 2023 we have released 3 new versions of the Arduino Lab for MicroPython!

HOW TO GET INVOLVED:

- **Test the application in real-world situations and report feedback**
- **Join the development and roadmap discussion on GitHub**



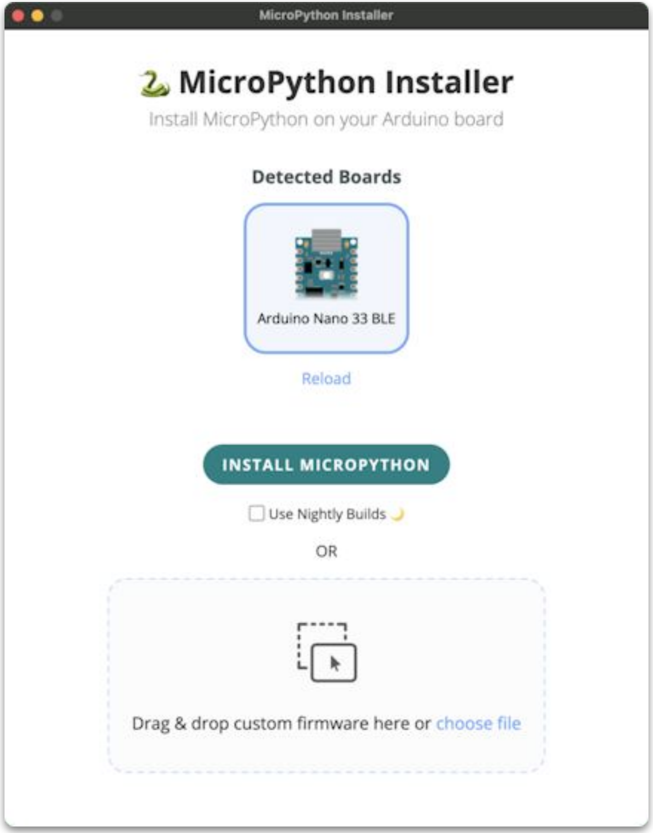
```
# Hello World Example
#
# Welcome to the OpenMV IDE! Click on the green run arrow button below

import sensor, image, time

sensor.reset()                      # Reset and initialize the sensor.
sensor.set_pixformat(sensor.RGB565) # Set pixel format to RGB565 (or G
sensor.set_framesize(sensor.QVGA)   # Set frame size to QVGA (320x240)
sensor.skip_frames(time = 2000)     # Wait for settings take effect.
clock = time.clock()                # Create a clock object to track t

while(True):
    clock.tick()                    # Update the FPS clock.
    img = sensor.snapshot()         # Take a picture and return the im
    print(clock.fps())              # Note: OpenMV Cam runs about half
                                    # to the IDE. The FPS should incre

```

MicroPython Package Index NEW

We have created an initial list of MicroPython packages that we consider useful to learn and experiment with this language. The list is published as Arduino MicroPython Package Index. You can browse the list, download the packages from their corresponding Github repository and install them via Arduino Lab Editor for MicroPython. We plan to release tools to easily search, download and install from this package index in the future.

HOW TO GET INVOLVED:

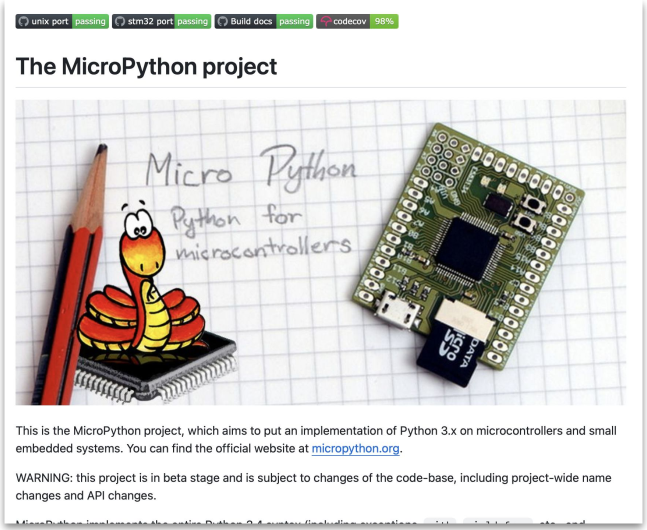
- **Contribute to the accuracy of the package index by submitting pull requests and joining the discussion on GitHub**



More MicroPython development

We have been working full-time on contributing to the upstream MicroPython project which we fully support as we believe in interoperability and collaboration. Some of the major contributions are:

- New networking interface and drivers to support ESP32 chips running the Espressif's esp-hosted firmware
- Support for Open-AMP in MicroPython, to standardize asymmetric multi-core support across different hardware
- MsgPack-based RPC library
- New sensor drivers: Renesas HS3003 and Bosch's BMM150 and BMI270.
- Refactored and fixed KPN's senml and cbor libraries
- Improved support for the IMXRT 117x series in imxrt port
- Improve standby/low-power modes support for STM32 H7xx series
- 100+ other fixes and improvements to MicroPython



The MicroPython project

This is the MicroPython project, which aims to put an implementation of Python 3.x on microcontrollers and small embedded systems. You can find the official website at micropython.org.

WARNING: this project is in beta stage and is subject to changes of the code-base, including project-wide name changes and API changes.

MicroPython implements the entire Python 3.4 syntax (including exceptions, `with`, `yield from`, etc., and

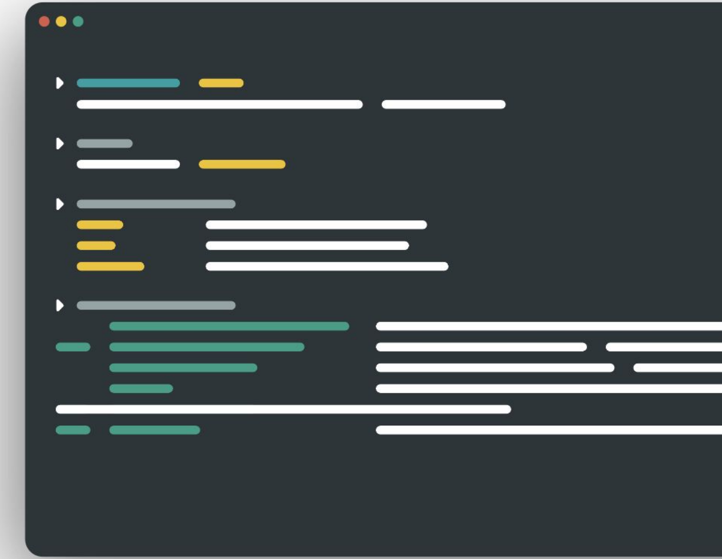
HOW TO GET INVOLVED:

- **Use MicroPython on Arduino boards in real-world projects and report issues.**
- **Contribute to development MicroPython libraries and documentation!**

Arduino Cloud CLI & Create Agent

The **Arduino Cloud CLI** supports, among other things, mass device provisioning and **Over-the-Air updates**: this allows anyone to **upload sketches on remote devices** without leaving the command line.
During 2023, we have been improving this tool and we released 4 new versions.

The **Arduino Create Agent** is the core of the Arduino Cloud services and it's fully open source.
During 2023, we released 8 new versions of it, improving its security and compatibility with the latest OS versions.



HOW TO GET INVOLVED:

- **Help testing bugs, fixing them and developing new features!**

Official libraries

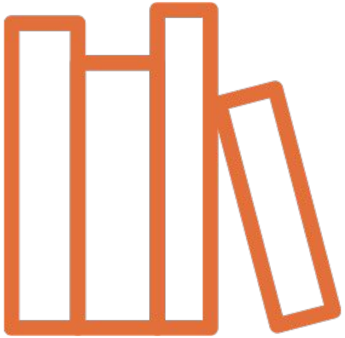
We released **two important libraries** providing a new standard API for **data storage** (see the blog post for more information):

- Arduino_UnifiedStorage
- Arduino_PosixStorage

In addition, 10 more new official libraries were published:

- Arduino_AdvancedAnalog
- Arduino_ESP32_OTA
- Arduino_GigaDisplay
- Arduino_GigaDisplayTouch
- Arduino_GigaDisplay_GFX
- Arduino_GigaDisplay_TinyGL
- Arduino_GroveI2C_Ultrasonic
- Arduino_PF1550
- Arduino_ScienceKitCarrier
- Arduino_USBHostMbed5

Also, during 2023 we performed **49 new releases** of the official libraries with bug fixes and new features.



HOW TO GET INVOLVED:

- **Please help us fix bugs, review pull requests and improve the examples shipped with libraries to better document their functionality!**

Official cores

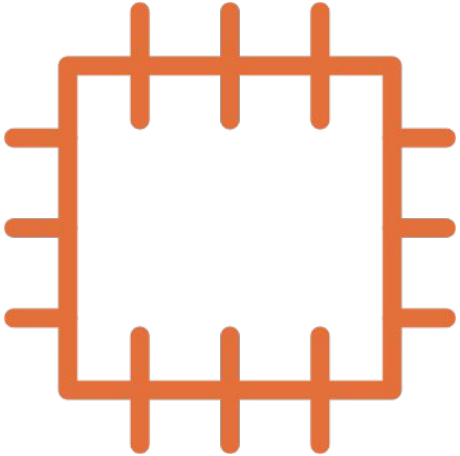
During 2023 we performed **13 new releases** of the official cores for AVR, megaAVR, SAMD, RP2040, STM32, nRF52, renesas with bug fixes, new features and support for more boards.

We have been spending more time on reviewing and merging the excellent contributions we get from the community, particularly on the core used for our Renesas-based boards (UNO R4, C33) for which we merged **~50 pull requests**, and the core used on our mbed-based boards (GIGA, RP2040, Portenta H7 and more) for which we merged **~20 pull requests**.

In addition, significant development was done on the **ArduinoCore-API** abstraction layer.

HOW TO GET INVOLVED:

- **There are still many pending issues and feature requests, so you’re really more than welcome to help us in GitHub.**



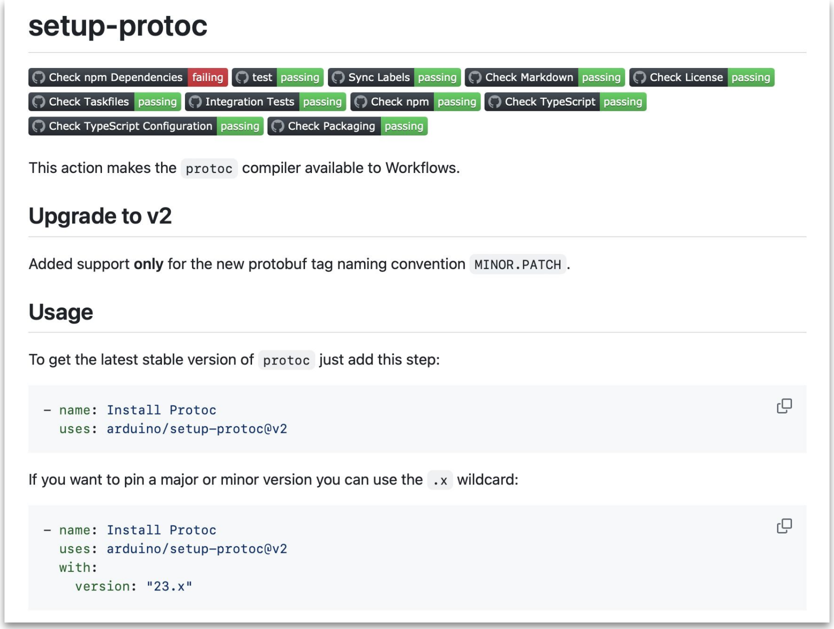
setup-protoc NEW

This is a minor one, but it’s still something we thought would be a nice contribution to release.

At Arduino we make extensive use of Continuous Integration to test our software, relying on GitHub Actions. In the past we already released actions (see the full list) to compile and analyze Arduino libraries and sketches. This one is relevant for projects using Protocol Buffers to serialize data, like the Arduino IDE does under the hood, and can now be used in any other context.

HOW TO GET INVOLVED:

- **Contribute to the project on GitHub**



setup-protoc

Check npm Dependencies failing · test passing · Sync Labels passing · Check Markdown passing · Check License passing · Check Taskfiles passing · Integration Tests passing · Check npm passing · Check TypeScript passing · Check TypeScript Configuration passing · Check Packaging passing

This action makes the `protoc` compiler available to Workflows.

Upgrade to v2

Added support **only** for the new protobuf tag naming convention `MINOR.PATCH`.

Usage

To get the latest stable version of `protoc` just add this step:

```
- name: Install Protoc
  uses: arduino/setup-protoc@v2
```

If you want to pin a major or minor version you can use the `.x` wildcard:

```
- name: Install Protoc
  uses: arduino/setup-protoc@v2
  with:
    version: "23.x"
```

Security

Last but not least, a lot of work has been carried out by our dedicated security team that works full-time to inspect code, handle reports, and secure the infrastructure including the way assets are developed, compiled and distributed.

During 2023, we have been improving security of our open source code thanks to proactive audits as well as prompt reaction to reports we received directly and in the form of CVEs.

HOW TO GET INVOLVED:

- **Help us inspect repositories to find vulnerabilities, and get in touch with our security team according to the security policy.**

Contributions to external projects

Open source is about sharing and giving back, so we care a lot about contributing to upstream projects. During 2023, we have been dedicating significant development time to contribute to the following excellent projects:

- MicroPython
- TinyUSB
- Zephyr
- OpenPLC
- ESP32 core for Arduino

Highlights from the community

We’re now going through the main contributions from the community in 2023.

+20%

YoY new libraries

Community contribution matters

1.068 new contributed libraries have been added to the Library Manager (once more, this number is higher than the previous year!), bringing the total number to **6,532**. The Arduino library ecosystem is having an impressive growth.

Libraries are a vibrant big thing

This number represents the incredibly active and continuous efforts of the Arduino library developers, growing each year.

5861

New versions of libraries in 2023

You will never walk alone

205 new open-source tutorials were added to Arduino Project Hub during the year.

(Note that we perform quality review and moderation to avoid duplicates, so this number does not include all the submissions but only represents the projects that were approved and published by the Project Hub maintainers.)

5300

INTERACTIONS

The community is more active than ever

This number represents the number of people interactions on the official Arduino repositories on GitHub reporting issues or submitting pull requests.

Many cores contributions

+101 new versions of contributed Arduino cores were released during the year (more than previous year).

Note that since there's no official platform registry, this number may not include platforms that we don't know about.

Top contributors of new libraries

Author	Number of libraries added in 2023
Rob Tillaart	228
Khoi Hoang	173
SparkFun Electronics	172
DFRobot	110
Seeed Studio	75
M5Stack	60
BESTMODULES	54
hideakitai	53
Pololu	43

Author	Number of libraries added in 2023
Luis LLamas	39
STMicrolectronics	38
Picovoice Inc.	34
RLL-Blue-Dragon	32
SRA	32
Zoran Pribičević	30
Soldered	39
RAKWireless	28
Brian Taylor	27

Author	Number of libraries added in 2023
FaBo	24
RFtek Electronics	24
Larry Bank	22
Bonezegei	21
Infineon Tech.	21
Adafruit	20
Sensiron	19
majicDesigns	18
ClosedCube	17

Most active library maintainers

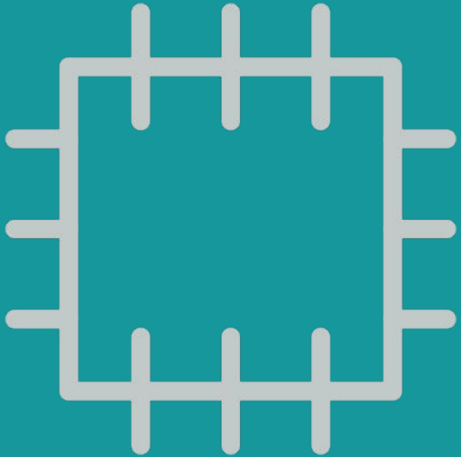
Maintainer	Number of releases in 2023
Rob Tillaart	1827
Khoi Hoang	1441
SparkFun Electronics	847
Mobizt	790
hideakitai	491
stm32duino	446
Adafruit Industries	370
Kevin Harrington	320
Brian T. Park	227
Wolfgang Ewald	216
M5Stack	184
marco_c	183
Brian Taylor	178
Zoran Pribičević	167
PowerBroker2	163
Pololu	133
Larry Bank	132
Benoit Blanchon	126
Picovoice Inc.	123
David Lloyd	121
Jochen Kiemes	121
Cesanta Software	114
Michael C. Miller	114
AlexGyver	95
thecoderscorner	95
Ricardo Lima Caratti	94
Seeed Studio	92

(This ranking is based on the frequency of releases, which does not necessarily reflect the complexity of each release.)

API interoperability

As the ecosystem grows, interoperability and portability become important concepts. How do we ensure that libraries work on all architectures, avoiding hard-coded architecture-specific code? How can we improve the core API so that libraries (and final users) can rely on a stronger abstraction layer?

We're pleased to mention the great contribution by Juraj Andrássy who worked on mapping the level of interoperability of the networking API exposed by the major Arduino cores.



HOW TO GET INVOLVED:

- **Join the discussion and help standardizing the Arduino APIs!**
- **Contribute with pull requests to the various cores and libraries to improve their portability!**

More contributions

The Arduino community is much more than this, and given its size it is nearly impossible to track all the contributions that are shared daily in **unofficial community platforms** and **independent websites**. This includes **software contributions** such as code examples and full open-source sketches, but also **knowledge contributions** such as documentation and tutorials, and last but not least **hardware design contributions** such as derivative or complementary products (shields, accessories, derived boards).

Tracking and representing such a variety in a future edition of this report, both in quantitative and in qualitative form, would be a valuable addition to recognize the tremendous efforts of thousands of people and companies contributing to the success of the Arduino ecosystem.

That’s a wrap
Thank you!

The Arduino Team