Introduction to Arduino

Mobile Computing, aa. 2016/2017

May 12, 2017

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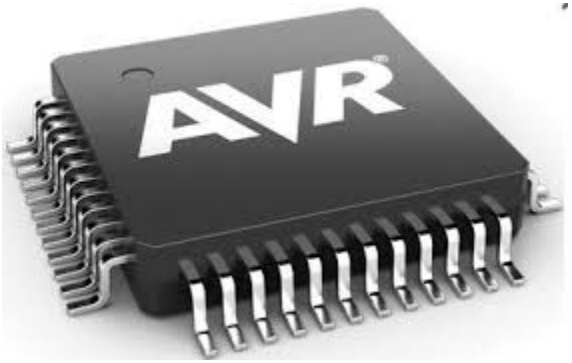
UNIVERSITÀ
DEGLI STUDI
DI PADOVA

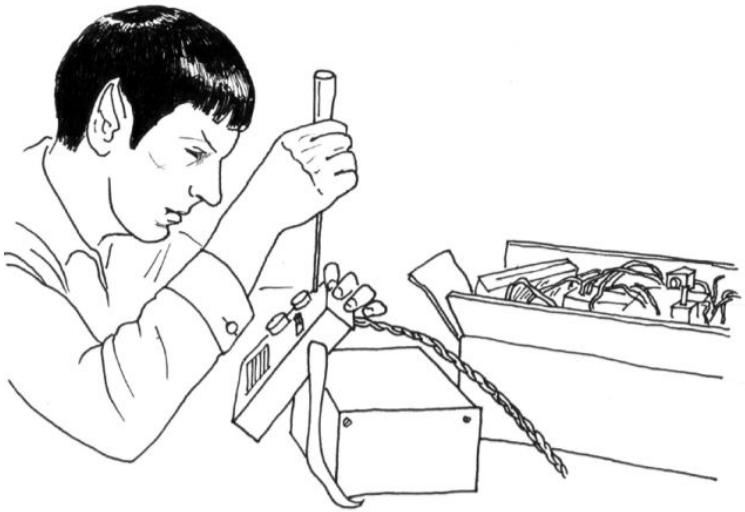
What are Microcontrollers



- Very small and simple computers
- Cheap and useful
- Present in every smart system
- **Atmel** is one of the family of microcontrollers

What is the DIY paradigm

- Create something without professional knowledge
- Many fields
  - Programming
  - Education
  - Critical theory
  - Business
  - **Electronics**
  - ...



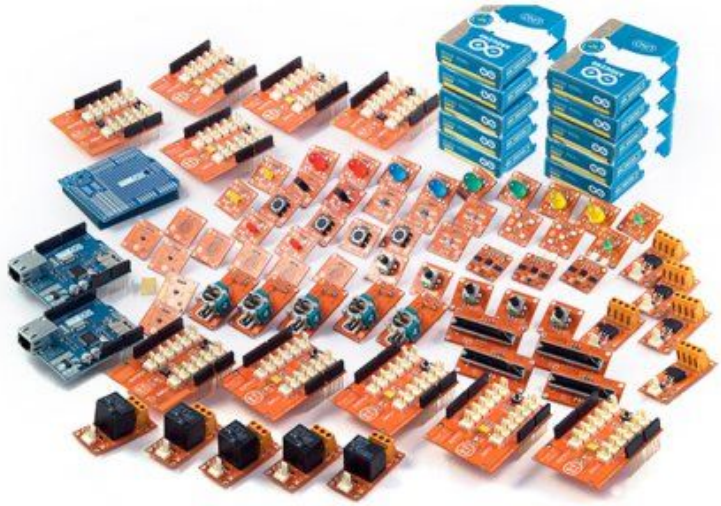
The Arduino project

Arduino UNO

Arduino *is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments.*

Arduino.cc

- An Italian prototyping tool project
- Ready-made electronic products at low costs
- Open Source
- Boards with different performances
- Shields that extend the functions
  - Wi-Fi, GPSR, Ethernet, microSD reader, ...



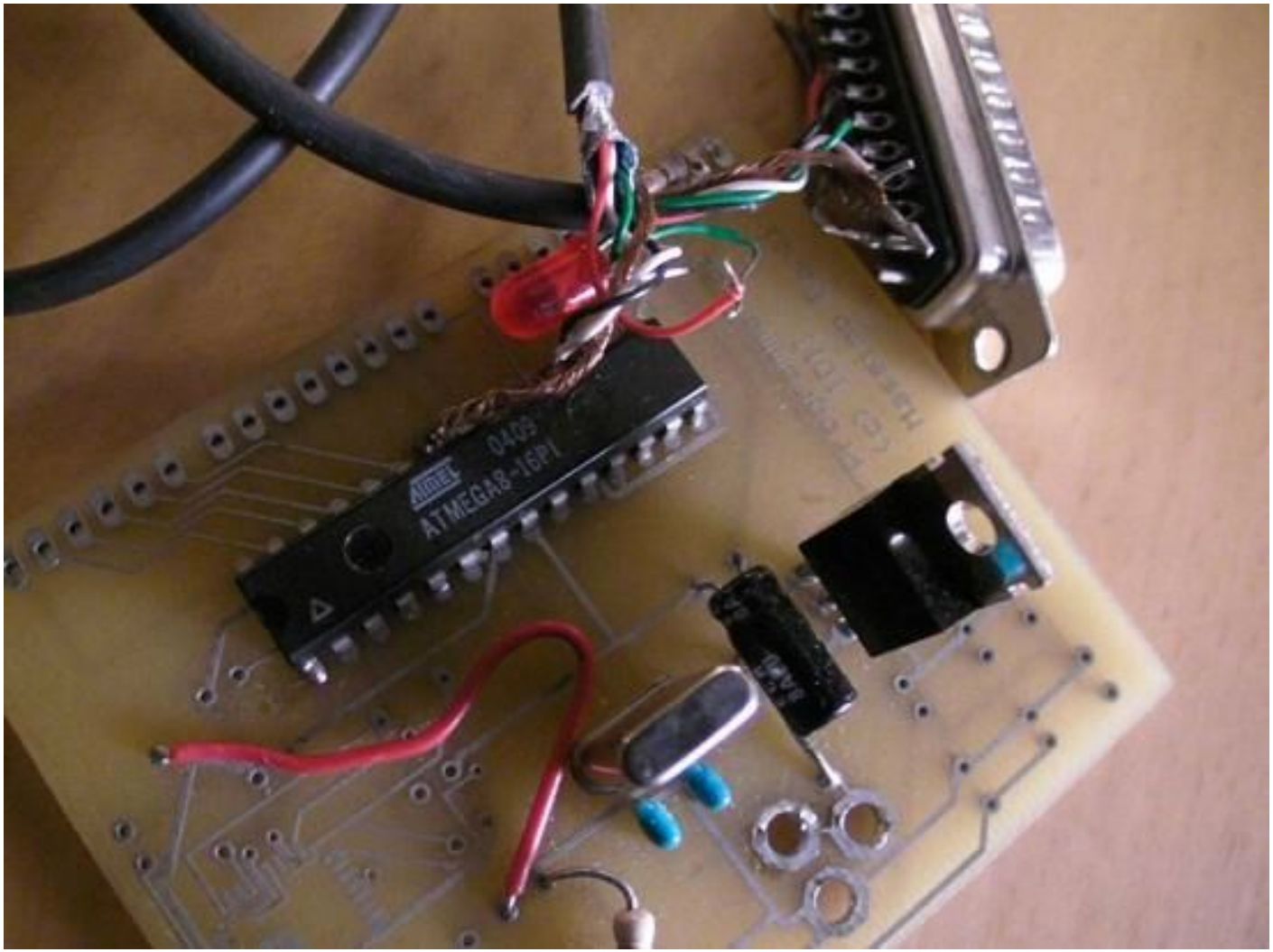
Shields and sensors

Some History of Arduino

- Arduino was born in 2005 in Ivrea, Italy
- **IDEA**: *less expensive device for controlling interactive electronic projects*
  - *Rapid prototyping*
- Name "*Arduino*" in honor of *Bar di Re Arduino*
- Start to produce boards in a small factory
- Arduino was built around the ***Wiring*** project of Hernando Barragan.
  - Hernando's thesis project at the Interaction Design Institute Ivrea.
  - Remove the deep knowledge barriers

Massimo Banzi

The First Protoype



Arduino Today

Google Trends - Web Search Interest: arduino - Worldwide, 2004 - present

Search terms

Arduino

+ Add term

Other comparisons

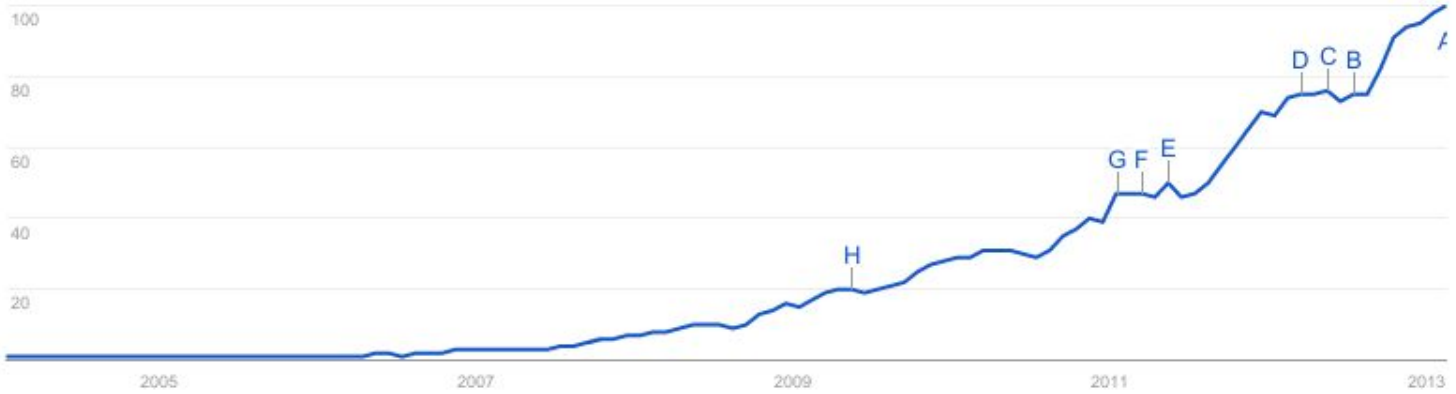
Limit to

Web Search

Worldwide

2004 - present

All Categories



Arduino community is mushrooming across the globe

Embed

Regional interest

80% from Europe and USA

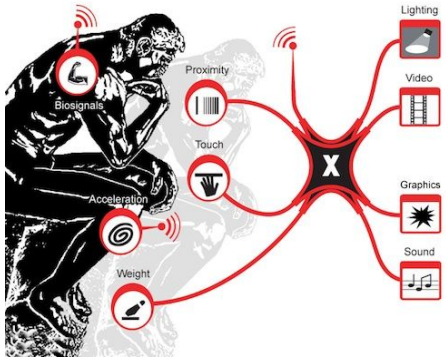
More than 200 distributors

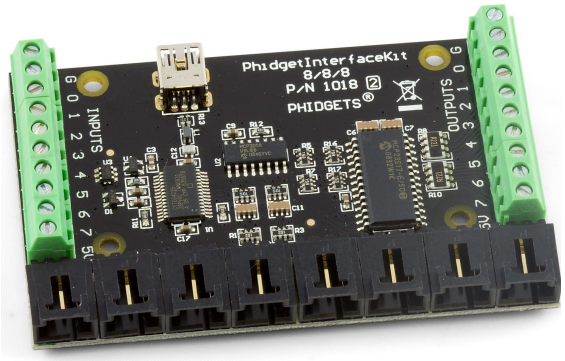
Related terms

Top | Rising

arduino uno	100
arduino shield	80
arduino projects	75
arduino serial	70
arduino led	70
arduino tutorial	50
lcd arduino	50

Some Competitors - 1





- **Lego Mindstorm**
  - Intelligent brick computer
  - Programmed in Brick Logo
  - Strong community
  - Too much expensive (cost: ~ $349)
- **i-cubeX**
  - Objects respond to human actions and environmental parameters
  - Human Interface Devices
  - Easy but expensive
- **Phidgets**
  - Easy-to-assemble sensors and controllers
  - Not open source (proprietary)
  - Requires less hardware and software knowledge
  - ~ 3.5 x the cost of Arduino board

Some Competitors - 2

- **Make Controller Kit**
  - More powerful CPU than Arduino
  - Has quite a lot of "*bang for the buck*"
- **Raspberry**
  - It is closer to a computer
  - Includes CPU, USB ports, Ethernet, HDMI, ...
  - Includes an own OS (Linux)
- **Teensy**
  - Same Arduino firmware
  - Compatible with Arduino
  - Very small size
- **UDOO**
  - Merges Arduino and Raspberry
  - Powerful prototyping platform
  - Linux or Android OSs

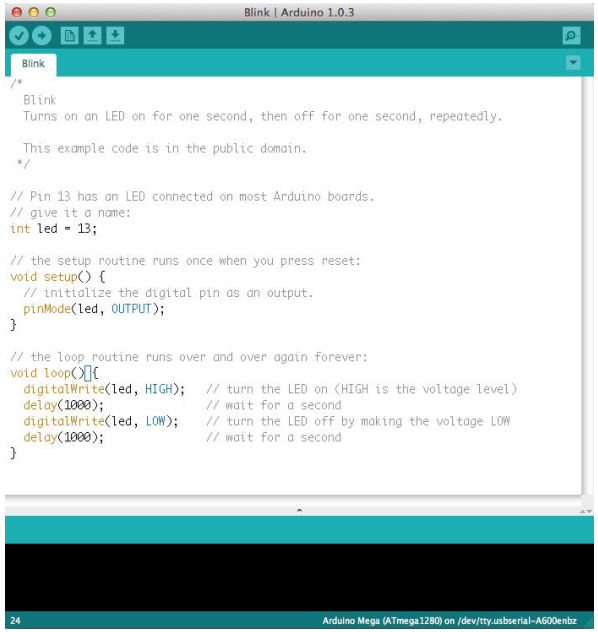
The three key concepts of Arduino Project

Hardware

Can sense the environment by sensors, and affects it by controlling lights, motors, and other actuators.

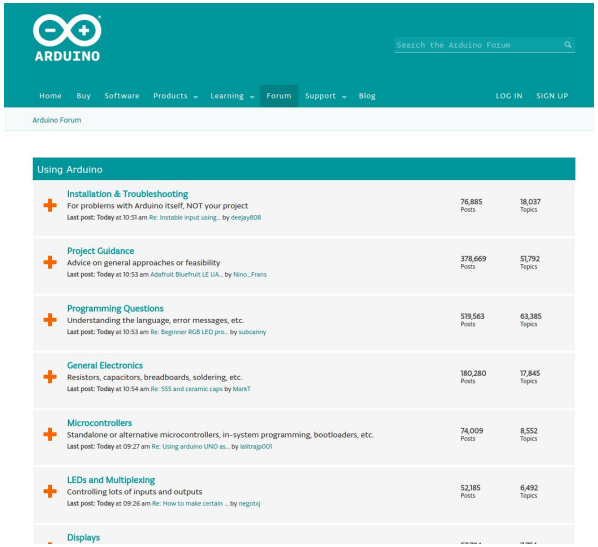
Environment

Allows to write code in the Arduino programming language and using the Arduino development environment.



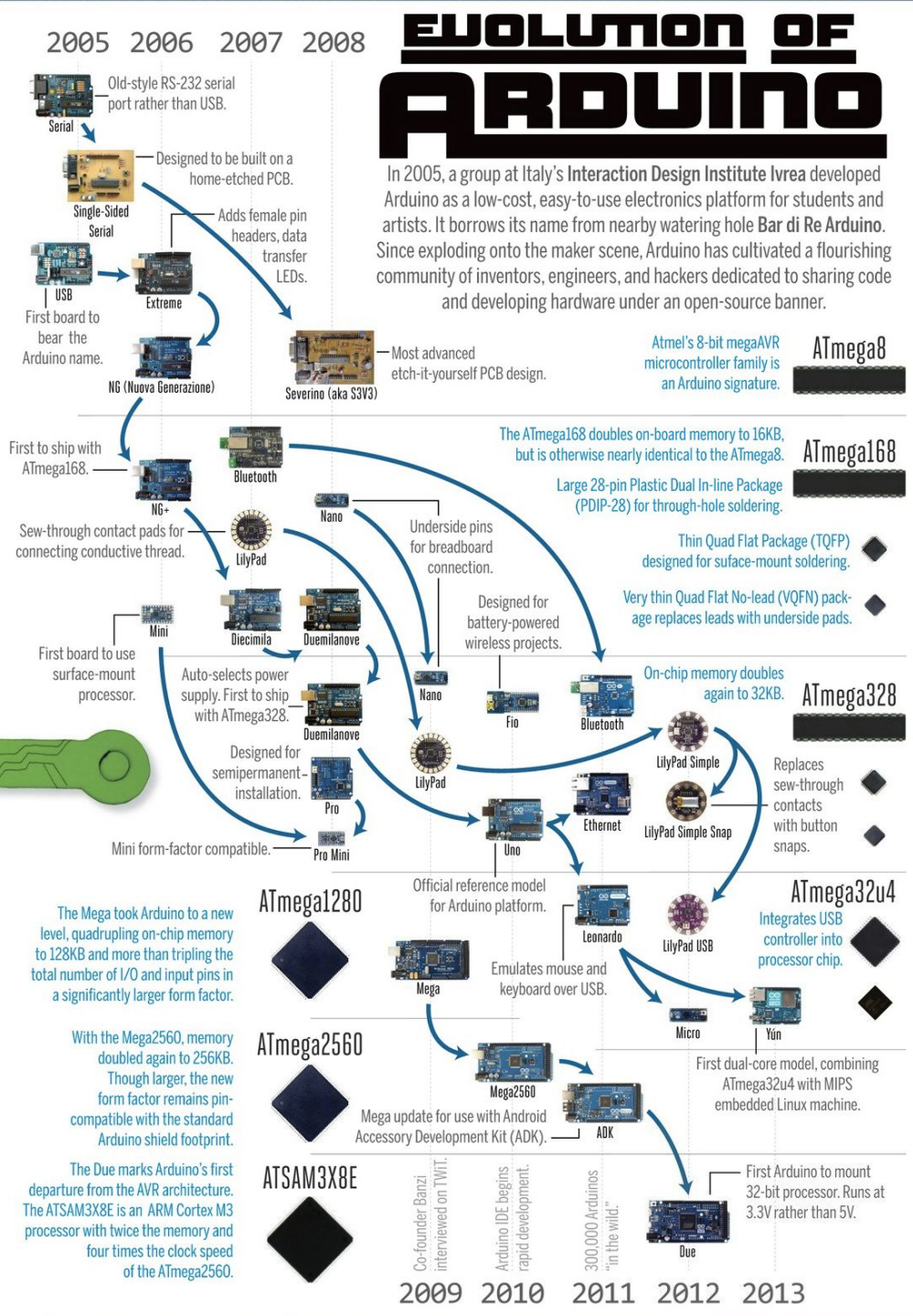
Community

It is made up of everyone from and to hobbyists, students, designers and engineers all across the world.



Why should we use Arduino?

- **Simple, academic purposes**
- **Open source**
  - **Hardware & Software:** permits to manufacture the boards and software distribution by anyone
    - Arduino compatibile: Canaduino, Freeduino, Linduino, SainSmart, ...
  - GNU Lesser General Public License (LGPL)
- Opportunistic **prototyping**
- **Community**
  - Wiki
  - Forum
  - Tutorials
- Could be used as an **IoT starting point**
  - Physical computing objects



- 2006: New Generation (NG)
  - ATmega168
  - First Mini Arduino
- 2007: Portable and communication
  - i-Bluetooth
  - Sew-through contacts pads
- 2009: Nano and LilyPad
  - New Arduino Mega with ATmega1280
- **2010**: Rapid development
  - **Official Arduino Uno**
- 2012: Miniaturization and CPU power enhance
    - LilyPad Simple/Snap and Micro
    - Arduino Due (32 bit)

Evolution of Arduino

- 2013: 700.000 official boards were sold
- 2016: **17** versions of the Arduino board have been commercially produced.


Arduino Uno


Arduino Leonardo


Arduino Mega ADK


Arduino Ethernet


LilyPad Arduino SimpleSnap


LilyPad Arduino


Arduino Due


Arduino Yún


Arduino Mega 2560


Arduino Mini


Arduino Nano


Arduino Pro Mini

Arduino Tre


Arduino Micro

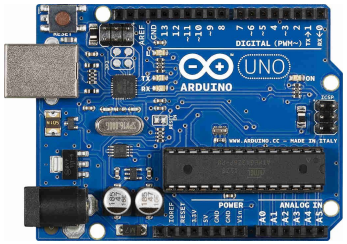

LilyPad Arduino USB


LilyPad Arduino Simple


Arduino Pro

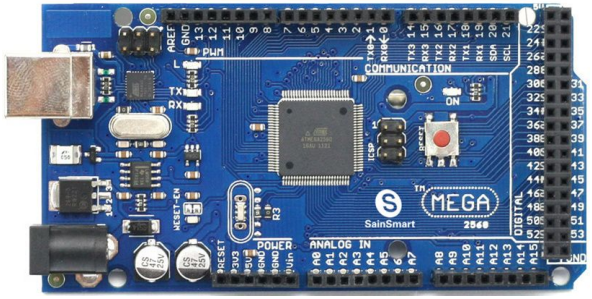

Arduino Fio

Some Current Arduino Boards



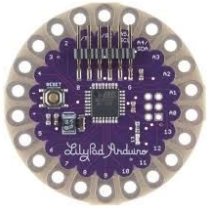
UNO

- Current official reference of Arduino Boards
- Most used and documented board



Mega

- Designed for more complex projects
- 54 digital I/O pins, 16 analog inputs
- ATmega2560



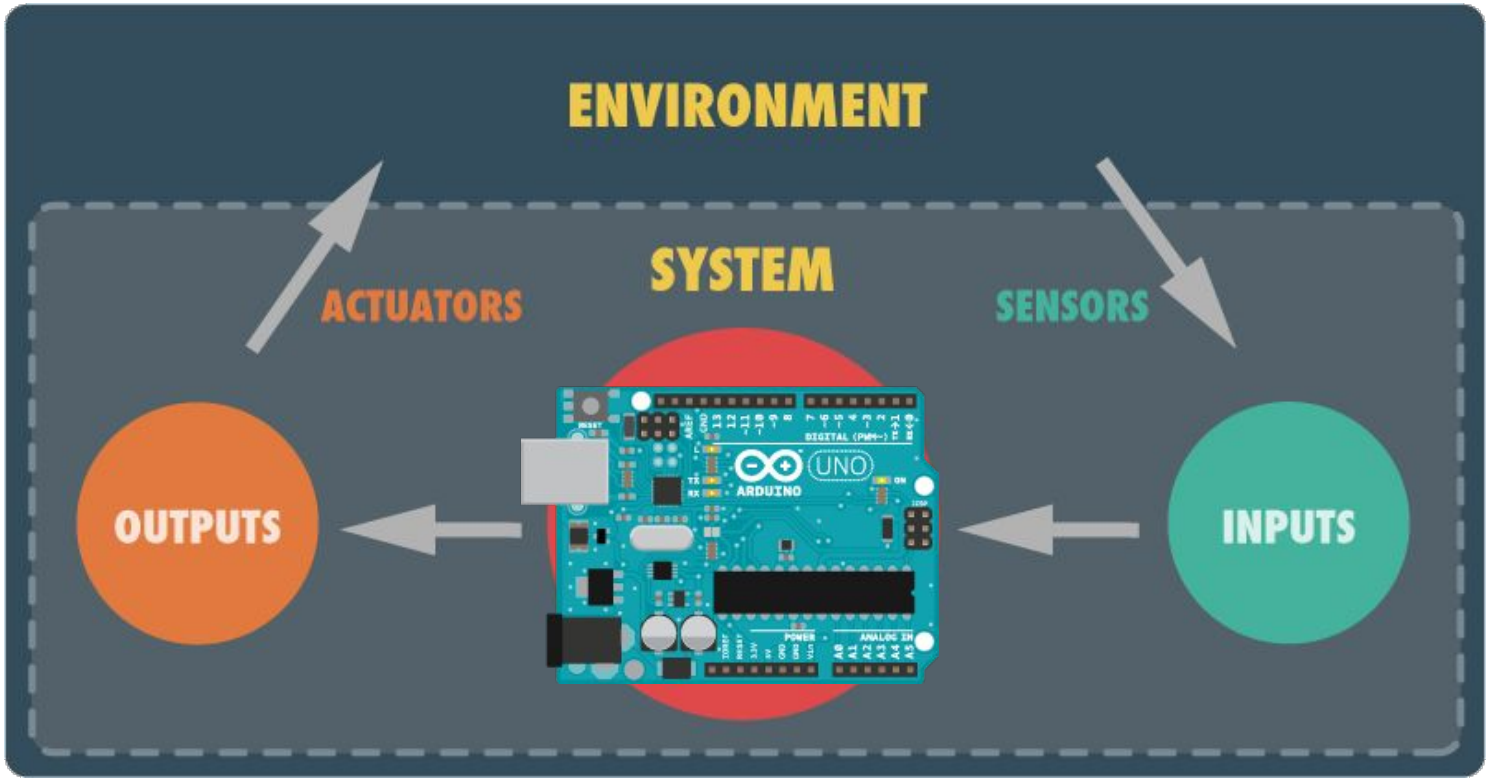
LilyPad

- Designed for e-textiles and wearables projects
- Can be sewn to fabric and to power supplies

Nano

- Compact board similar to the UNO

Arduino as Physical Computing Platform

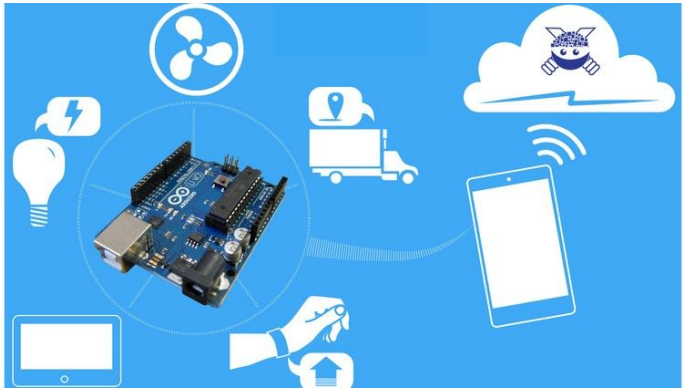


Physical Computing involves the design of interactive objects that can communicate with humans using sensors and actuators controlled by a behaviour implemented as software running inside a microcontroller.

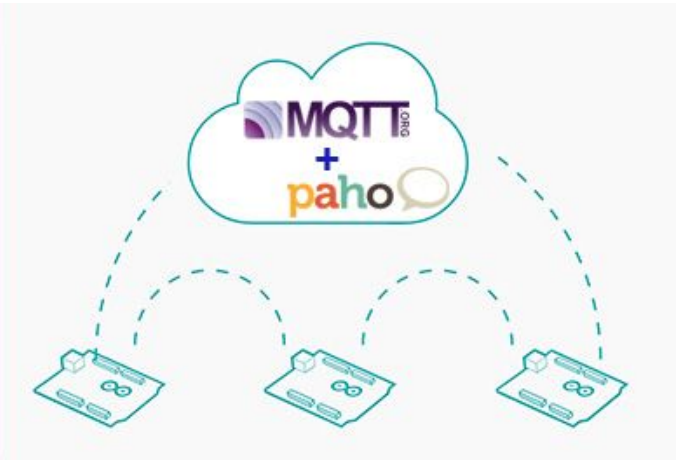
Smart Objects in the Internet Of Things

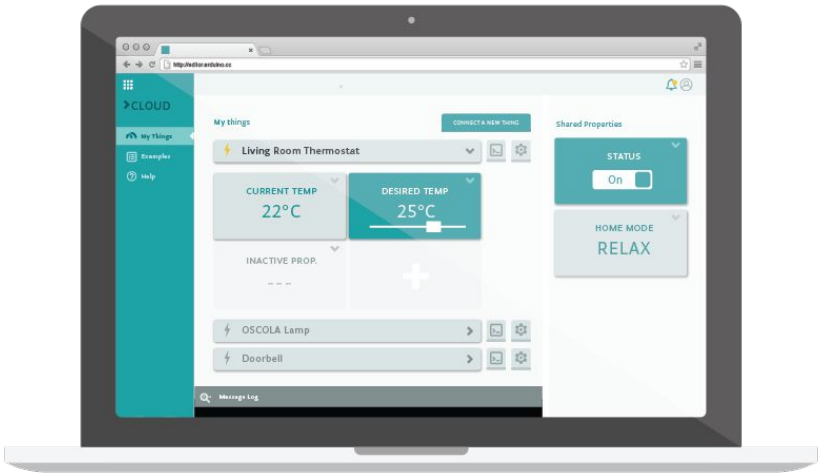
IoT is a new emerging technology where the things are connected altogether and interact

- Arduino provides the tools
  - Remote processing of data
  - Connection of physical objects to the Internet
- IoT Manifest
  - **Open** SW & HW:
    - Possibility to share works
    - More innovation
  - **Sustainable**
    - Devices should be easily upgraded
  - **Fair**
    - You should have control of your devices
    - Security



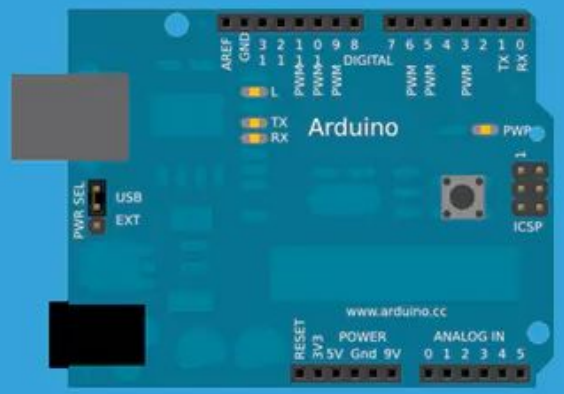
Arduino Cloud

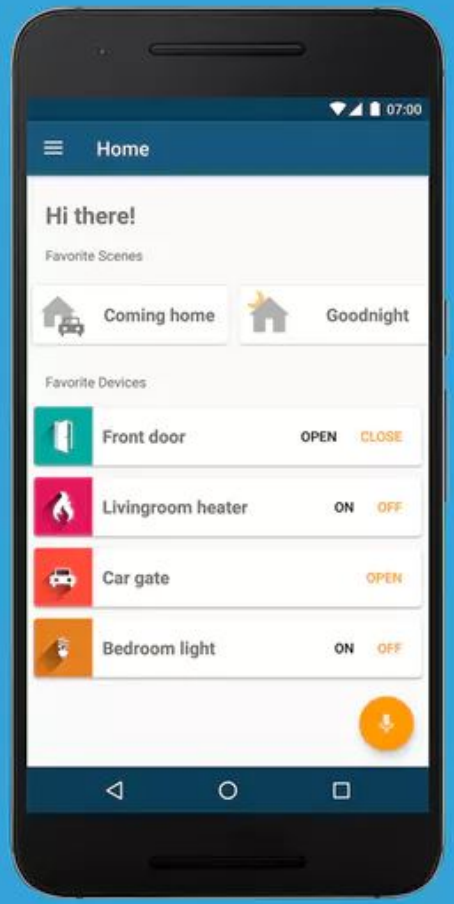




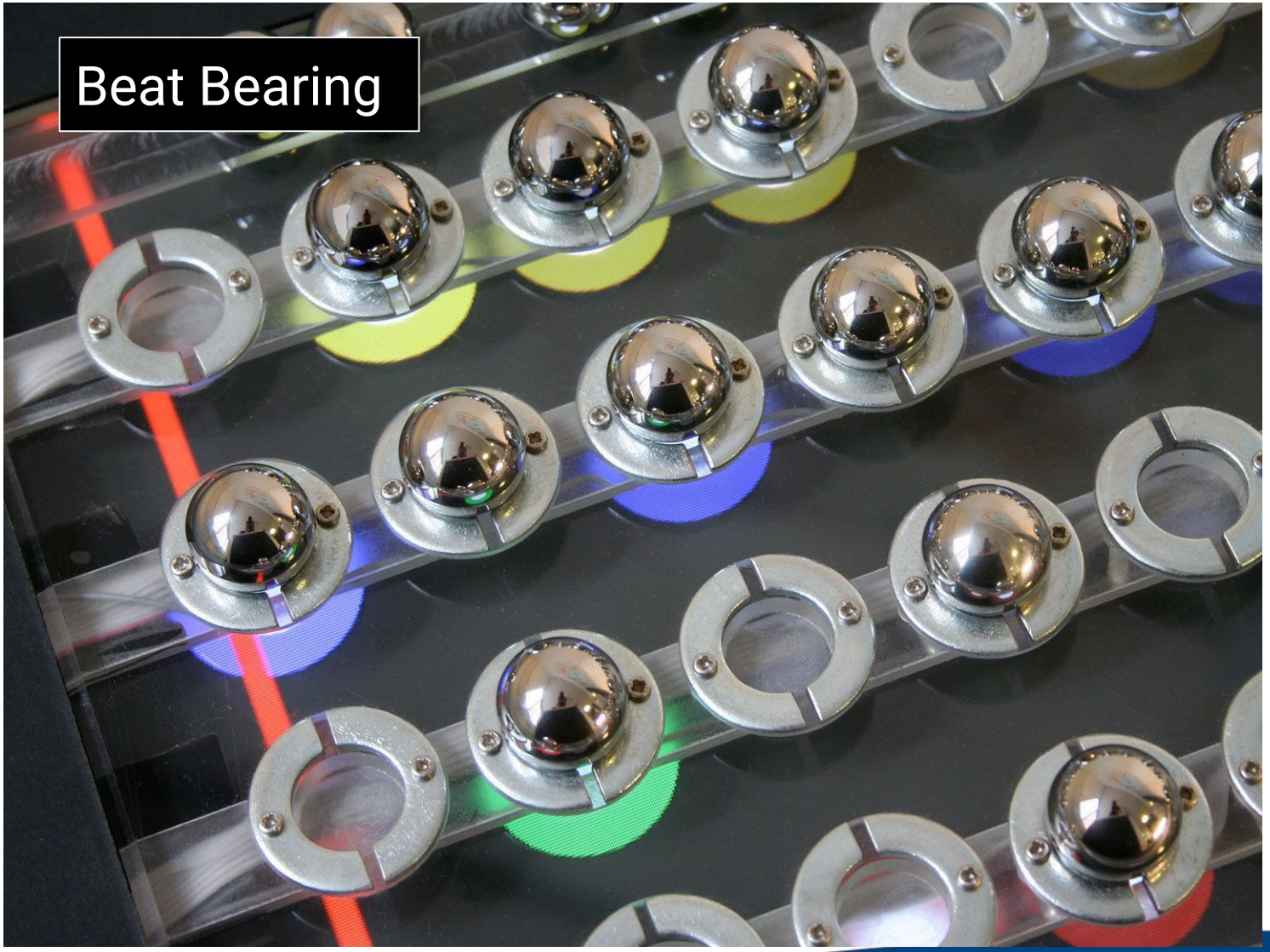
- A new platform to make building IoT
- Creation of tools that allow connection and control of device on/by the Internet
- MQTT broker makes connection between each object

Arduino & Android Home remote control

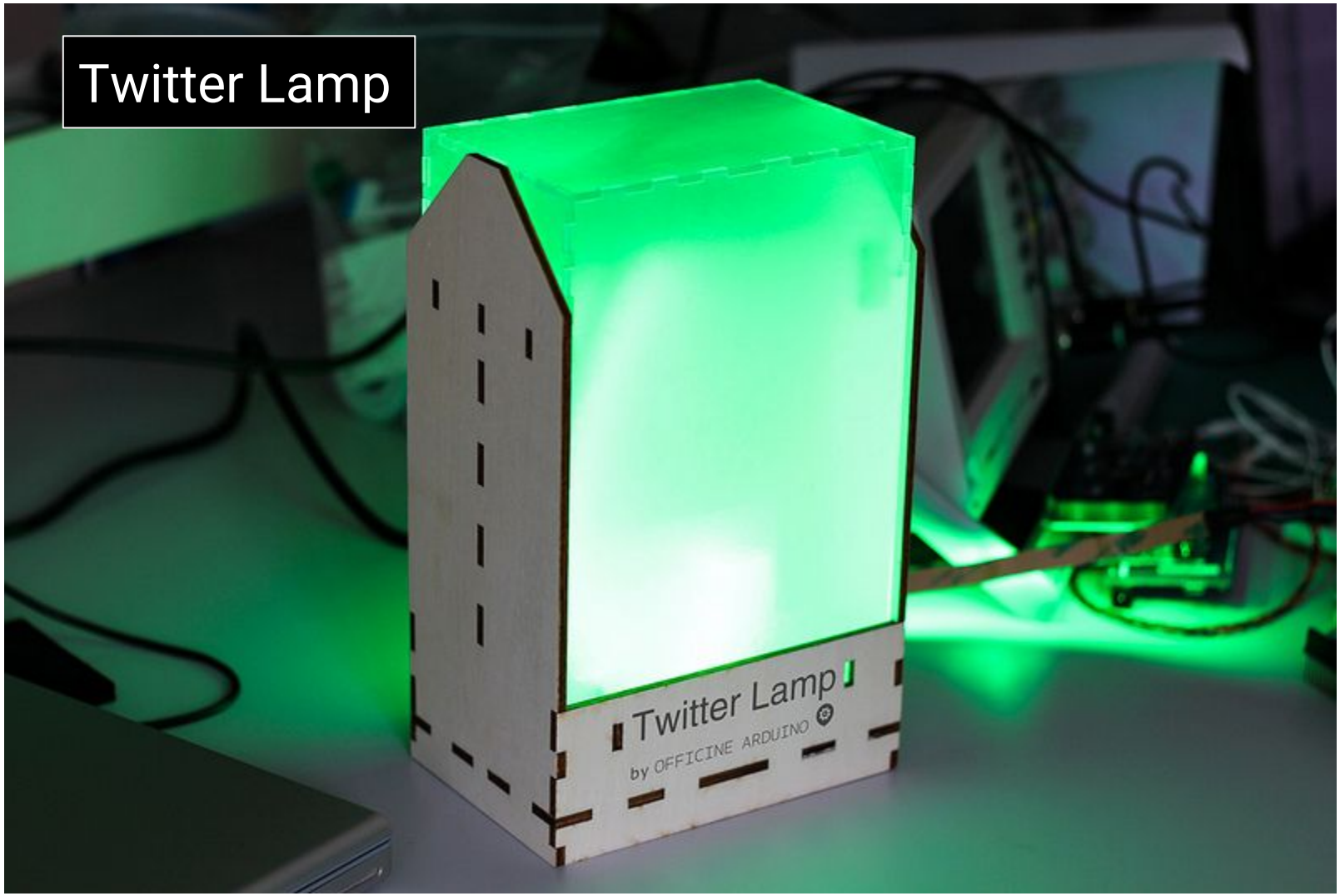




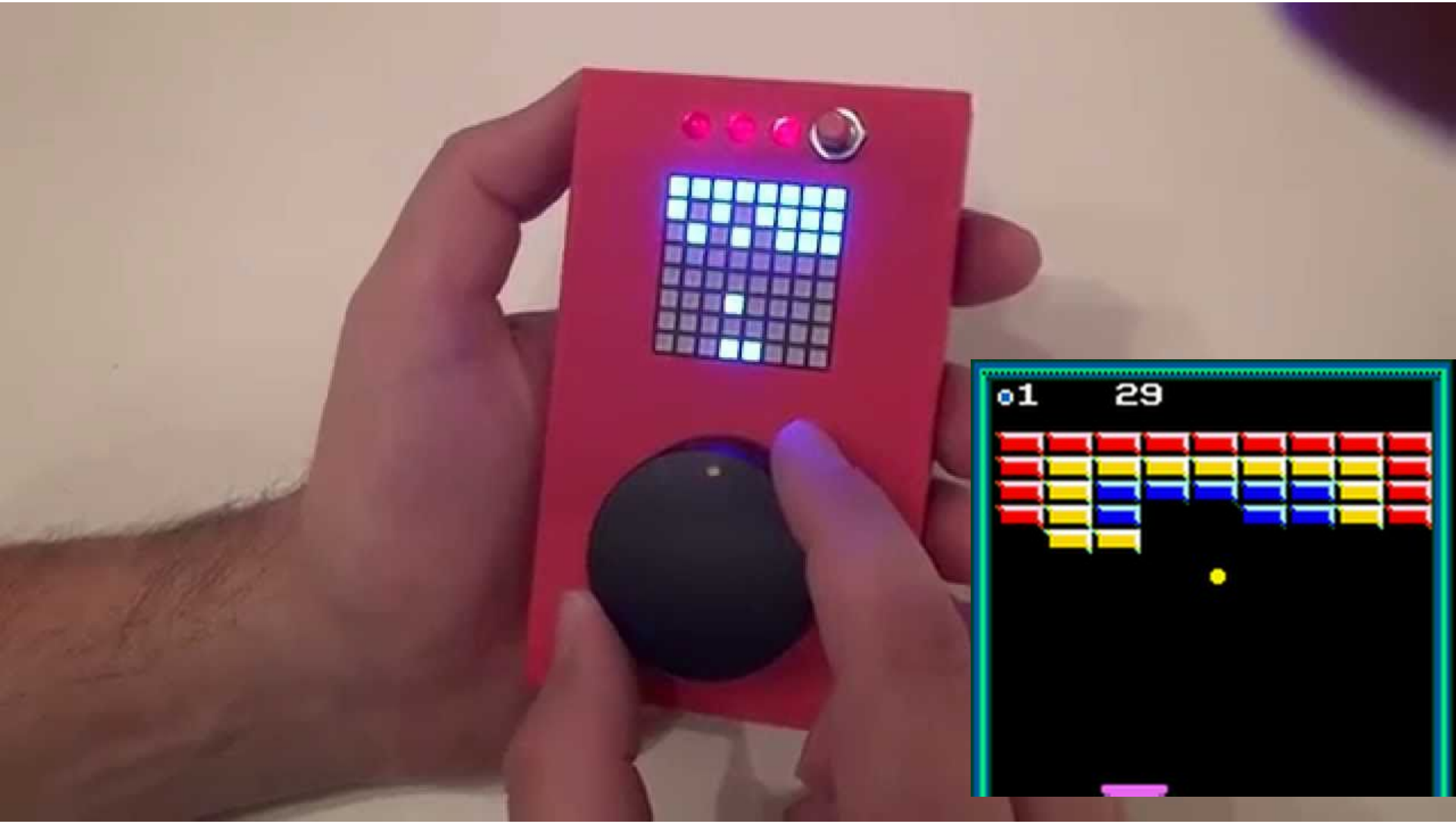
Arduino Usage Examples



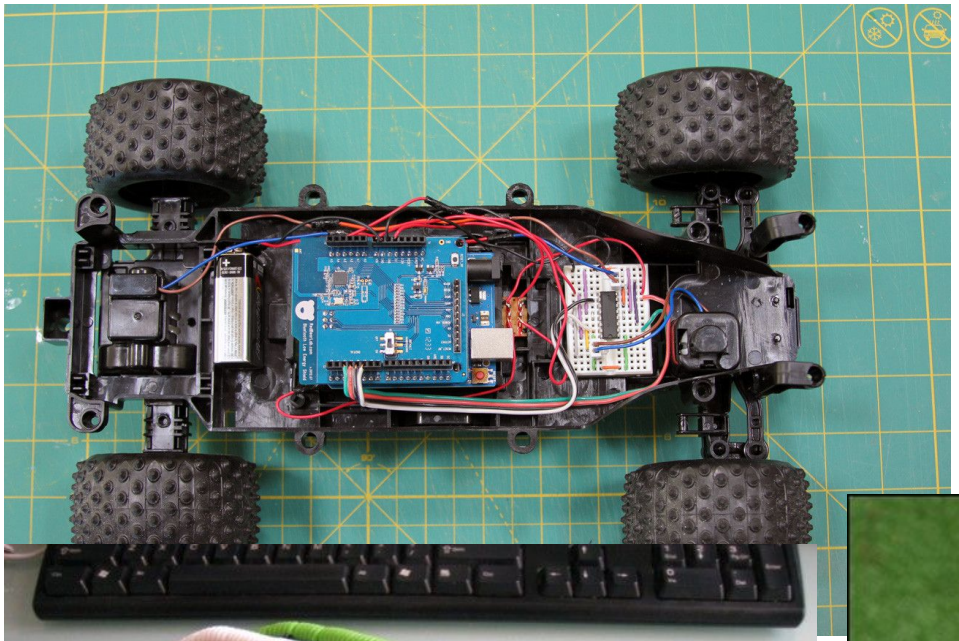
Arduino Usage Examples

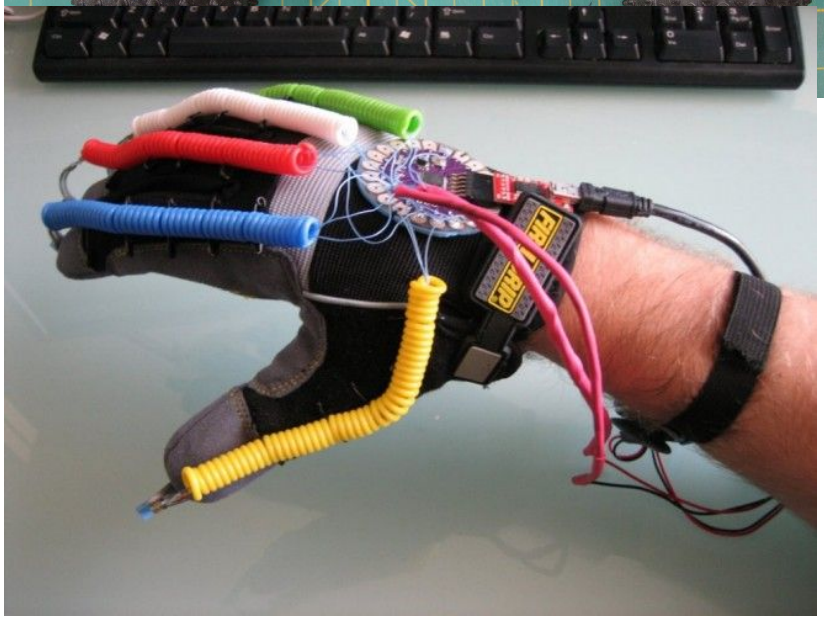


TeleBall (Breakout game)



Other Examples

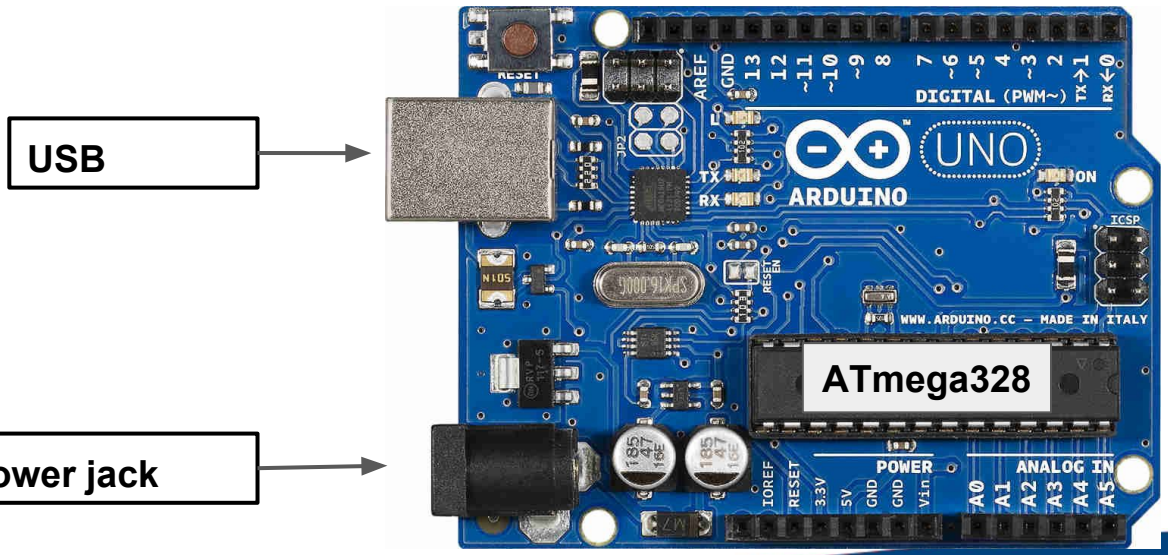




Arduino Architecture and Components

Main components

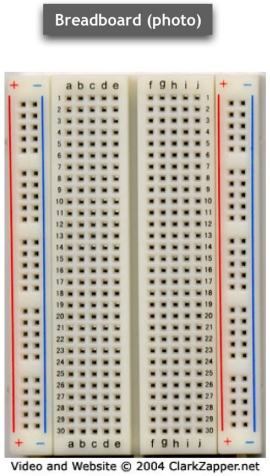
- AVR Microcontroller
- Analog and digital I/O pins
- Flash memory
  - Integrated in the microcontroller
- USB port for serial communication

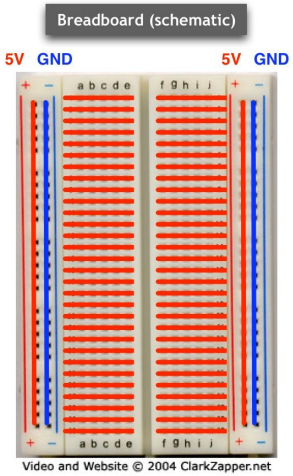


Components: mandatory

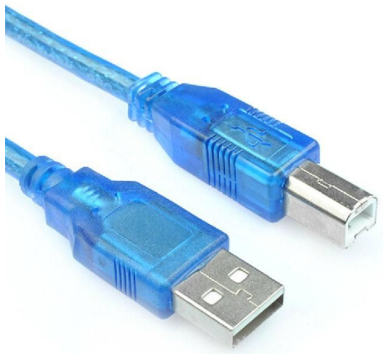
Wires

Prototyping board (breadboard)

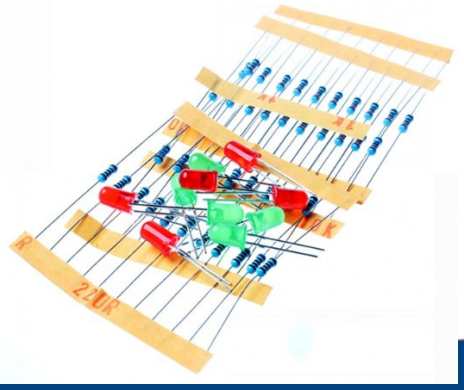




USB connector

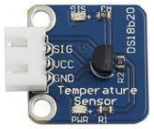


Resistors and leds

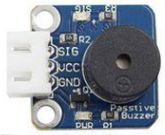


Components: I/O devices

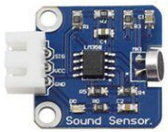
Barometer



DS18B20 Temperature



Passive buzzer



Sound Sensor

Mercury Switch

Rotary Encoder

Tracking sensor

Auto-flash LED

Dual-color LED

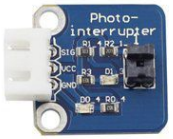


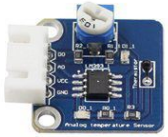
Photo-interrupter

Switch Hall


Obstacle Avoidance

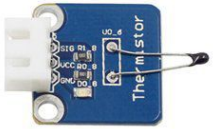
RTC-DS1302

Ultrasonic


Analog temperature

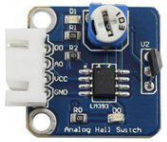
Flame Sensor

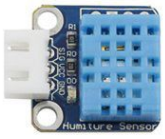
Photoresistor



Thermistor module

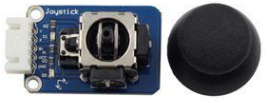

ADDA Converter


Analog Hall

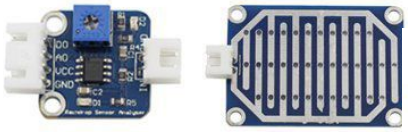


Humiture sensor

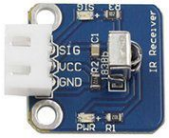
Potentiometer


Joystick PS2 module

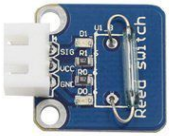
Color Sensor


Raindrop Sensor

Active buzzer

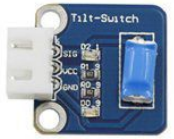


Infrared-Receiver



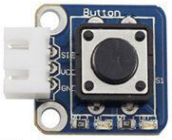
Reed Switch

MQ-2 Gas Sensor



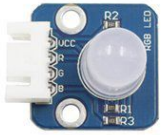
Tilt Switch

Touch Switch



Button module

Laser Transmitter

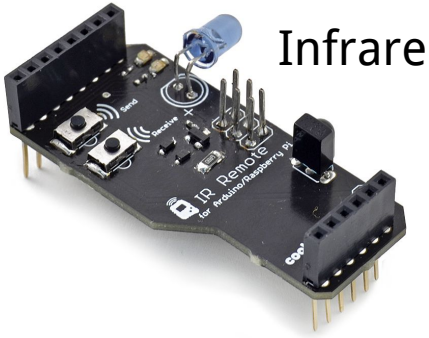


RGB LED

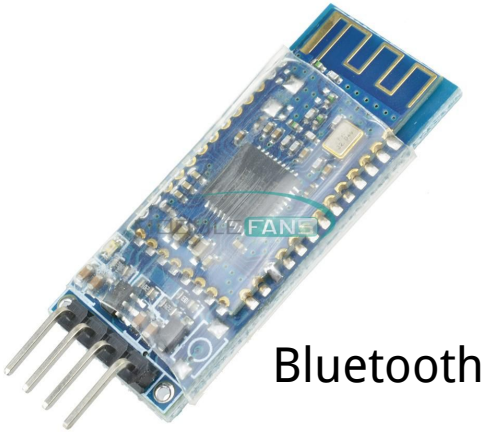
Relay Module

Wired and Wireless comm. devices

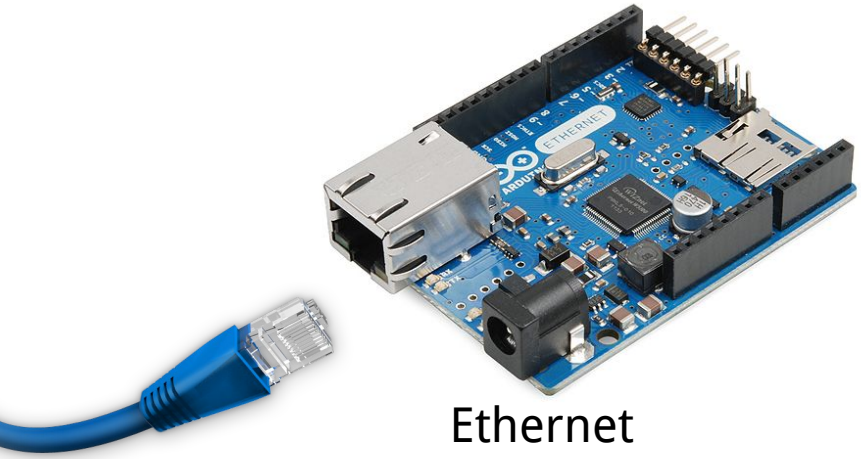
WiFi



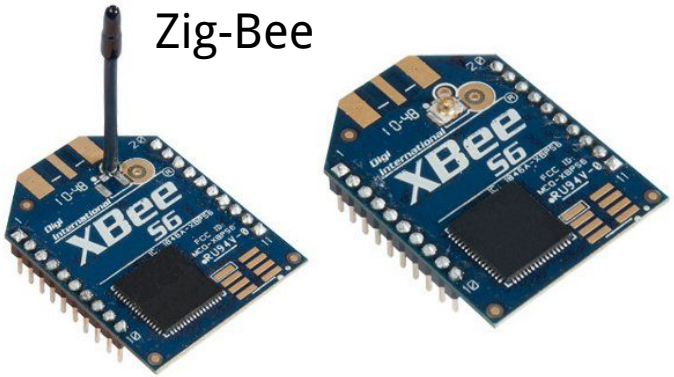
Infrared



Bluetooth

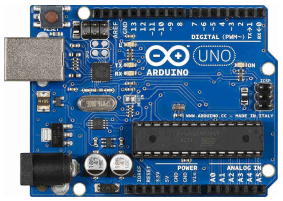


Ethernet



Zig-Bee

Arduino UNO (ATmega 328)



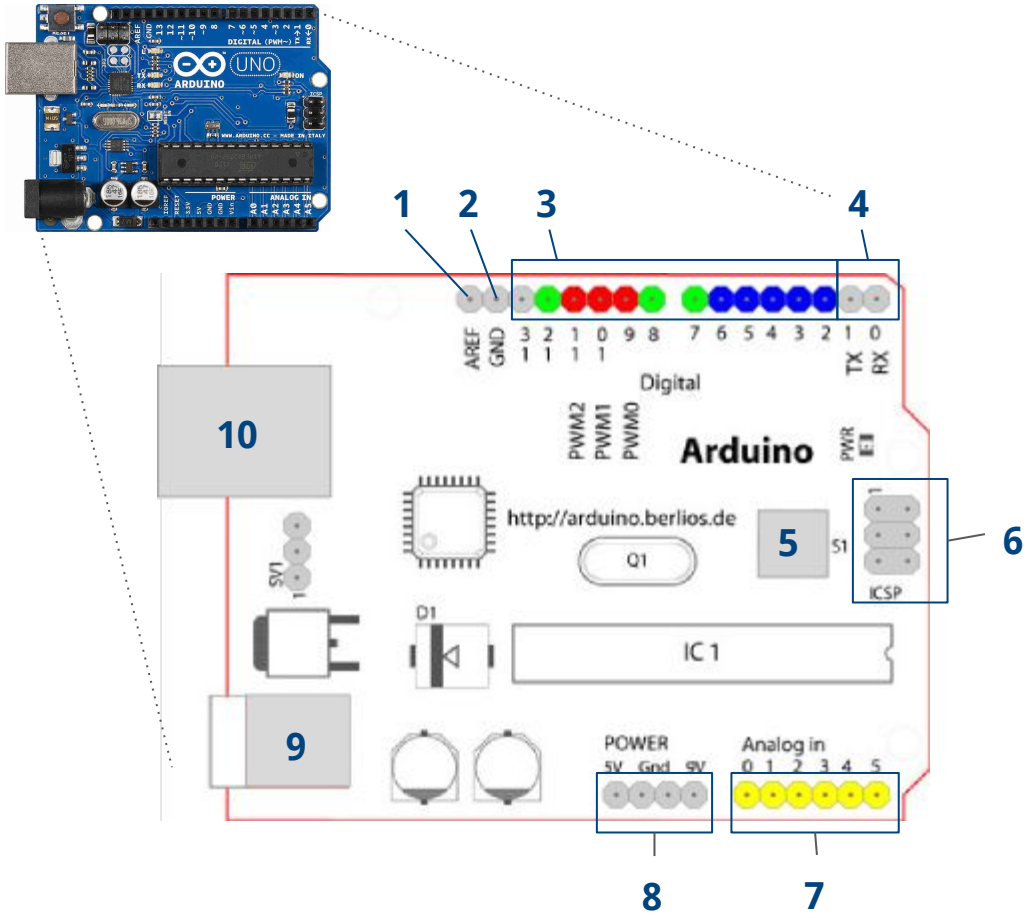
Technical characteristics

- Clock speed: 16 MHz (*Intel 286*: 12.5 MHz) - 8-bit
- Flash program memory: 32 KBytes (0.5 used by bootloader)
- SRAM: 2 KBytes
- Input / Output
  - 14 digital input/output pins
  - 6 analog input pins
  - 6 analog output pins (PWM)

Characteristics - 2

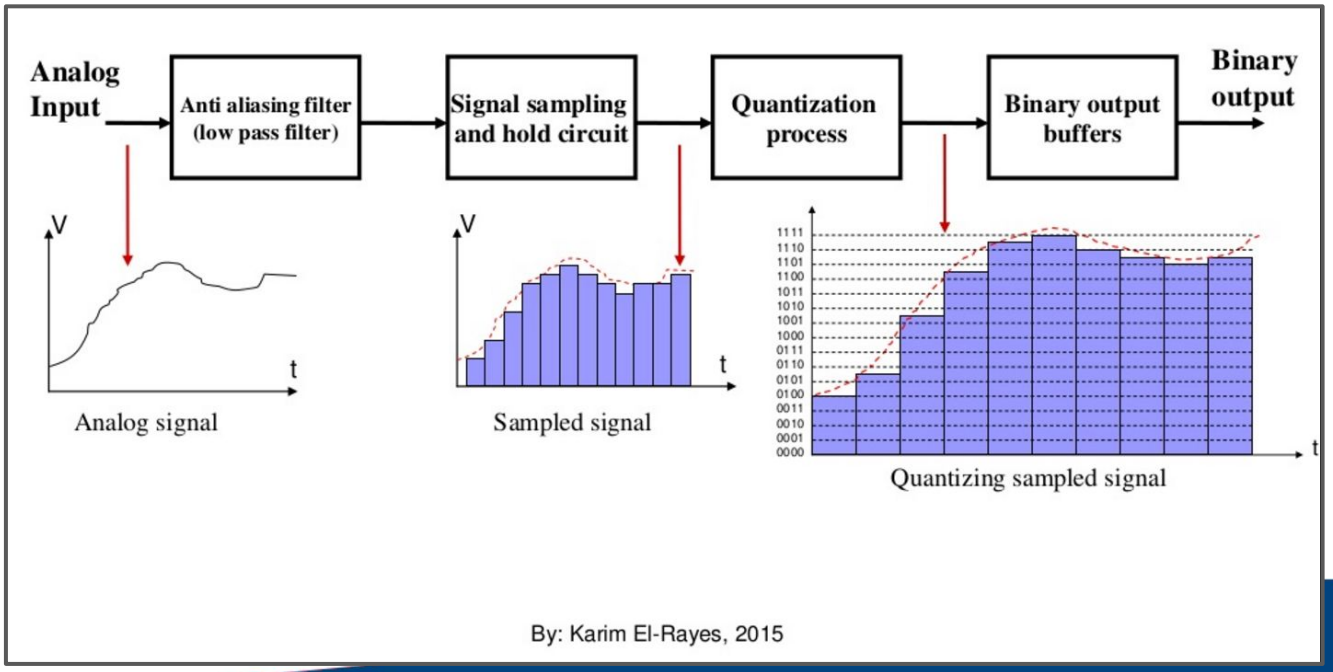
Layout of Arduino UNO

1. Analog Reference pin
2. Digital Ground
3. Digital pins 2-13
4. Digital pins 0-1/Seral In/Out
5. Reset Button
6. In-circuit Serial Programmer
7. Analog In pins 0-5
8. Power and Ground pins
9. External Power Supply In
10. USB port



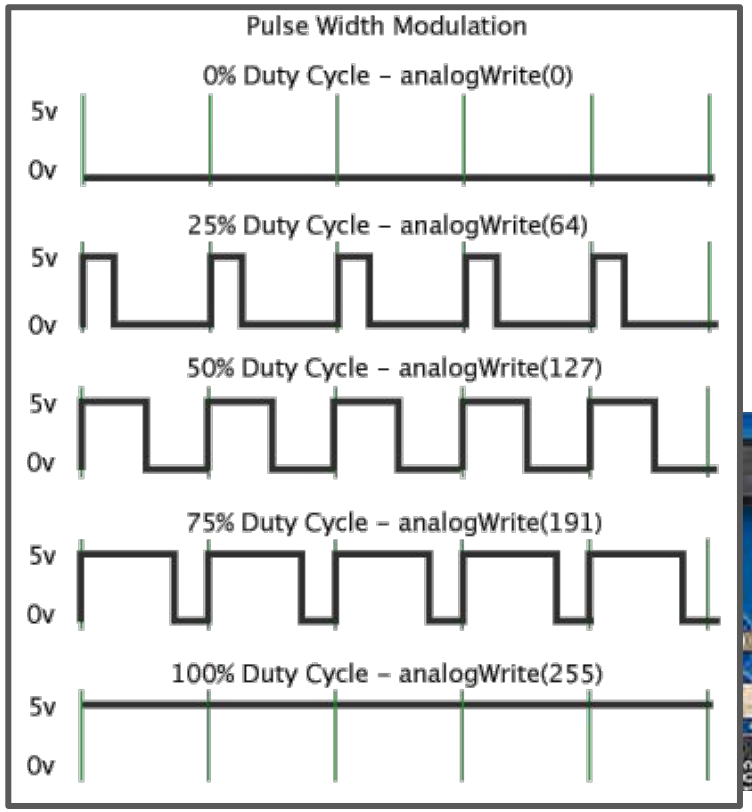
Digital and Analog pins

- Digital pins have only two values on/off (0/1)
  - Arduino UNO has 14 digital I/O pins
  - To connect devices that read/produce digital values (switch, leds, ...)
- Analog pins use many states using quantization
  - Arduino UNO has 6 input analog pins
  - To read analog sensors (temperature, pressure, ...)
  - An A/D converter of 10 bit returns integers from 0 to 1023



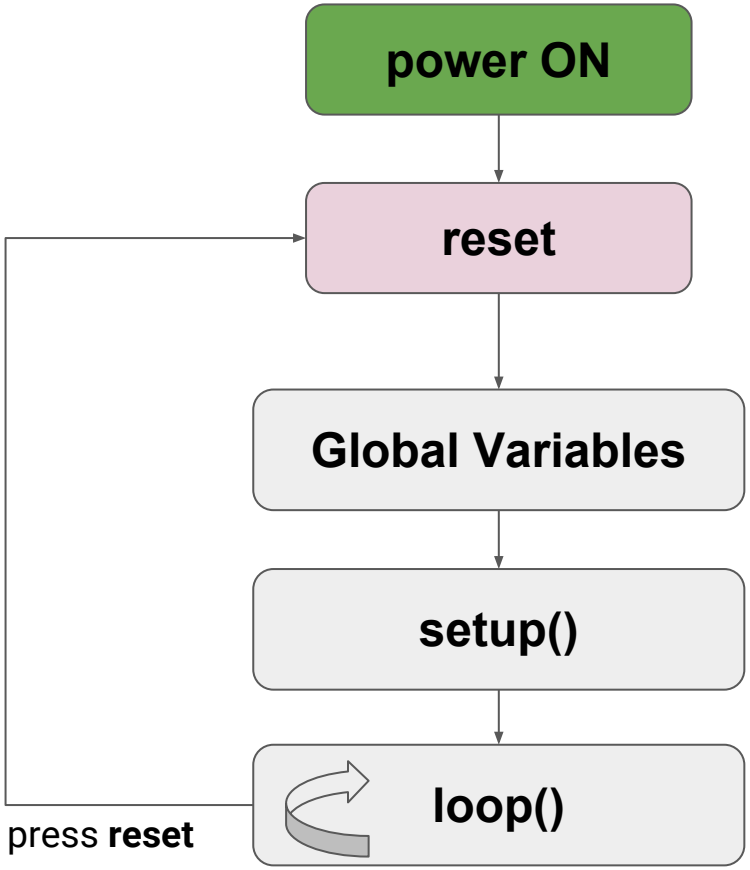
Digital and Analog pins

- Analog output pins use PWM technique
  - Arduino UNO has 6 digital pins used as PWM (~)
  - The signal is affected on the input pulse duration



Programming in Arduino

Life Cycle of a program

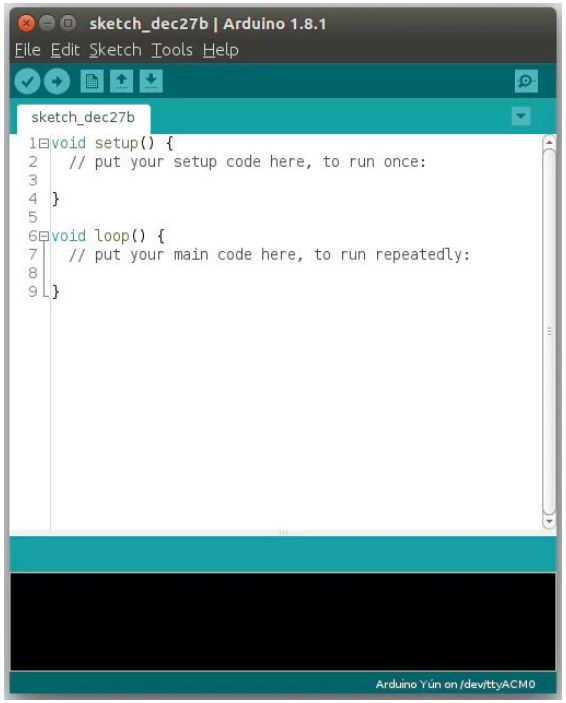


- Declare variables
- Initialize variables

- Run once at beginning
- Set pins

- Run the main program
- Repeatedly, after the setup

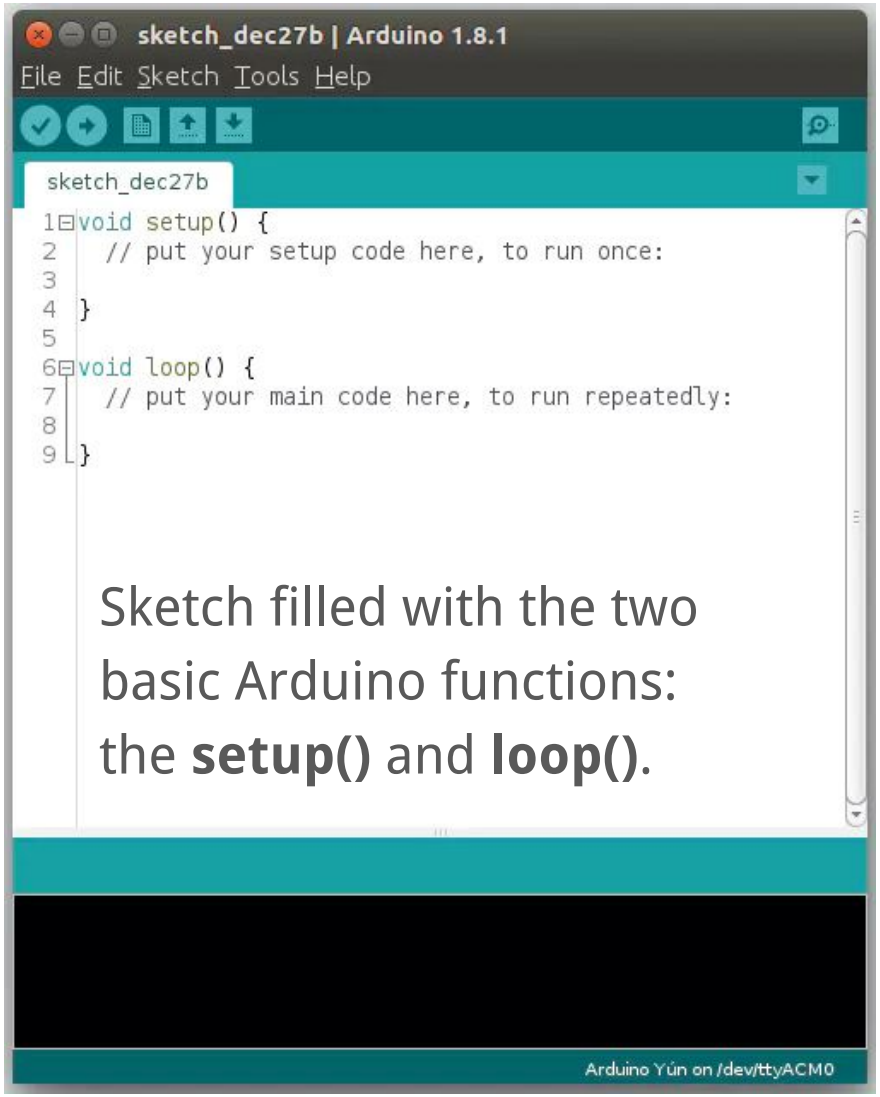
Arduino IDE software



- Friendly Multi Platform application written in Java
- Allows you to write programs and upload them to your Arduino board
- Derived by "Processing" IDE
  - Initially developed in 2003 to simplifies electronic projects
- Very simple for novice programmers
  - Simple programming language
  - Bootloader

- Source code of IDE and library are distributed under the free GNU GPLv2 license

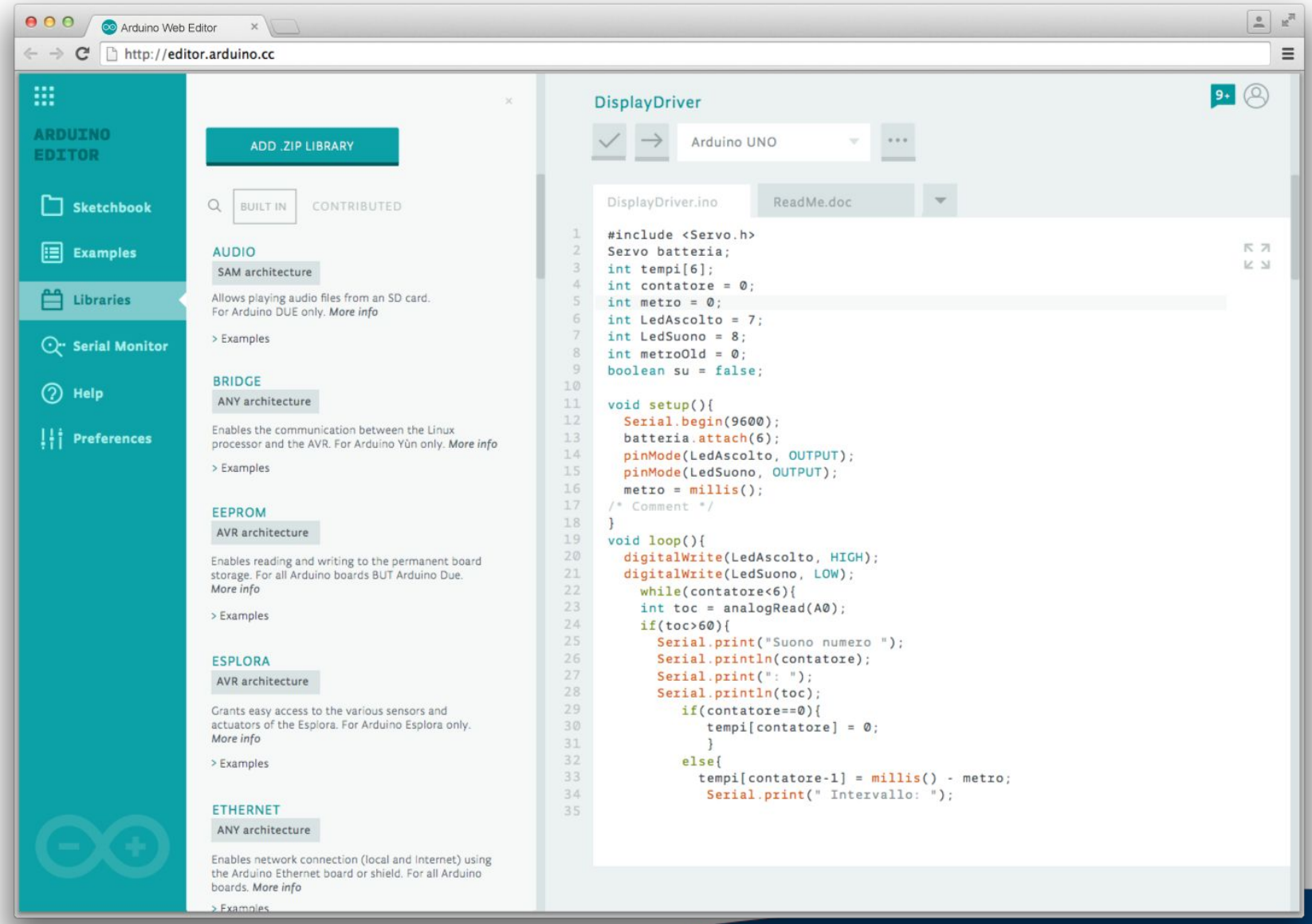
Arduino IDE software



Sketch filled with the two basic Arduino functions: the **setup()** and **loop()**.

- **Text editor** containing syntax highlighting and automatic indentation
- **Toolbar**
- **Text Console**
- **Compiler**
- **Serial monitor** to debug
  - Allows you to read the data that Arduino communicates through the COM serial port

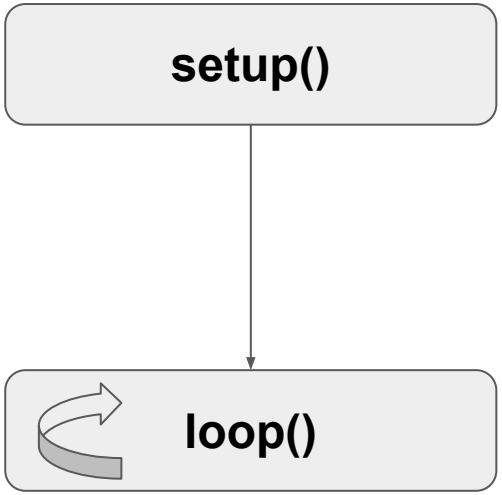
Online IDE - Web Editor



Wiring-based Language

- Open Source computer programming language
- Derived by C/C++ language
  - With some slight simplifications and modifications
  - Includes classical libraries and functions
    - Data types (Integer, float, long, character, ...)
    - Operators (Mathematical, logical, comparison, ...)
    - Control statements (If, switch/case, while, for, ...)
- Offer to the programmer simple access to I/O devices
- Wiring programs are called ***sketch***

Some functions



- `pinMode(pin, Input|Output)` set pin ledPin as an input or output
- `Serial.begin(9600)` talk to the computer at 9600 baud rate
  - Some values: 300, 600, 1200, 2400, 4800, 9600, 14400, 19200, 28800, 38400, 57600, or 115200

- `Serial.print(" ... ")` write text on Serial Monitor
- `digitalWrite(pin, HIGH|LOW)` set a digital pin high/low
- `digitalRead(pin)` read a digital pin's state
- `analogRead(pin)` read an a analog pin
- `analogWrite(pin, intValue)` write an "analog" PWM value
- `delay(milliseconds)` wait an amount of time

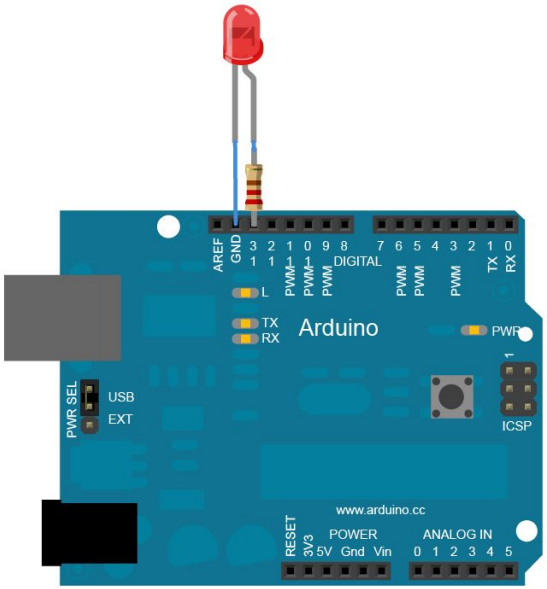
Arduino's Hello World: LED blinking


```
/*
     Blink
     Turn on and off a LED every one second
 */

int ledPin = 13; // LED connected to digital pin 13

void setup()
{
     Serial.begin(9600);
     pinMode(ledPin, OUTPUT); // sets the digital pin as output
}

// the loop routine runs over and over again forever:
void loop()
{
     digitalWrite(ledPin, HIGH);   // turn the LED on (HIGH is the voltage level)
     delay(1000);                  // wait for a second
     digitalWrite(ledPin, LOW);    // turn the LED off by making the voltage LOW
     delay(1000);                  // wait for a second
}
```



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Initialise the variable with the pin number

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Setup the serial connections and LED

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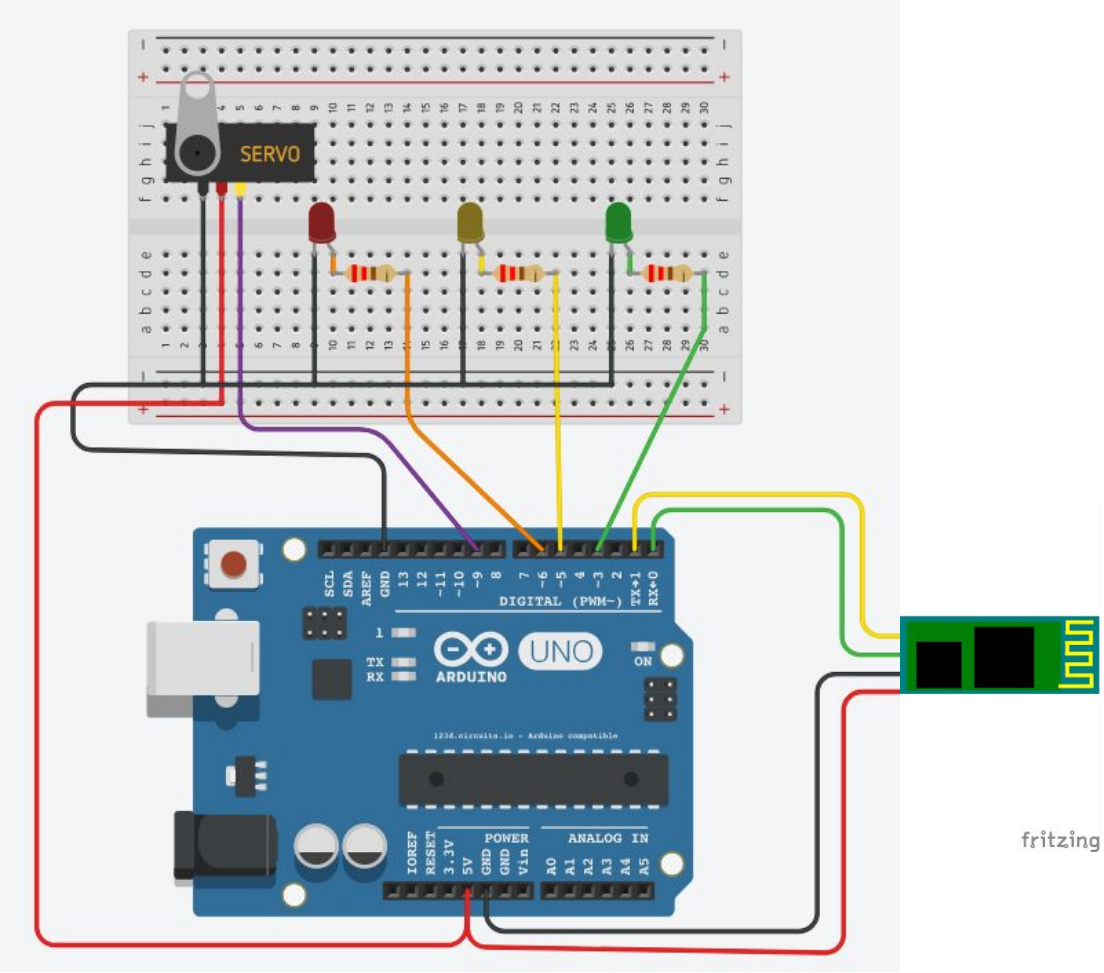
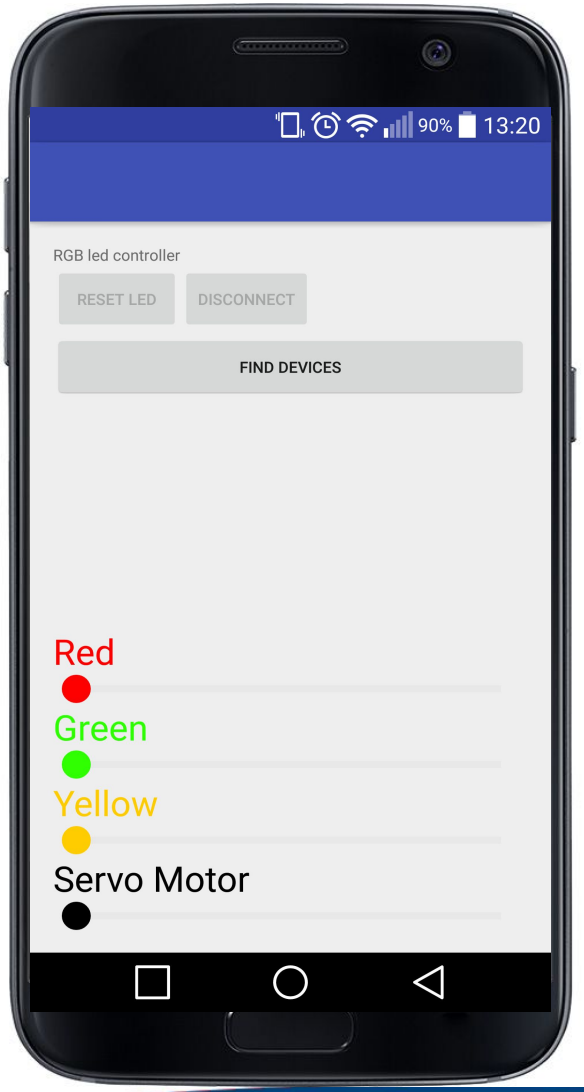
     delay(1000);                  // wait for a second
     digitalWrite(ledPin, LOW);    // turn the LED off by making the voltage LOW
     delay(1000);                  // wait for a second
}
```

Turn the LED on and off continuously in the loop

LED and Servo control via Android Application





Thank you for the attention

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