ARDUINO
family of boards
for Internet of Things - IoT

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What is IOT?

- IoT consists of many small computing devices capable of interacting with environment and which are at the same time connected to network
- Interaction with environment means that devices can measure some physical characteristics that are important, and that can also act upon the environment in order to change some environmental physical characteristics.
- Network connection enable both transfer of data and commands for initiation of various actions
- IoT is very convenient to be implemented with various Arduino boards that can be programmed and interconnected in various ways

ARDUINO members

- General purpose ARDUINO boards
  - MCU only boards
  - Combined MCU / MPU boards
- Special purpose ARDUINO boards
  - ARDUINO Esplora
  - ARDUINO Robot
- ARDUINO compatible boards
  - Intel Galileo, Gen 2
  - Intel Edison
- ARDUINO shields
  - Ethernet, WiFi, GSM, Motor, Relay and others

MCU versus MPU

ARDUINO

- MCU (Micro Controller Unit)
  - Real time predictable
  - Self contained
  - Limited memory
  - Used for embedded tasks
  - Price: CHEAP
- MPU (Micro Processor Unit)
  - No real time
  - Not self contained
  - Limitations less strict
  - Used for general purpose
  - Price: EXPENSIVE
- MCU & MPU are complementary!

General purpose MCU only boards

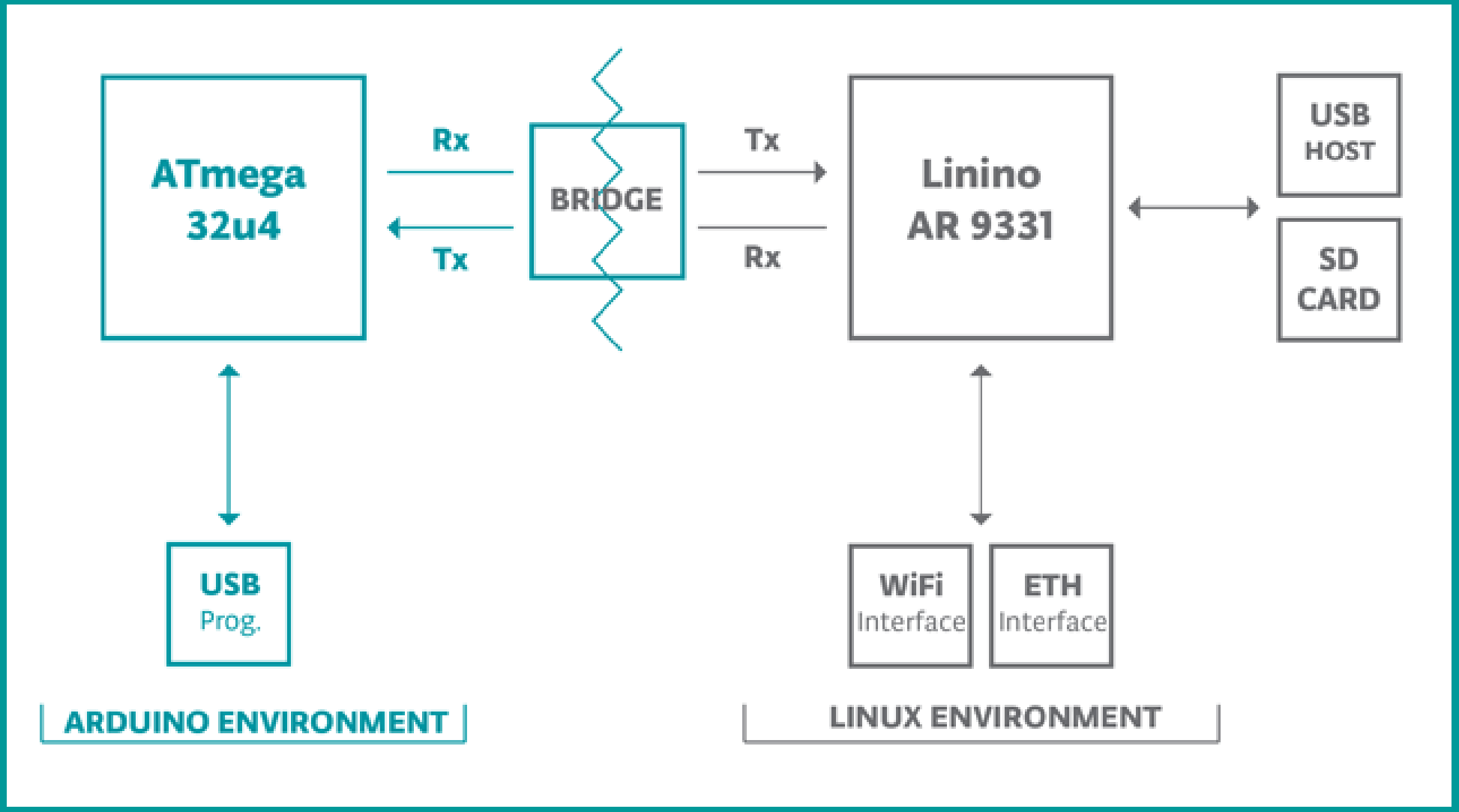
- ARDUINO UNO - Atmel AVR ATmega 328
- ARDUINO Ethernet - Atmel AVR ATmega 328
- ARDUINO Leonardo – Atmel AVR ATmega 32u4
- ARDUINO Leonardo ETH – Atmel AVR ATmega 32u4
- ARDUINO Mega – Atmel AVR ATmega 2560
- ARDUINO M0 – Atmel ATSAMD21G18 based on ARM Cortex M0 processor
- ARDUINO Due - Atmel SAM3X8E based on ARM Cortex-M3 CPU

General purpose MCU & MPU combined boards

- ARDUINO Yun – ATmega 32u4 & Atheros AR9331 processor – Linux, WiFi, Ethernet, microSD card, USB host

- ARDUINO Tian - Atmel SAMD21 MCU, based on 32-bit ARM Cortex® M0 core & Qualcomm Atheros AR9342, which is a highly integrated MIPS processor - Linux, WiFi, Ethernet, Bluetooth, USB host

Arduino YUN Bridge



What a general purpose board can do ?

- Elementary tasks
  - Measurement and generation of analog voltages
  - I/O operations on digital pins
- Number of analog & digital pins may vary
- More complex tasks can be broken down to elementary tasks
- Communication, measurements with various sensors, management of Ethernet, WiFi, LCD and other complex tasks are supported by a number of easy to use libraries
- Arduino is open source both hardware & software

Board / features	Uno	Due	Galileo
AI	6, 10 bits	12, 12 bits	6, 12 bits
AO	6, PWM, 8 bits	2, DAC, 12 bits	6, PWM 8 bits
DIO	14, 6 PWM, 8 bits	54, 12 PWM 8 bits	14, 6 PWM 8 bits
Processor	ATMega 328	AT91SAM3X8E	Intel Quark SoC X1000
Clock	16 MHz	84 MHz	400 MHz
Flash	32 KB	512 KB	8 MB / 512KB
SRAM	2 KB	96 KB	512 KB
DRAM	-	-	256 MB
EEPROM	1 KB	-	-
Micro SD	- (on shield only)	- (on shield only)	Up to 32 MB
Ethernet	- (on shield only)	- (on shield only)	10/100 Mb/s

Serial communication among boards

- **USB** using **UART** (Universal Asynchronous Receive Transmit) with PC for development purposes
- **UART** Hardware / software among two boards using digital I/O pins
- **TWI** (Two Wire Interface) **SDA** / **SCL** pins (Serial Data / Serial CLocK)
- **SPI** (Serial Peripheral Interface) using 4 pins **MISO** (Master Input Slave Output), **MOSI** (Master Output Slave Input), **SCLK** (Serial CLocK), SS (Slave Select)
- **Network** connection with **Ethernet** / **WiFi** / **GSM** built in or shields – extensions
- **microSD** cards – copy on one device, read on other

Why to connect boards?

- Arduino boards are similar to Lego building blocks
- Not very much can be done with only one block, but with many blocks one has almost unlimited possibilities
- Processing power or some other requirements may exceed capacities and resources of a single board
- In that case, joined resources of two or more connected boards may solve the problem
- Single board or system of boards can be connected to other larger computer systems

Various ways of board programming

- Programming from Arduino IDE in Arduino Language (AL) similar to C ++
- Programming in Java Script
  - NodeJS with JohnnyFive library on PC using Firmata protocol on board
  - NodeJS with JohnnyFive library using Galileo-IO on board from Linux
  - Libmraa library on board from Linux (Galileo board)
  - NodeJS on server with web interface to ARDUINO board with network adapter
  - Arduino Yun has Bridge library that connects MCU with MPU
- Programming in other languages - Python from Linux which communicates with a board through some serial wire interface or network

Arduino board connected with PC

Arduino IDE

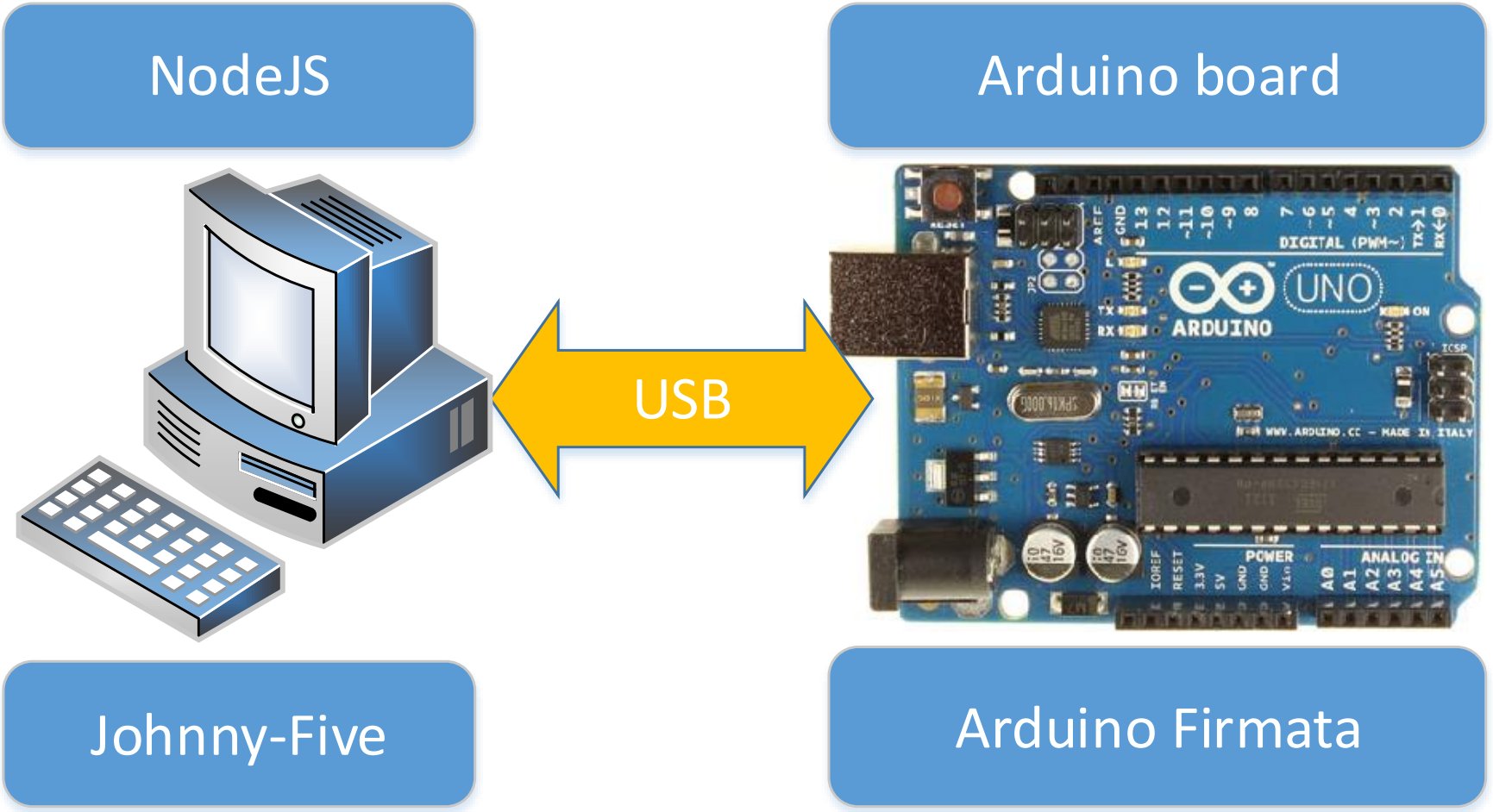
USB

Arduino board

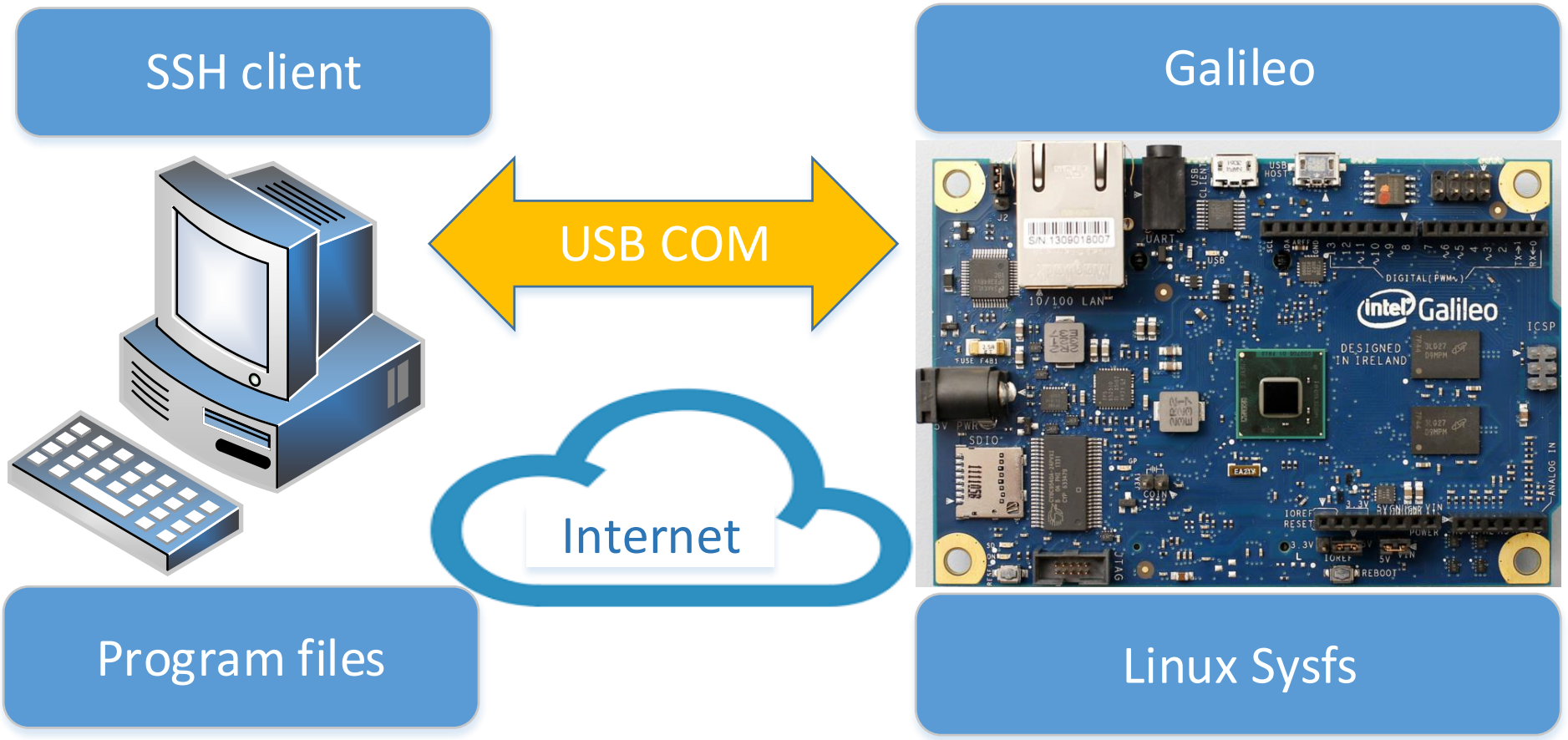
Arduino sketch

Compiled code

Arduino programming with JS



Program development with Sysfs



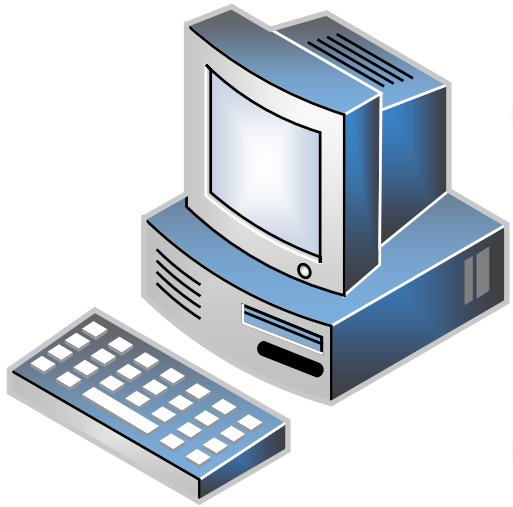
Configuration and reading of A0 with Sysfs

147.91.204.225 - PuTTY

```
login as: root
root@galileo:~# echo -n "37" > /sys/class/gpio/export
root@galileo:~# echo -n "out" > /sys/class/gpio/gpio37/direction
root@galileo:~# echo -n "0" > /sys/class/gpio/gpio37/value
root@galileo:~# cat /sys/bus/iio/devices/iio\:device0/in_voltage0_raw
711
root@galileo:~# cat /sys/bus/iio/devices/iio\:device0/in_voltage0_raw
351
root@galileo:~# cat /sys/bus/iio/devices/iio\:device0/in_voltage0_raw
926
root@galileo:~#
```

Program development with JF / Galileo-IO

SSH client

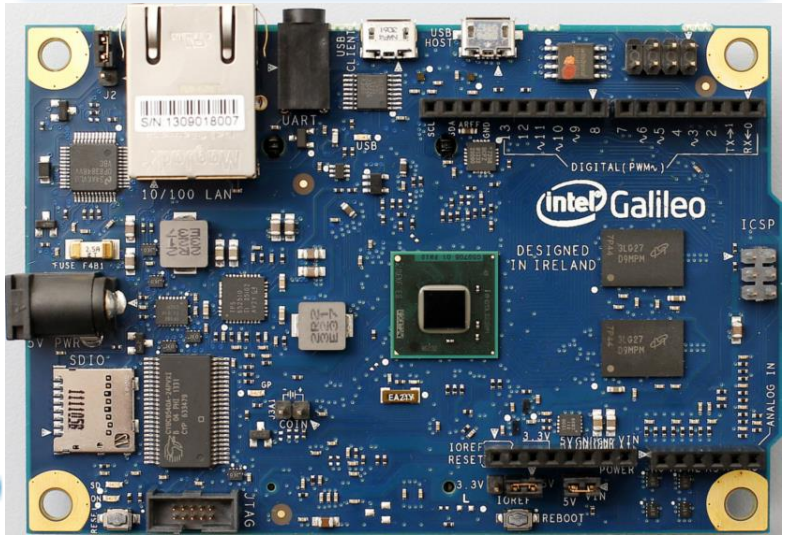


USB COM

Internet

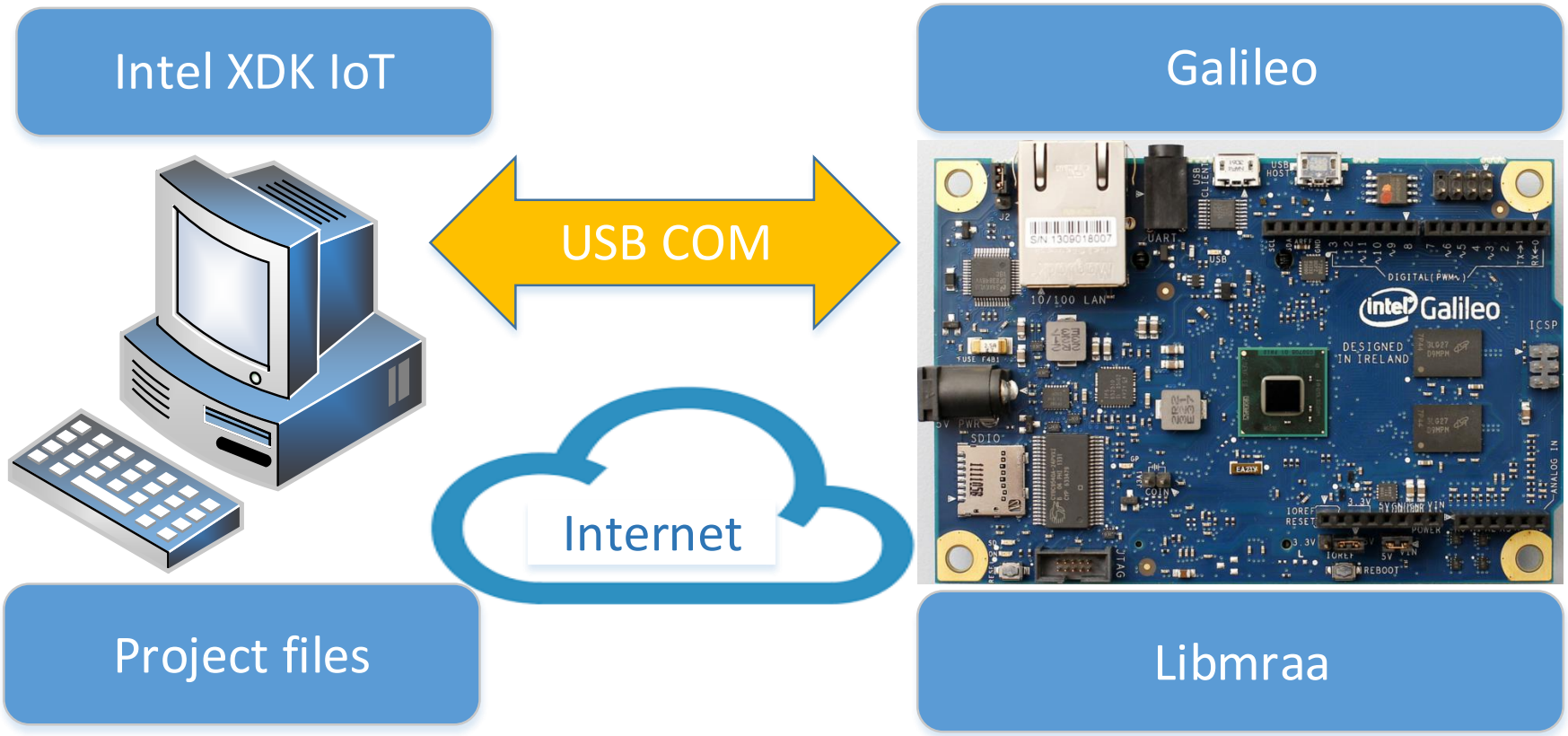
Program files

Galileo

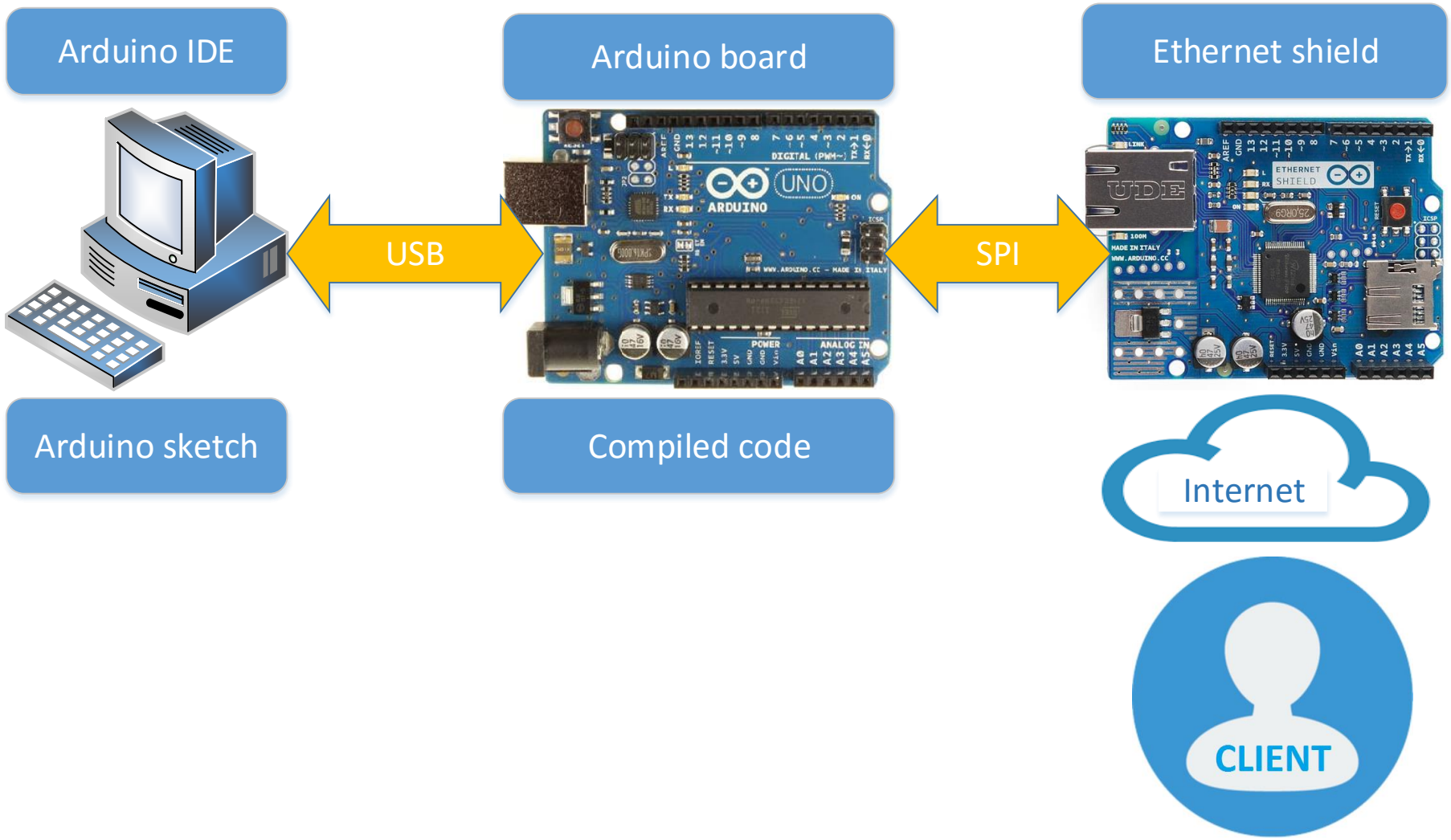


Johnny Five / Galileo-IO

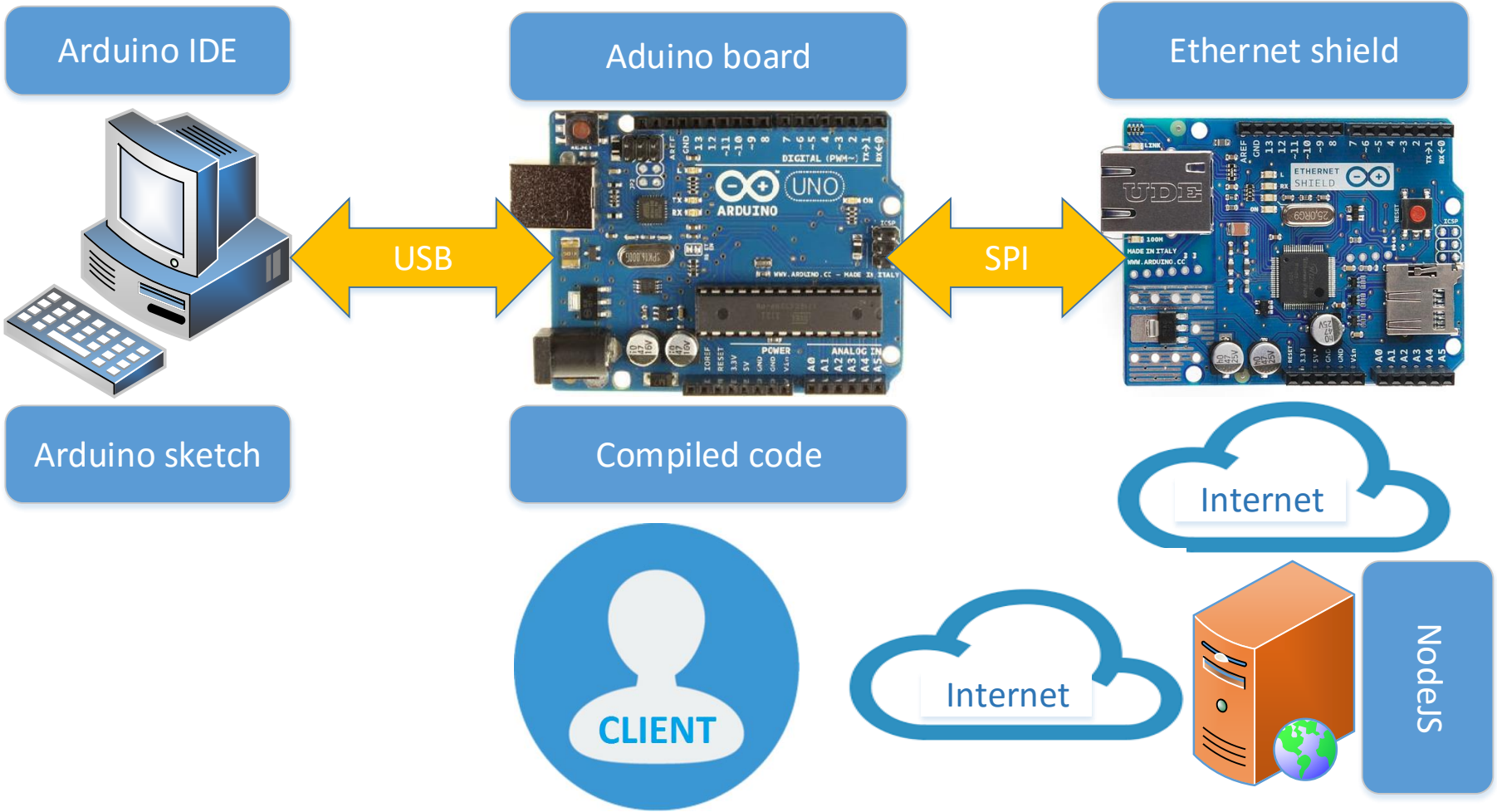
Program development with Intel XDK IoT IDE and mraa library



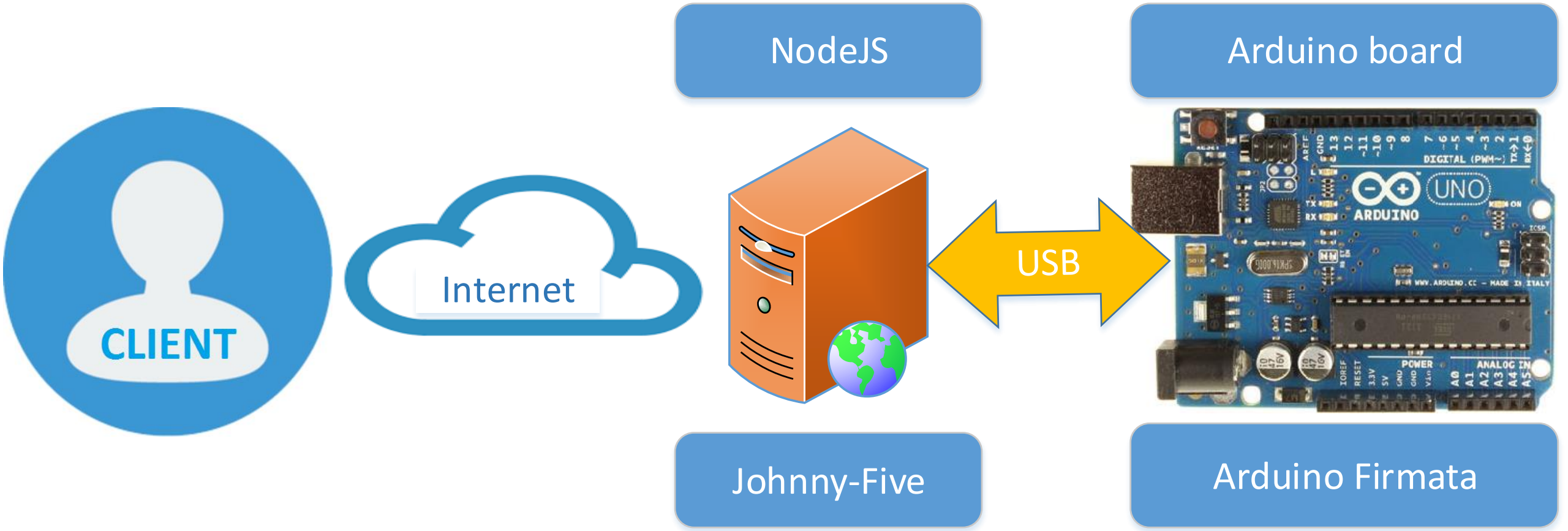
Single board with Ethernet adapter



Arduino with web client access



Arduino board with Firmata and Johnny-Five



Arduino IDE

Arduino sketch

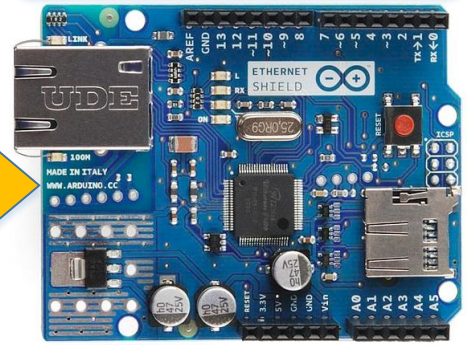
USB

Arduino board
Acquisition web server

Compiled code

SPI

Ethernet shield

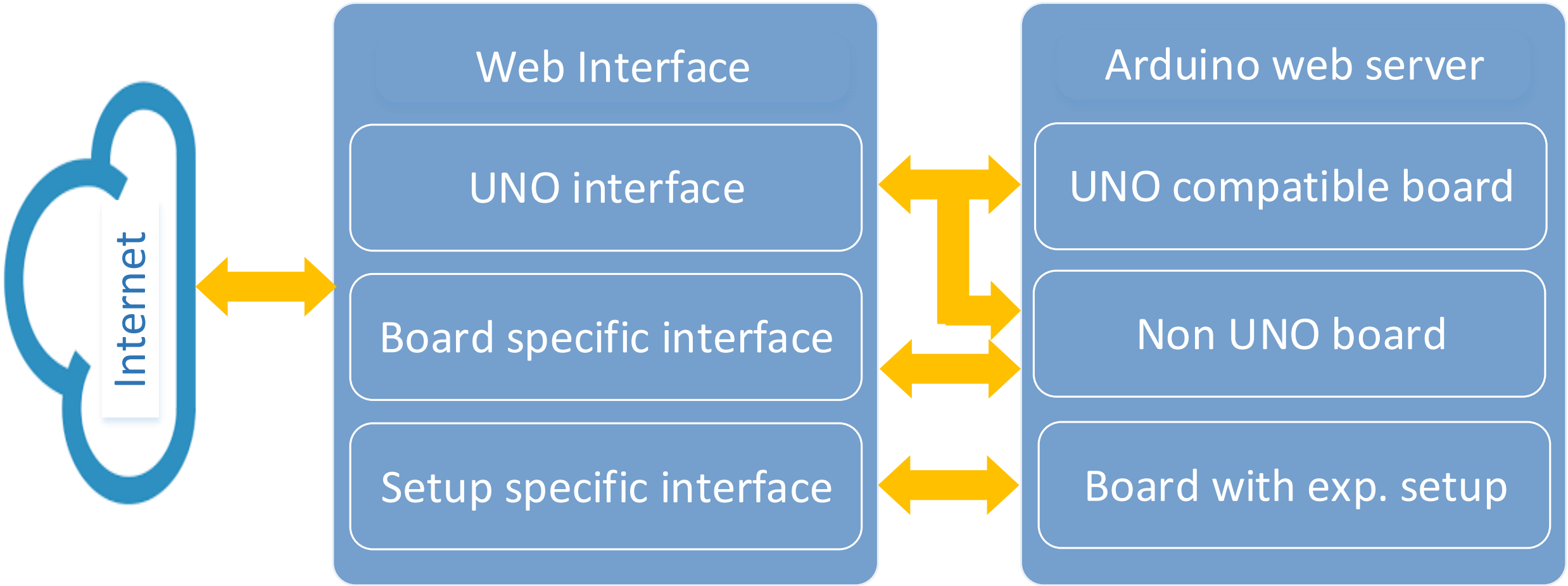


Web Interface

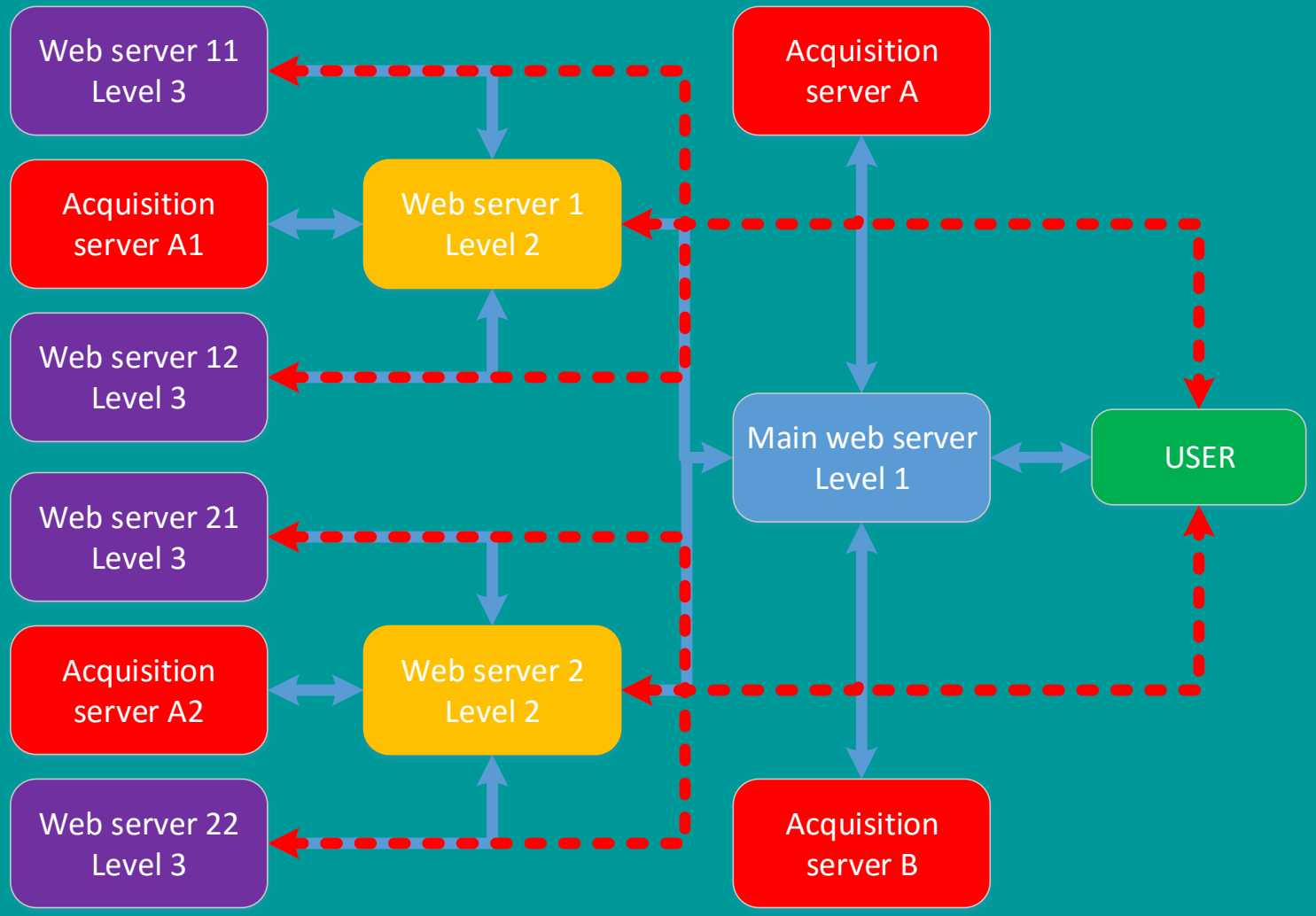
Galileo board
Main web server

NodeJS code

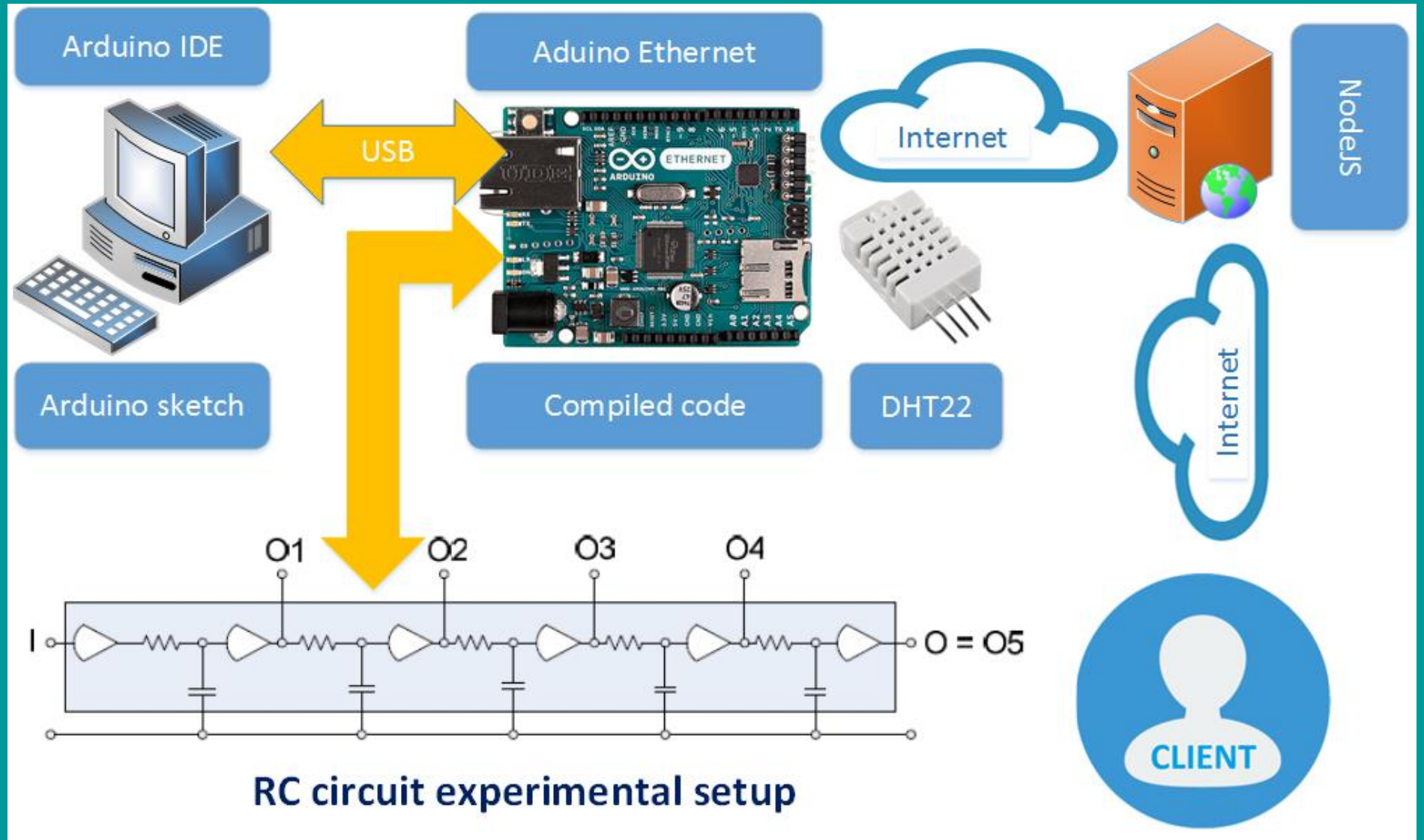
Web interface structure



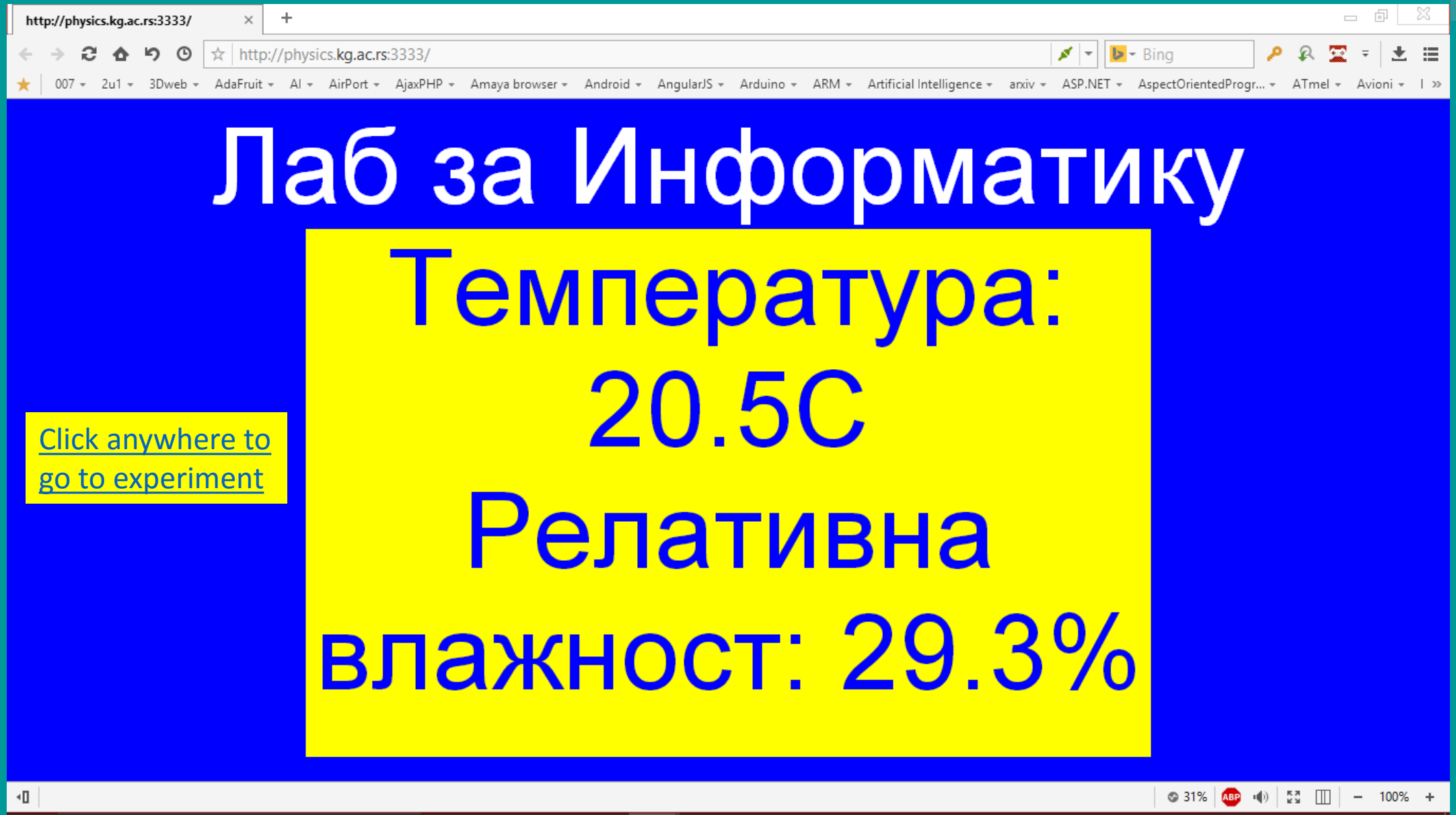
Scaling of measurement and control system



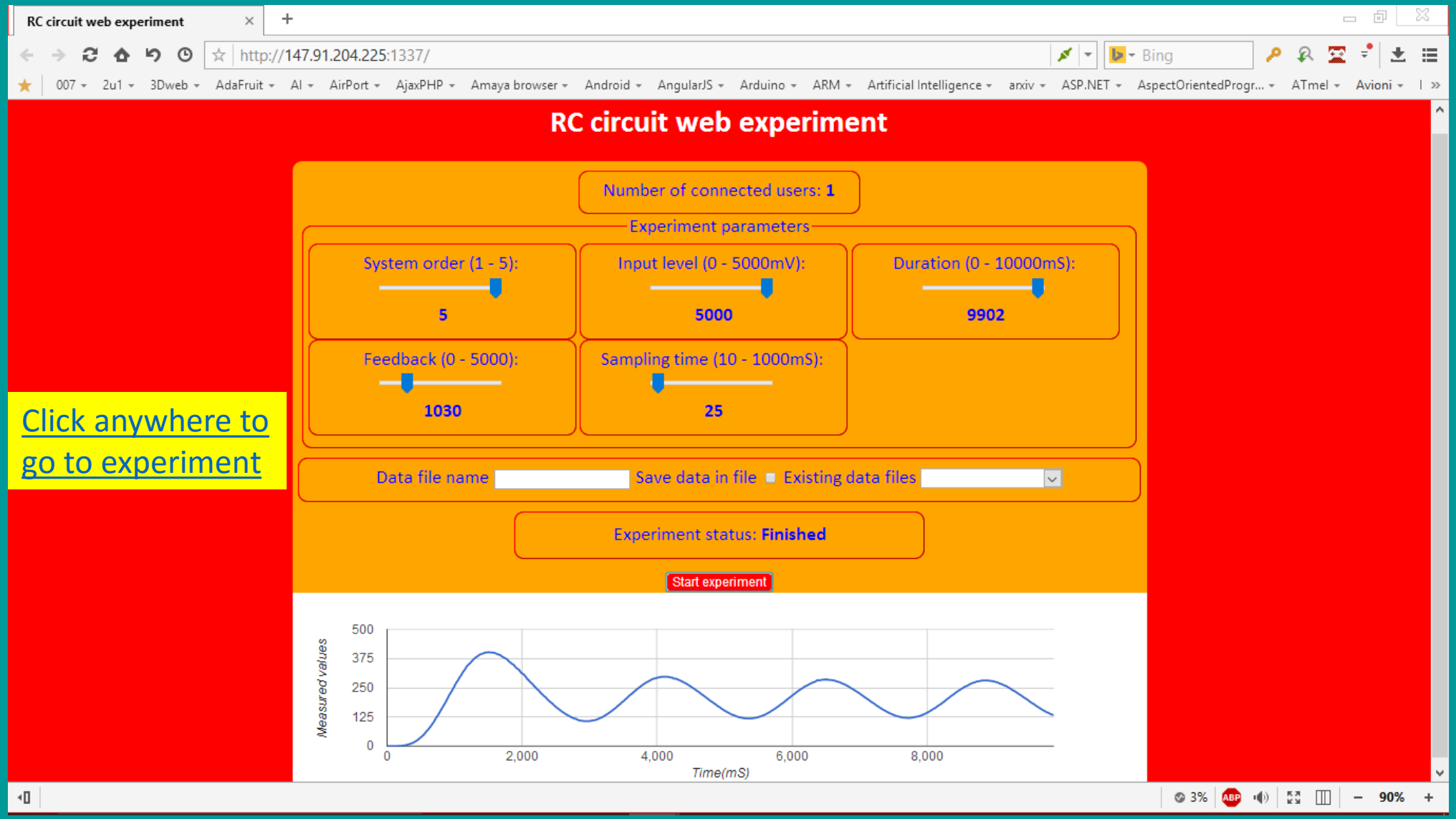
ARDUINO application for temp. & rel. hum. & RC exp.



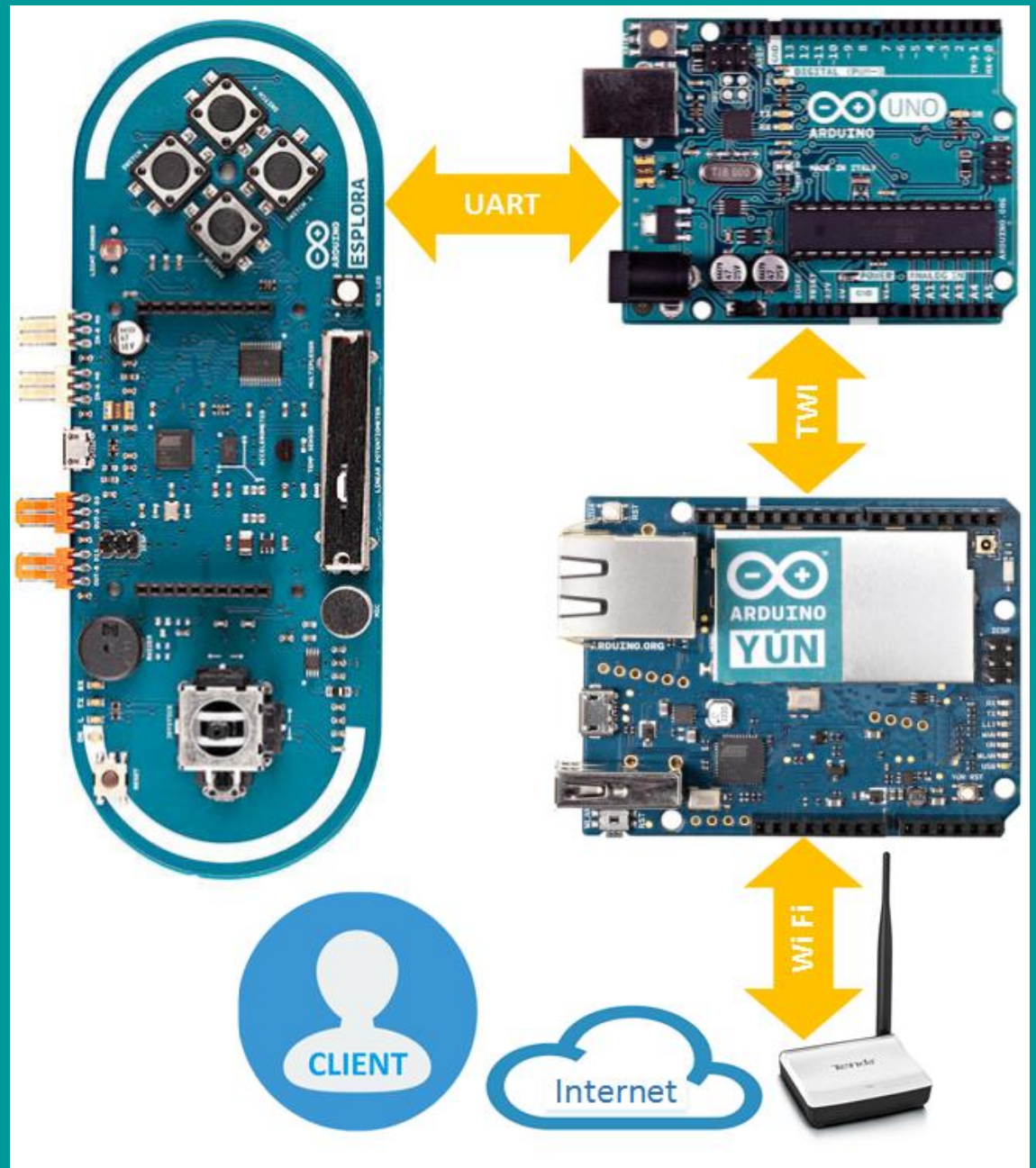
Temp & rel. hum measurement



RC circuit experiment



3 connected ARDUINO cards



Web page controlling Esplora

Arduino Esplora

http://192.168.1.12:3000/

Arduino Esplora sensors & actuators

Click anywhere to go to experiment

Sensor: Accelerometer

Temperature C: 23 F: 73

Light: 958

Microphone: 1

Slider: 512

Button Right: 1 Left: 1 Up: 1 Down: 1

Joystick Jx: -4 Jy: 9 Jb: 1

Accelerometer Ax: 22 Ay: 41 Az: 172

RGB LED color

Red: 67

Green:36

Blue: 204

Set LED color

Signal:97

Pause: 1000

Set tone

Tone: 254

Esplora sensors and actuators
Acronyms from previous slide

- **A** – Accelerometer
- **B** – 4 Buttons (on / off) up, down, left, right
- **J** – Joystick
- **L** – Light sensor
- **LS** – Loudspeaker
- **M** - Microphone
- **MCU** – Micro Controler Unit
- **RST** – ReSeT button
- **RGB** – Red Green Blue LED diode
- **Rx/Tx** – Serial connectors (UART) – Receive / Transmit
- **SL** – SLider – potentiometer
- **T** – temperature
- **USB** – USB connector for power supply & programming