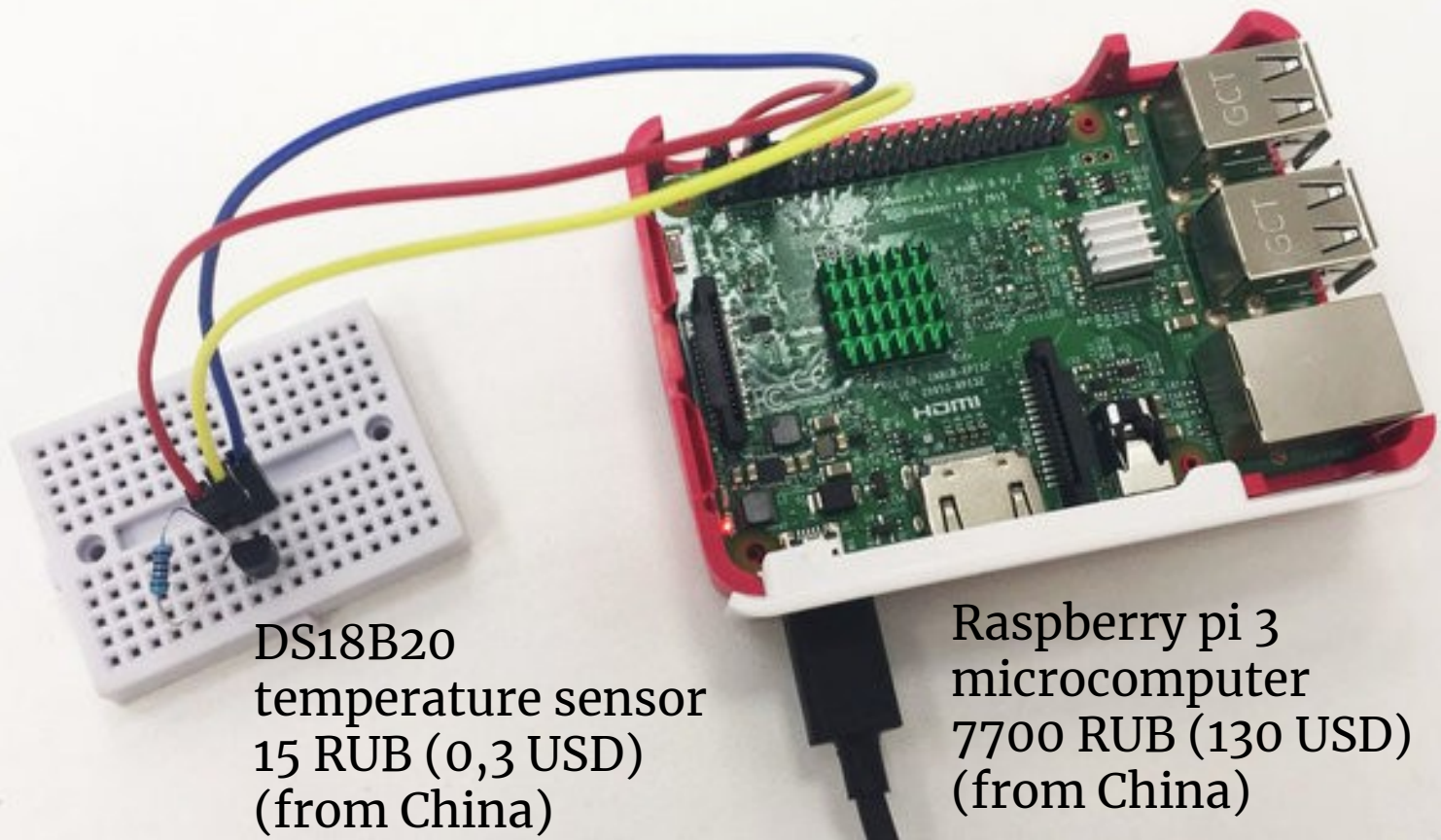


Cost-effective automatization of the experiment

N.A. Fedorov, FLNP JINR

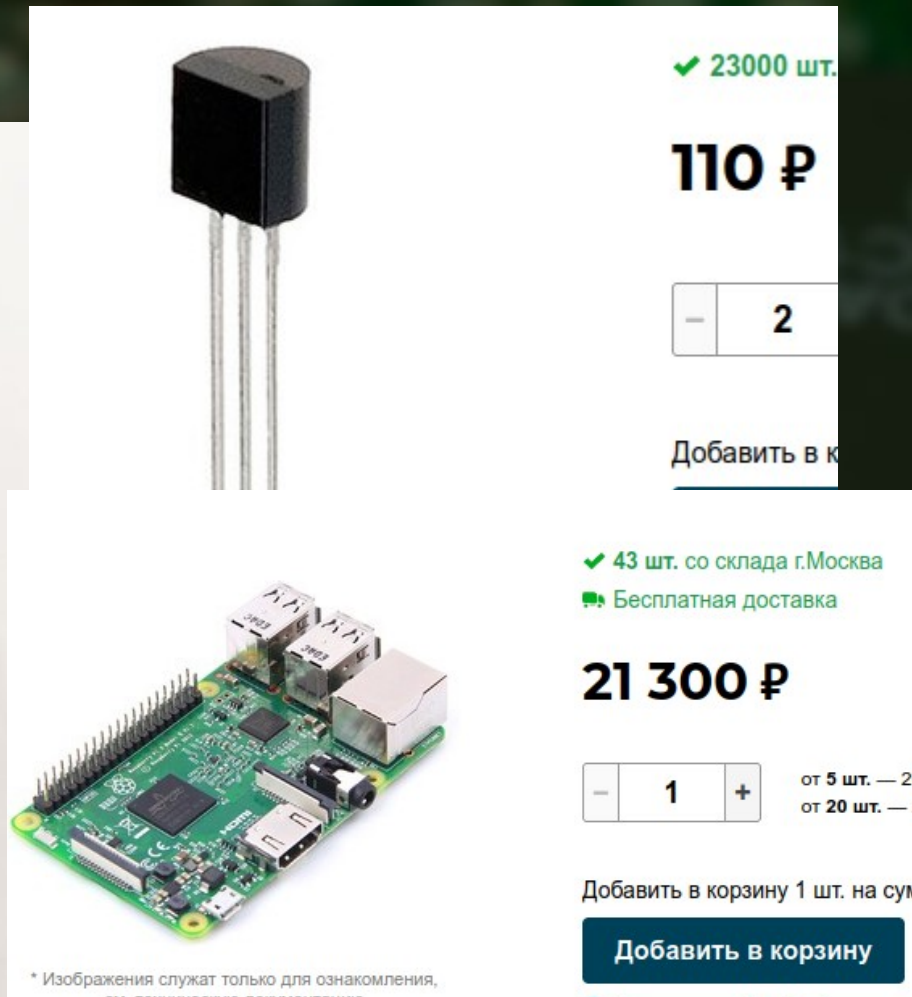
Motivation

- About 4 month ago there was an interesting AYSS seminar, dedicated to the physical experiment monitoring (speaker: D. Egorov, LHEP JINR)



DS18B20
temperature sensor
15 RUB (0,3 USD)
(from China)

Raspberry pi 3
microcomputer
7700 RUB (130 USD)
(from China)



The image shows two product listings from a Russian e-commerce site. The top listing is for a DS18B20 temperature sensor, showing a black component with three pins. The price is 110 RUB, and there are 23,000 units in stock. The bottom listing is for a Raspberry Pi 3 microcomputer, showing the board with its ports. The price is 21,300 RUB, and there are 43 units in stock from the Moscow warehouse. Both listings include a 'Добавить в корзину' (Add to cart) button.

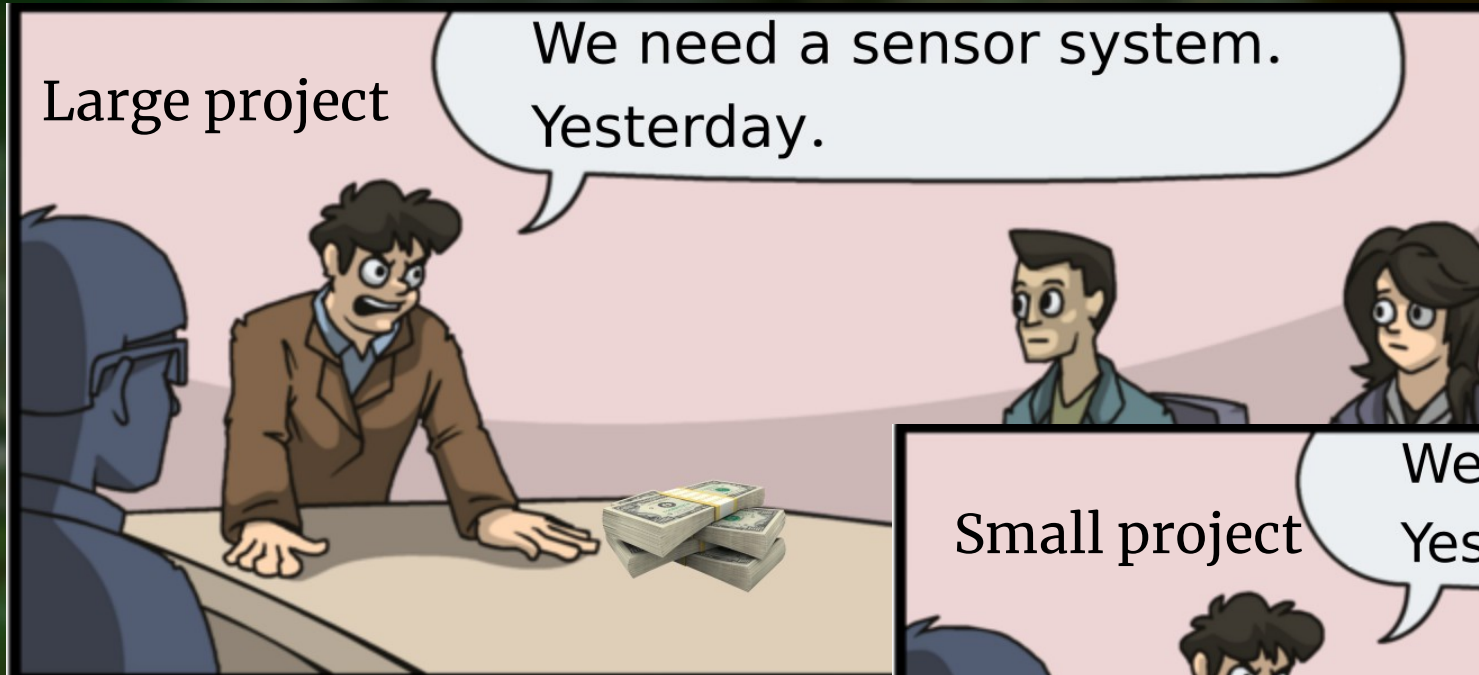
✓ 23000 шт.
110 ₽
- 2 +
Добавить в корзину

✓ 43 шт. со склада г.Москва
🚚 Бесплатная доставка
21 300 ₽
- 1 +
Добавить в корзину 1 шт. на сумму 21 300 ₽

* Изображения служат только для ознакомления, см. техническую документацию.

Motivation

- There are two variants:

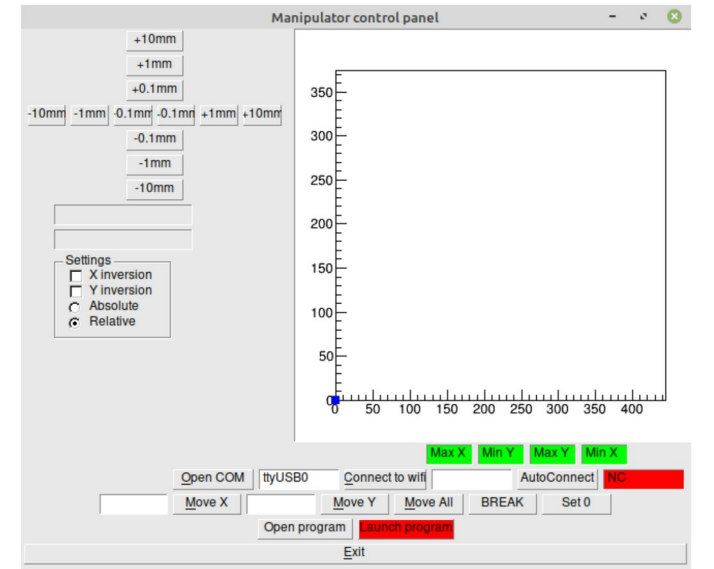
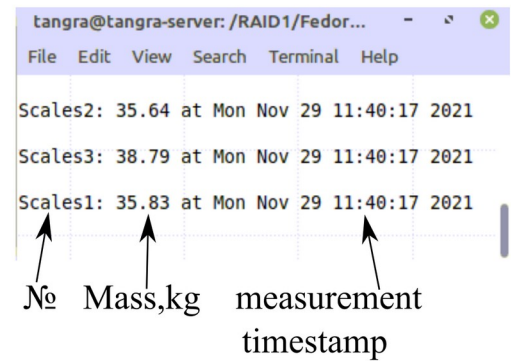
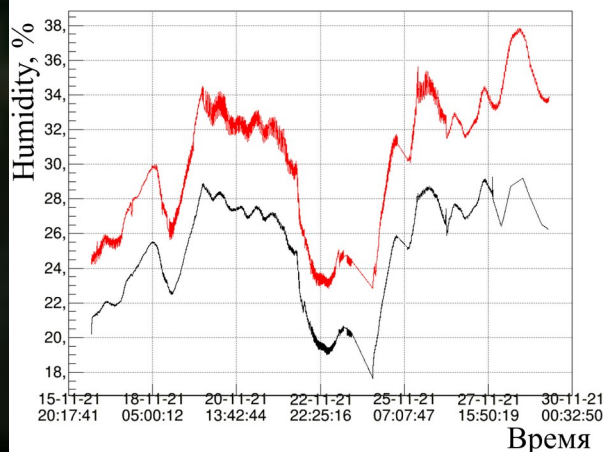
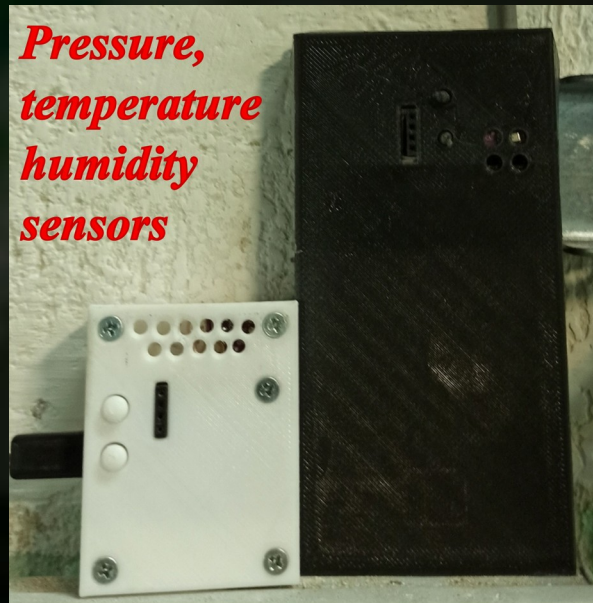


Solution?

	Raspberry Pi 4	Arduino nano	Cheap AVR (Atmega8)	ESP 8266	ESP32
Price	>100 USD	4-20 USD	1-10 USD	1-12 USD	2-5 USD (!)
CPU	4x1.5GHz 64bit ARM	1x16MHz 8bit Atmega	1x8MHz 8bit Atmega	1x80MHz 32bit Tensilica	2x240MHz 32bit Tensilica
RAM	≥2GB	2kB	1kB	112kB	520kB
Memory	>8GB	32kB	8kB	4MB	4MB
GPIO	26	19	23	10	30
Built-in ADC	x	10bit x 6 ch	10bit x 6 ch	10bit x 1 ch	12bit x 18ch
Native USB	y	x	x	x	x
Ethernet	y	x	x	x	x
Wi-Fi	y	x	x	y	y

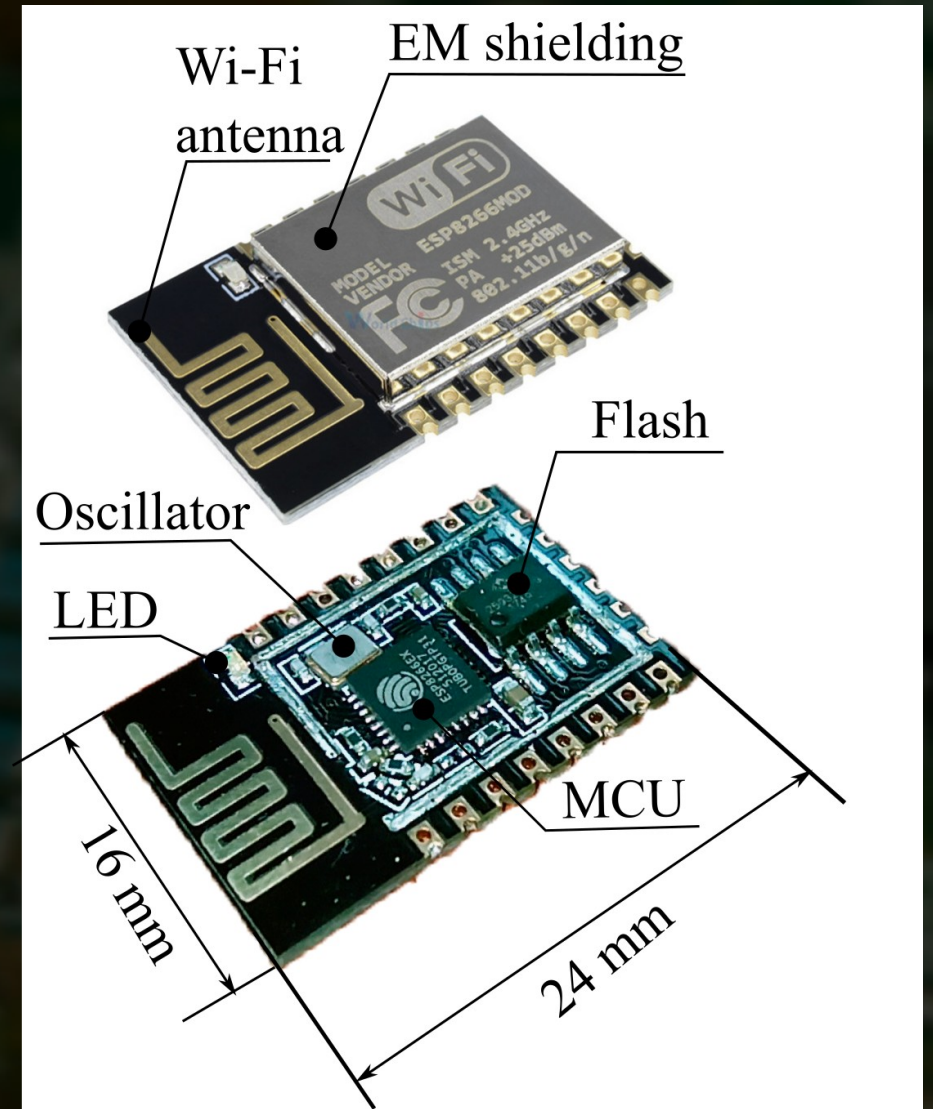
- Computing power is not so important for sensors and simple devices
- Communication interfaces are needed for data transfer from sensors to logging/control server

Tasks for automatization in the TANGRA project



Core of developed devices

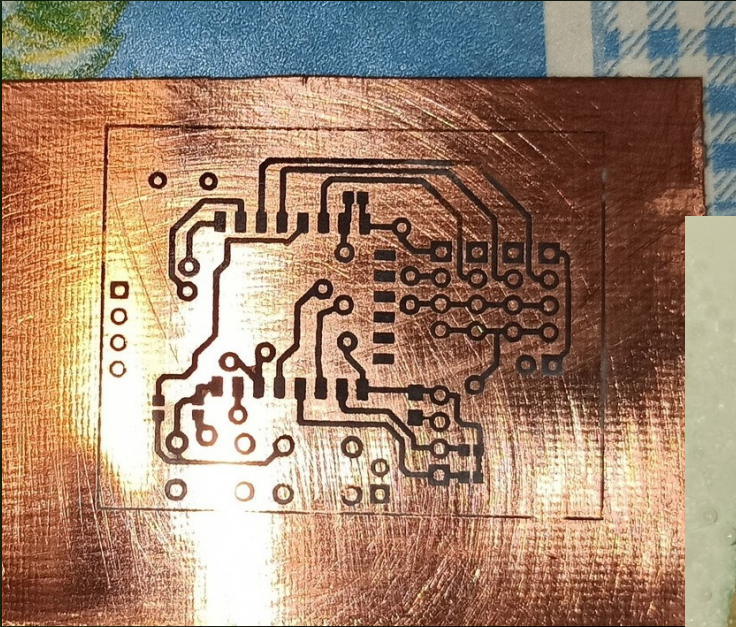
- ESP8266 (ESP12 variant) was chosen as a “brain” of developed devices
- ESP8266 is a compact module suitable for soldering
- MCU uses a 4 MB external flash memory for firmware and data
- It is possible to extend flash memory or replace broken one (but we never tried)



Printed circuit board (PCB) manufacturing

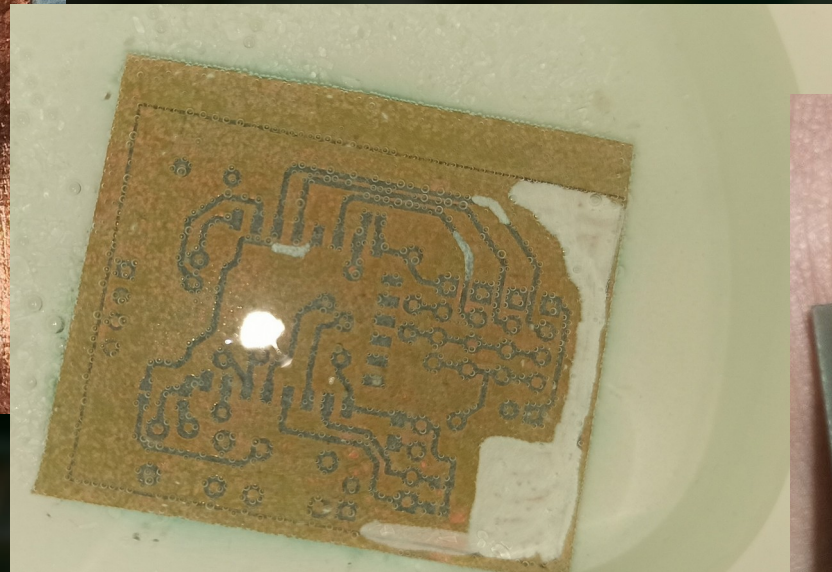
- Etching

- Assembled PCB

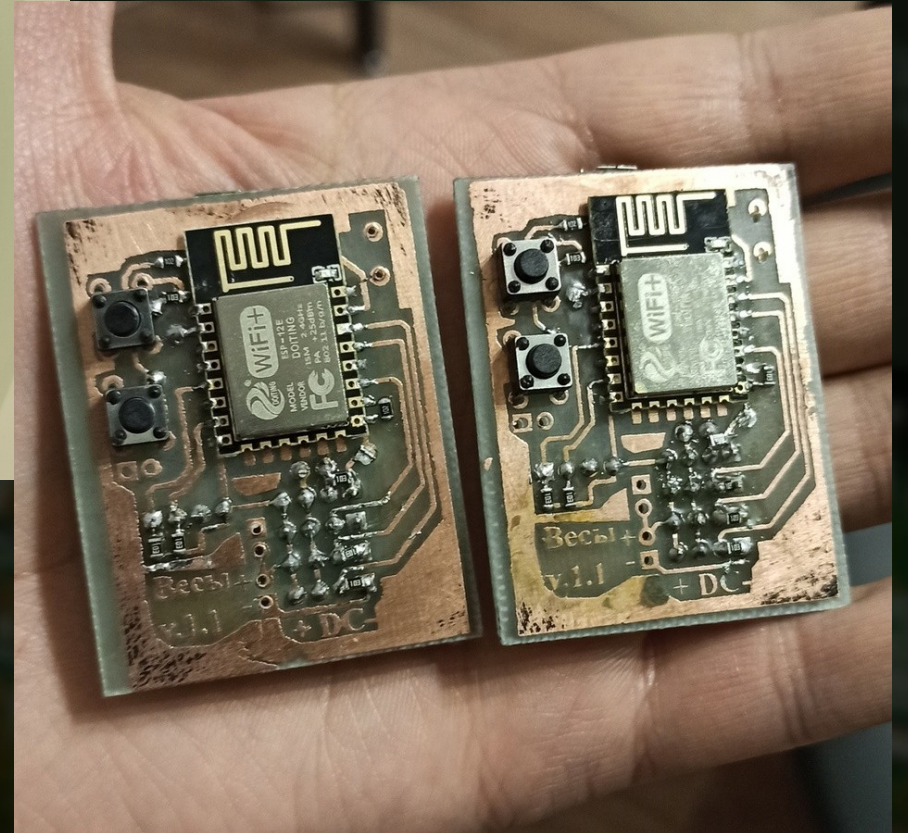


- Laser printer toner transfer

using iron and ads paper
(Eco-friendly!)

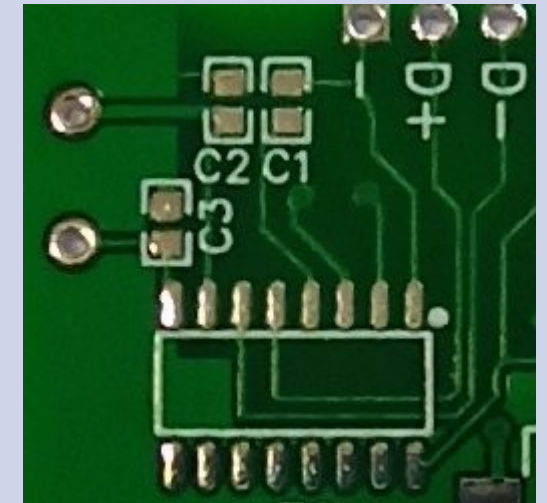
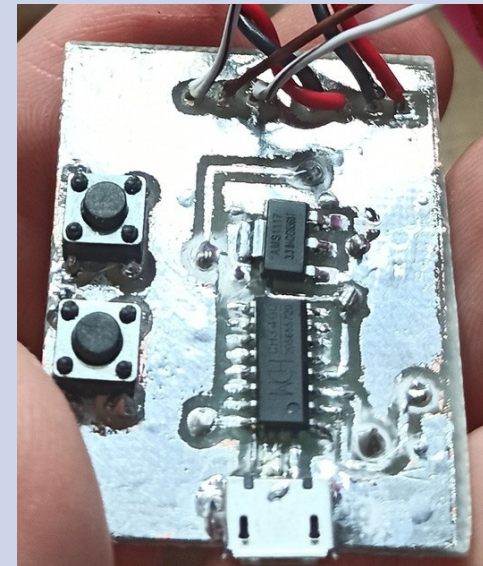
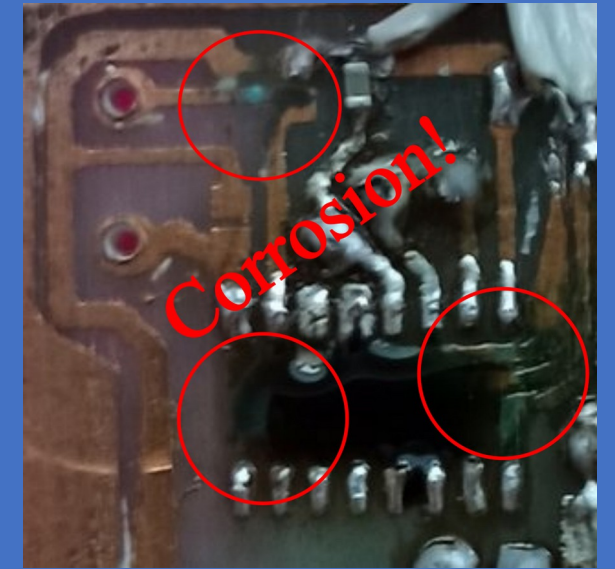
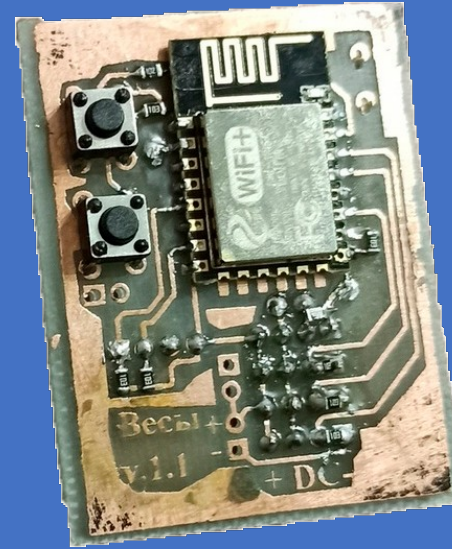


in the hydrogen
peroxide and citric
acid solution



Printed circuit board (PCB)

- There is a massive corrosion on non-tinned PCB after 6 month of usage at 70% air humidity
- Always tin all copper surface of PCB!
- In very wet places use fabricated PCB



Communication with PC

- The simplest way to communicate with PC is TCP/IP socket usage
- ESP 8266 can act as client (initiate data transfer) or as server (wait data transfer)
- It is easy to pack data into a char string

ESP 8266 side (Arduino language)

```
WiFiClient client;
void loop() {
  //collect data from sensor
  ...
  if (client.connect("159.93.XXX.XXX",8081)) {
    String Message=String(ID)+" P "+String(P)+

    " T "+String(T) ...;
    client.print(Message); }
  if(client.available()) {
    String recv_comm=
      client.readStringUntil('\n');}
  //do something
  ...
}
```

C side (C language)

```
//headers; function initialization
int sock, listener;
struct sockaddr_in addr;
char buf[1024];
//opening the socket
...
while(1) {
  recv(sock, buf,1024, 0);
  //parsing "buf" and save data
}
```

Problems

- Low resource of the flash memory (about 60 firmware updates)
- There is no emulator of the ESP8266 (at least I don't know about it)
- Debugging will improve soldering skills :)



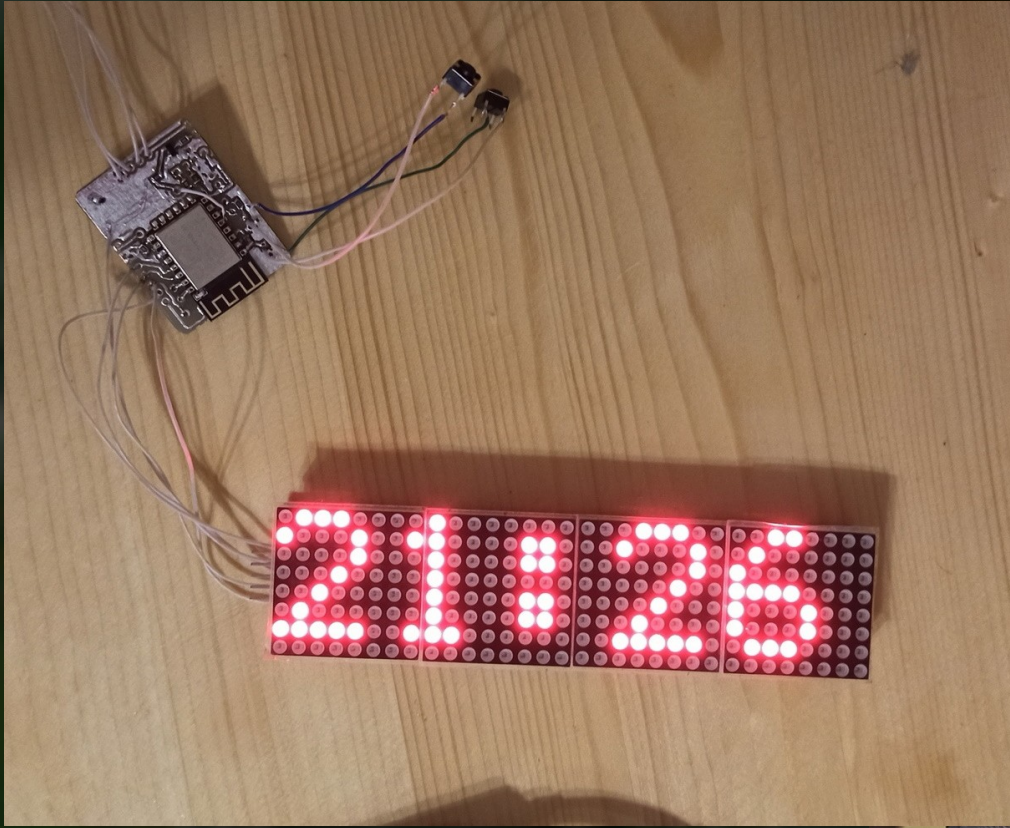
Conclusion

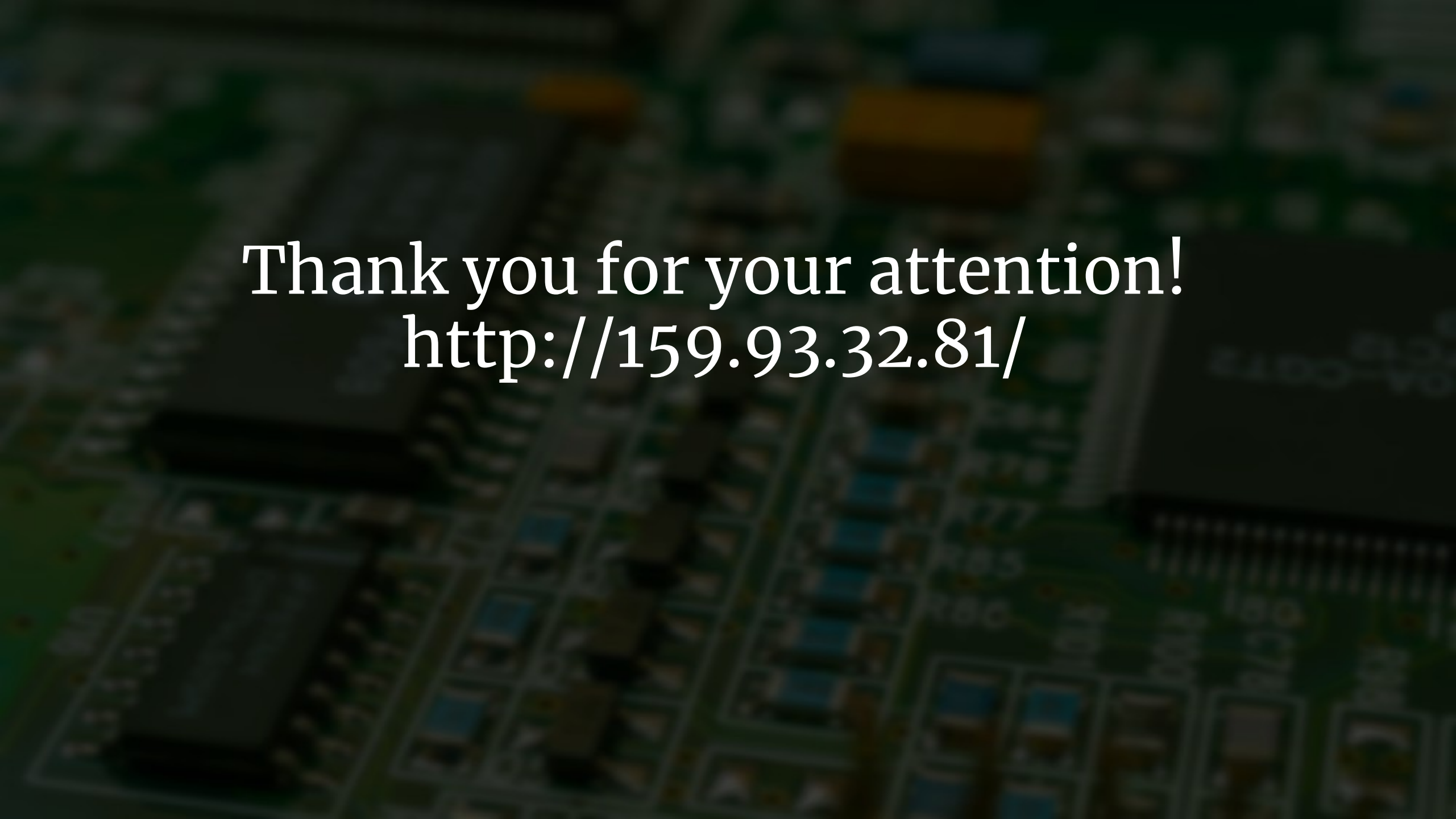
- It is plausible to build a low-cost wireless sensor system
- And even remote controlled devices

But be ready for:

- Interesting work process
 - Soldering
 - DEBUGGING
-
- Is a ESP8266/ESP32 a good choice for experiment automatization? Definitely, yes!

Let's automate the conference!





Thank you for your attention!
<http://159.93.32.81/>