

FROM A WEEKEND HACK, TO A
FUTURE-PROOF IOT DEVICE...



ME? BENJAMIN CABÉ

Developer Advocate for the
Zephyr Project

Baker, potter, photographer

@kartben

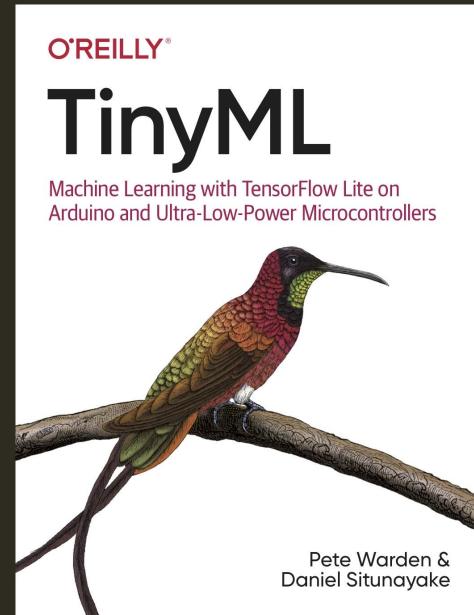




TINYML?

“

The ability to run a neural network model at an energy cost of below 1 mW.





Make:

MACHINE LEARNING

Swear Bear... Trash Sorter... Easy AI Trainers
Teach your project to think for itself

BENJAMIN CABÉ'S "NOSE" KNOWS!
Build this smell-identifying AI sniffer

23 PROJECTS!

- Raspberry Pi Meteor Camera
- Digital String Art Portraits
- Animated LED Shirt
- Arduino Borealis Lights

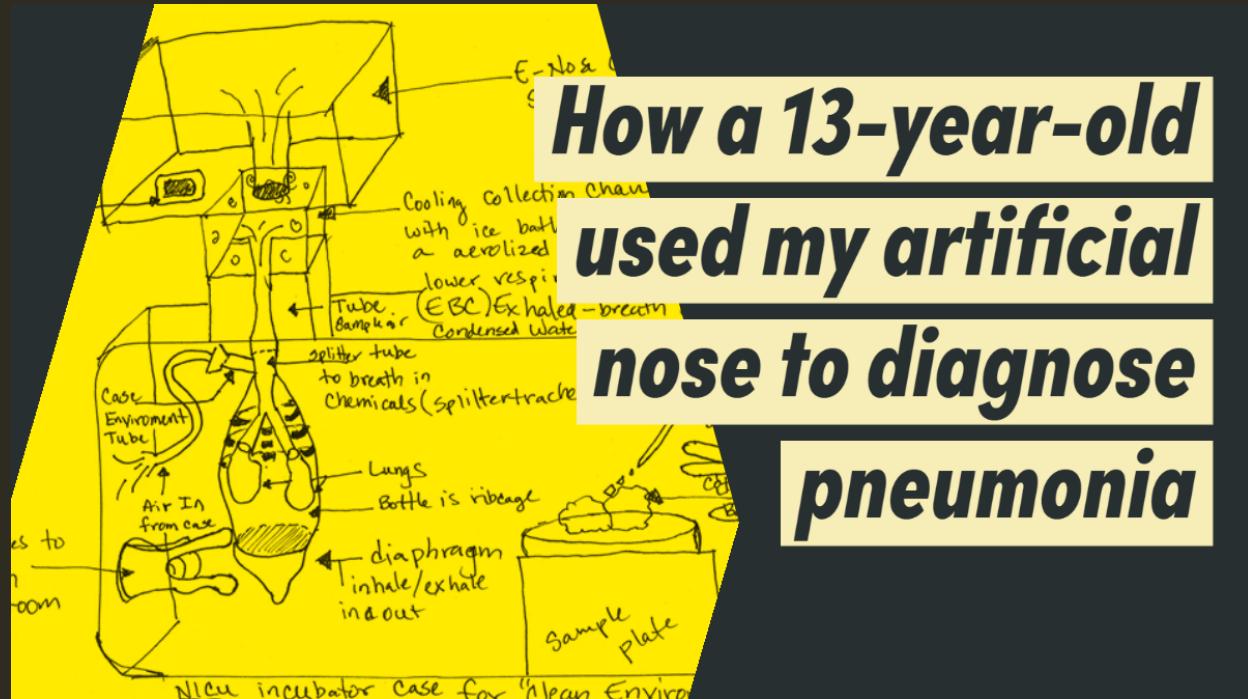


SKILL BUILDERS

- Digital Mobile Radio
- Hack a Knitting Machine



MOTORIZED
SELF
SOLVING
RUBIK'S
CUBE



How a 13-year-old used my artificial nose to diagnose pneumonia

news.ycombinator.com

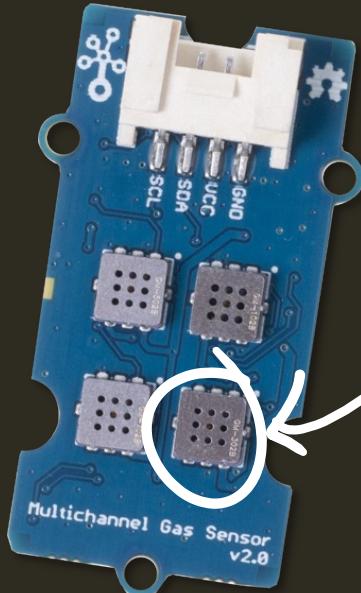
Hacker News new | threads | past | comments | ask | show | jobs | submit

1. A 13-year-old used my artificial nose to diagnose pneumonia (benjamin-cabe.com)
229 points by kartben_ 5 hours ago | hide | 128 comments
2. ▲ My smart home 2021: A Home Assistant love story (jorisroovers.com)
151 points by jorisroovers 4 hours ago | hide | 31 comments

A small watermark at the bottom right of the page reads: "Smart Home 2021: A Home Assistant love story" followed by a URL.

BUT HOW CAN A MACHINE SMELL ANYWAYS?

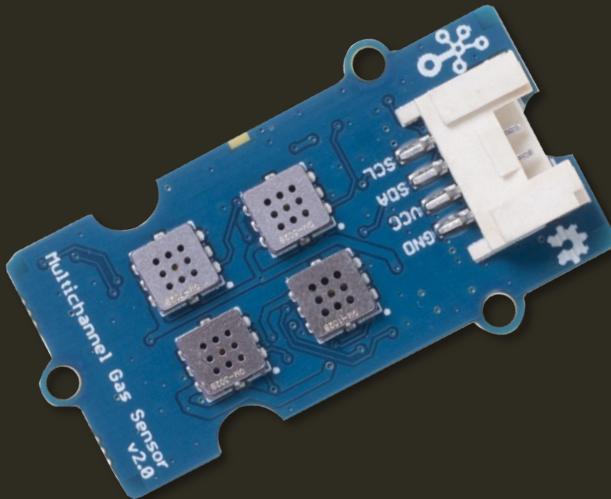
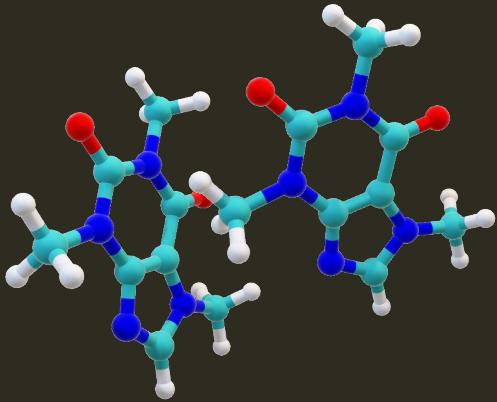
MOS (metal-oxide semiconductor)



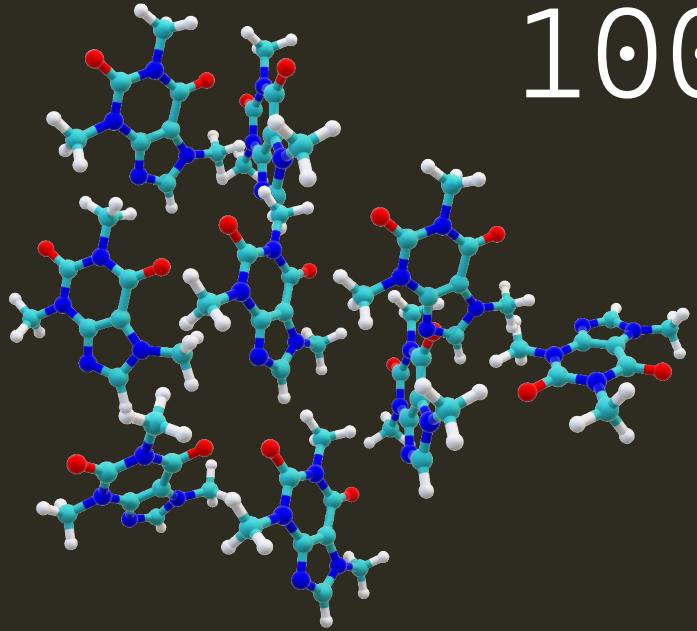
Reacts with chemical compounds
contained in the air...

... causing a change in resistance

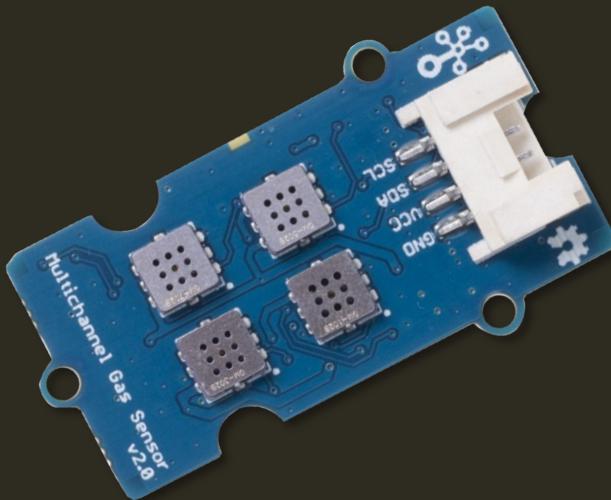
10 ppm



VOC?
100 Ω!

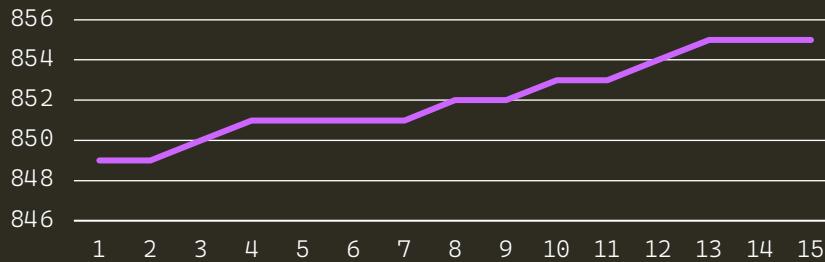


1000 ppm

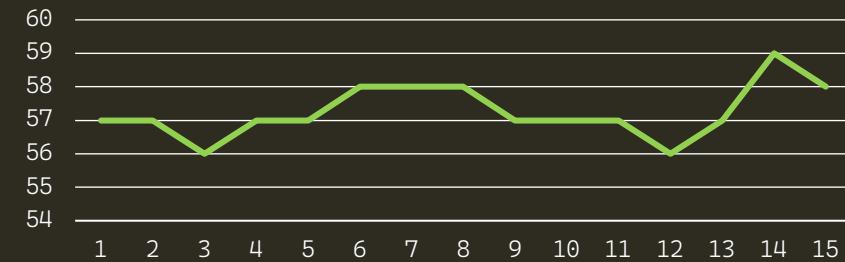


VOC?
200 Ω!

Nitrogen dioxide



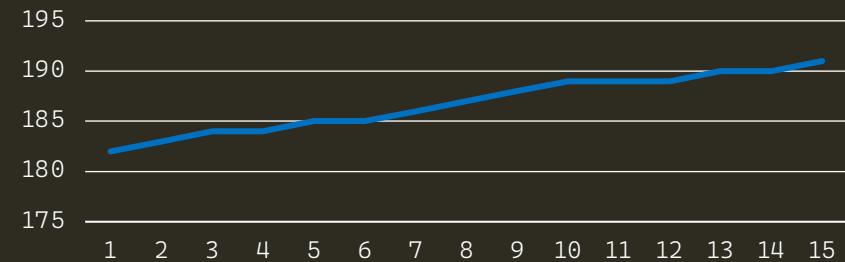
Carbon monoxide



Ethyl alcohol



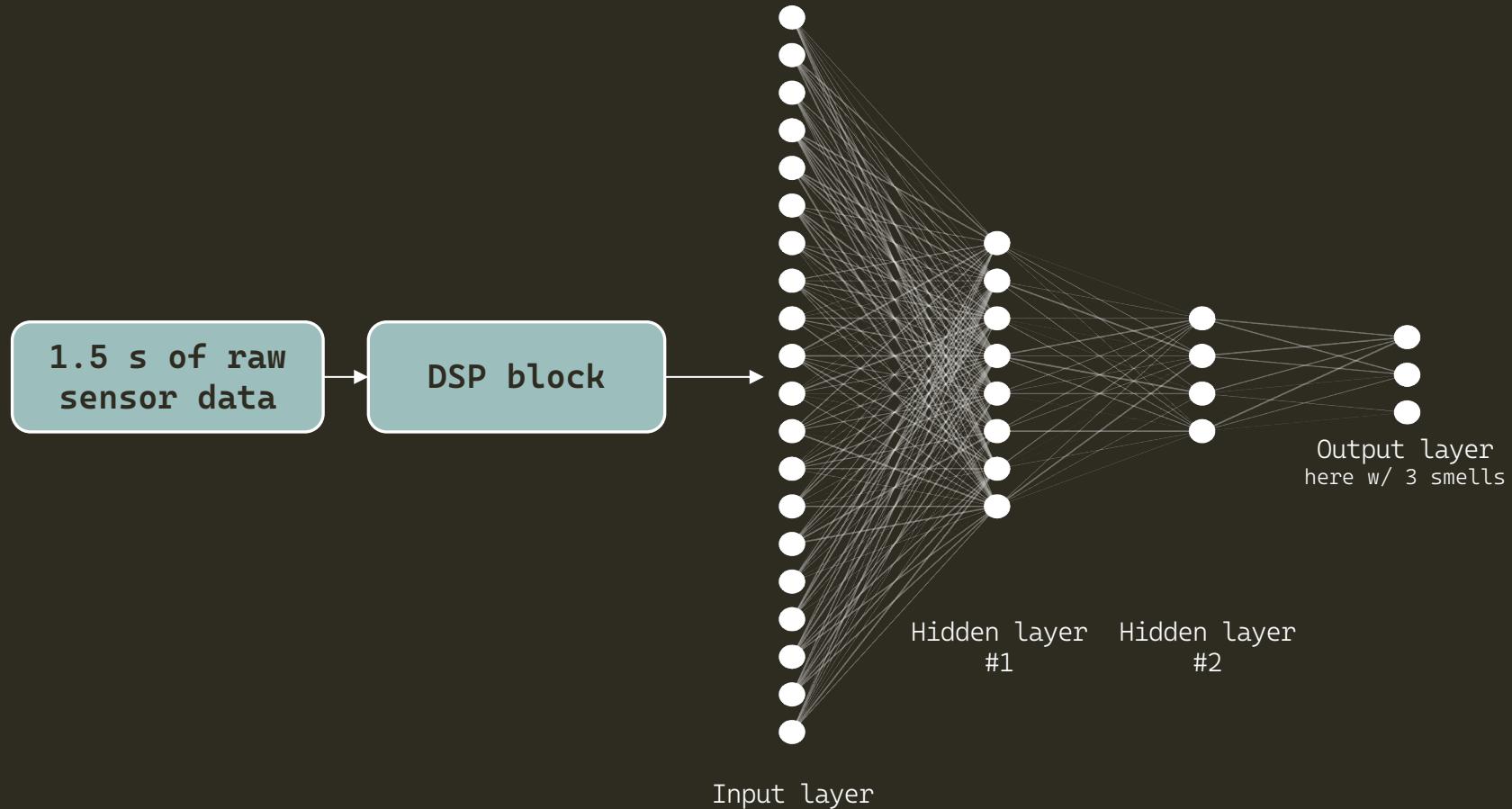
Volatile organic compounds



0

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Nitrogen dioxide	849	849	850	851	851	851	851	852	852	853	853	854	855	855	855
Carbon monoxide	57	57	56	57	57	58	58	58	57	57	57	56	57	59	58
Ethyl alcohol	95	96	96	95	97	97	98	98	98	99	98	99	100	100	100
Volatile organic compounds	182	183	184	184	185	185	186	187	188	189	189	189	190	190	191

AI MODEL FOR SMELLS?









Hardware interactions



Wireless connectivity

TinyML



ambient (91%)

Power Management



Graphical User Interface



THE DREADED SUPER-LOOP

```
void loop() {  
    // acquire sensor data  
    // feed it to TensorFlow Lite for µC  
    // check if some buttons were pressed  
    // refresh GUI  
    // post results to IoT server  
}
```



ZEPHYR RTOS

Small **real-time operating system**

Supports many architectures (Arm, RISC-V,
Xtensa, etc.)

Batteries included

... **Open Source** ☺

THE DREADED SUPER-LOOP

```
void loop() {  
    // acquire sensor data  
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SENSOR DATA ACQUISITION

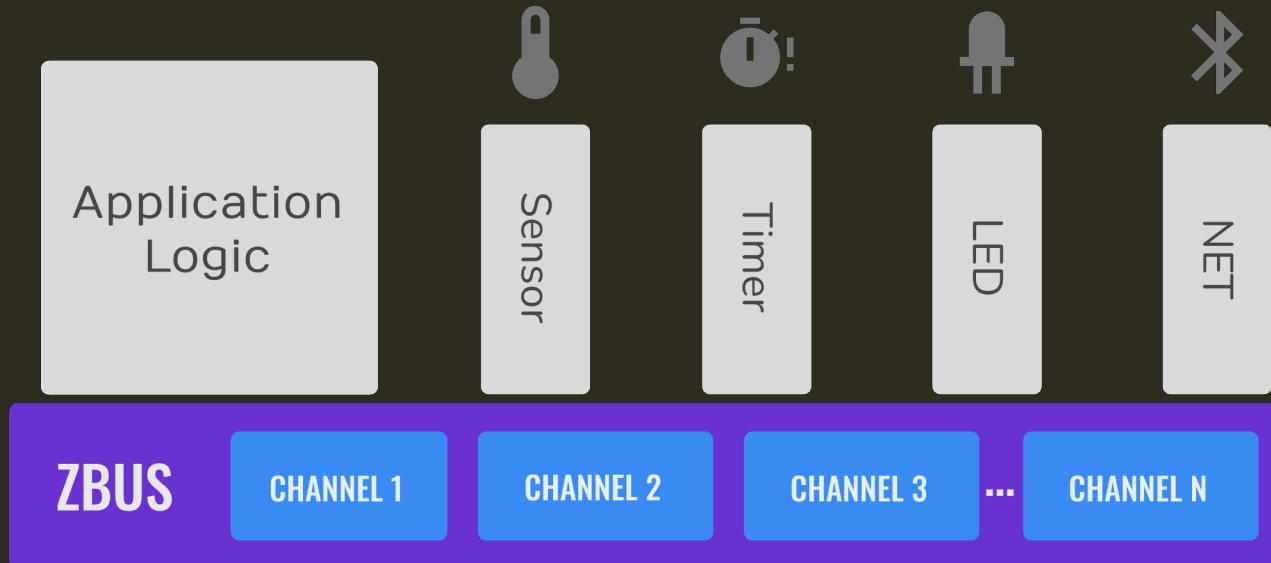
- Dedicated, high-priority **thread**
 - Samples gas sensors and put readings in a ring buffer
- Leverage **sensor driver API**
 - 100s of sensors already supported
 - Easy to mock sensor data
 - Switch sensors without changing code
 - Power Management

THE DREADED SUPER-LOOP

```
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```

INTER-PROCESS COMMUNICATION

- Zbus framework
- Decouple producer and consumer



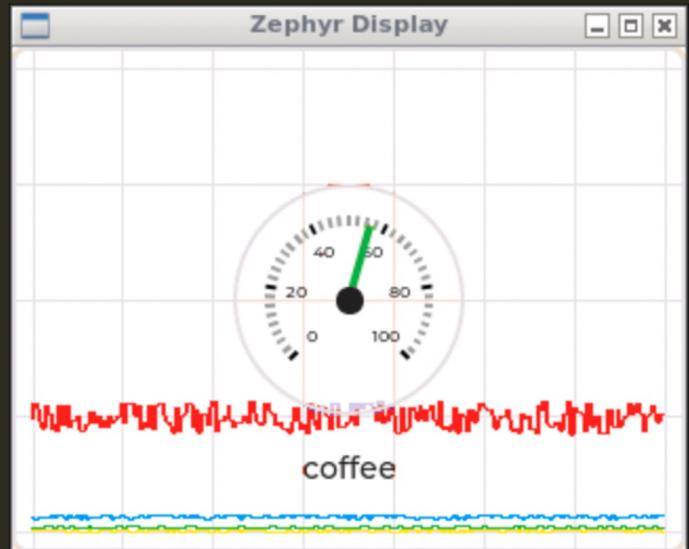
THE DREADED SUPER-LOOP

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```

LVGL FTW



- A lightweight, versatile, graphics library
- **Natively integrated with Zephyr**
 - Input subsystem
 - Display drivers
 - Memory management
- Can run in a desktop environment



```
static void inference_cb(const struct zbus_channel *chan)
{
    const struct inference_result_msg *msg =
        zbus_chan_const_msg(chan);

    lv_label_set_text(inference_result_label,
                      msg->label);

}

ZBUS_LISTENER_DEFINE(inference_ui_listener,
                     inference_cb);
```

THE DREADED SUPER-LOOP

```
void loop() {  
    // acquire sensor data  
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```

NETWORK CONNECTIVITY

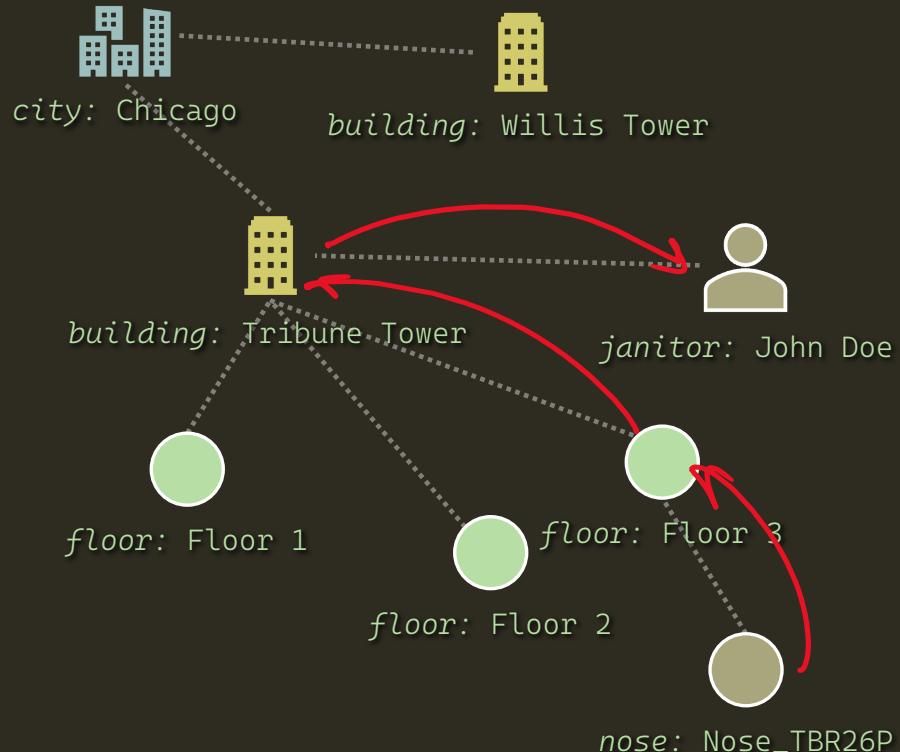
- Zephyr is **designed with IoT scenarios in mind** and has plenty of connectivity options:
 - **MQTT**, CoAP, LwM2M, Bluetooth, USB, ...
- Sending « smells » to an IoT server is as simple as adding a new thread + zbus subscriber



Photo by [Wilhelm Gunkel](#) on [Unsplash](#)

FROM CONNECTED THINGS TO CONNECTED ENVIRONMENTS*

Nose_TBR26P:
“foul air!”



* a.k.a. Digital Twins

AND ALSO...

Kconfig + DeviceTree = ❤

Testing framework

Easy CI integration

The community 

ZEPHYR 3.6: MOARR NEAT FEATURES!

LLEXT

GNSS subsystem

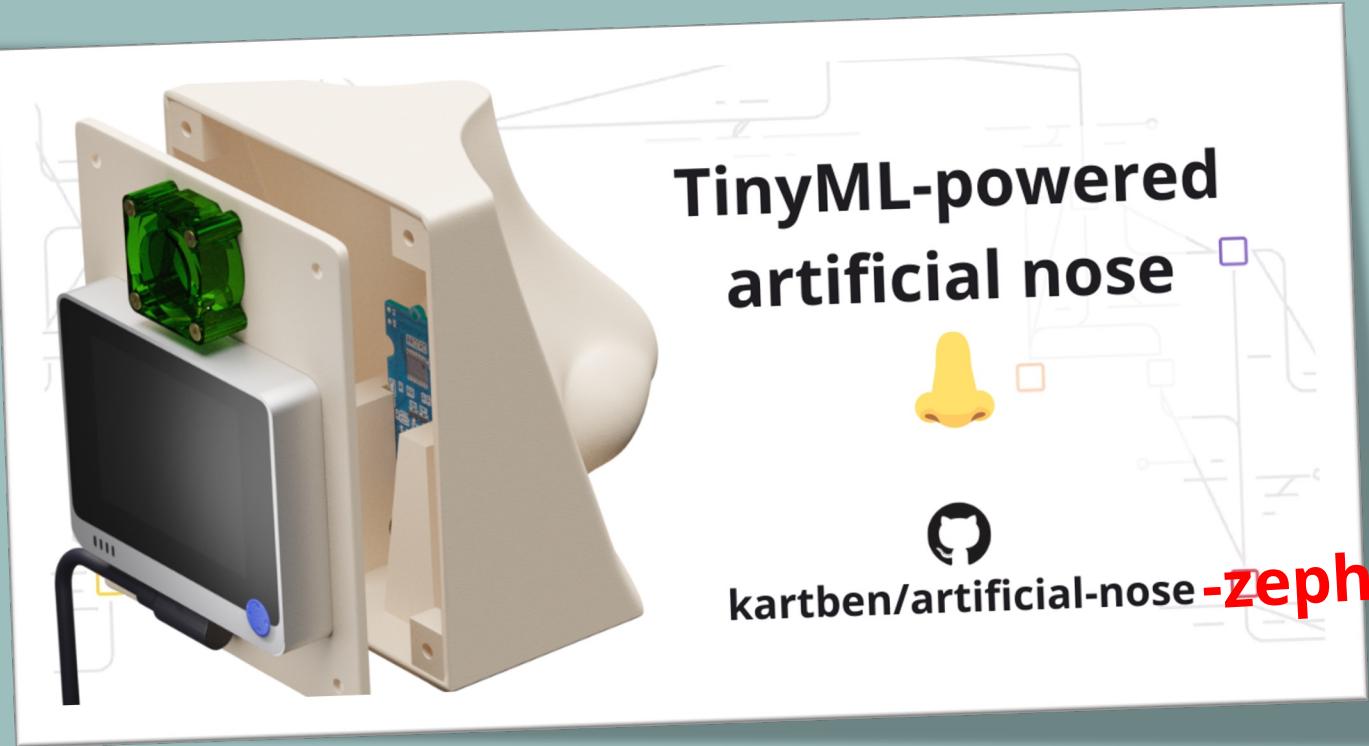
New display drivers, inc. round LCD displays

...



[GITHUB.COM/KARTBEN/ARTIFICIAL-NOSE](https://github.com/kartben/artificial-nose)

Bill of materials,
source code,
schemas, ...



TinyML-powered artificial nose



[kartben/artificial-nose-zephyr](https://github.com/kartben/artificial-nose-zephyr)

[GITHUB.COM/KARTBEN/ARTIFICIAL-NOSE-ZEPHYR](https://github.com/kartben/artificial-nose-zephyr)

The screenshot shows a product page on the Seeed website. At the top, the Seeed logo is displayed along with navigation links for Shop, Fusion, Solution, Customization, and Community. A search bar and a login button are also present. The main content area features a large image of a person holding a blue 3D-printed nose-shaped enclosure next to a real baguette. Below this image, the product title is "Tiny ML powered Artificial Nose Project kit with Wio Terminal". The SKU is listed as E21000010. The product description highlights Benjamin Cabé's artificial nose project, which uses TensorFlow, Edge Impulse, and open-source libraries to train AI modules. It mentions the use of a Wio Terminal, Grove - Multichannel Gas Sensor v2, and Grove - MOSFET. The price is \$36.90. The quantity selector shows a value of 1. An "Add to Cart" button is visible, with a note below it stating "Grove is required". On the left side of the page, there is a sidebar with various project categories and a detailed breakdown of the kit components: "Wio Terminal" (1x Wio Terminal: ATSAMD51 Core with Realtek RTL8720DN BLE 5.0 & Wi-Fi 2.4G/5G Dev Board with Free Course) and "Grove" (1x Grove - Multichannel Gas Sensor v2).

TINYURL.COM/AINOSE-KIT

Wio Terminal + Gas
sensors + Fan
controller

Thanks! Questions?



@kartben



benjamin@zephyrproject.org



<https://blog.benjamin-cabe.com>

<https://zephyrproject.org>



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