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Q&A WITH SPEAKER | SPEAKER BIO

Maksim Masalski
Software Engineer
Intel

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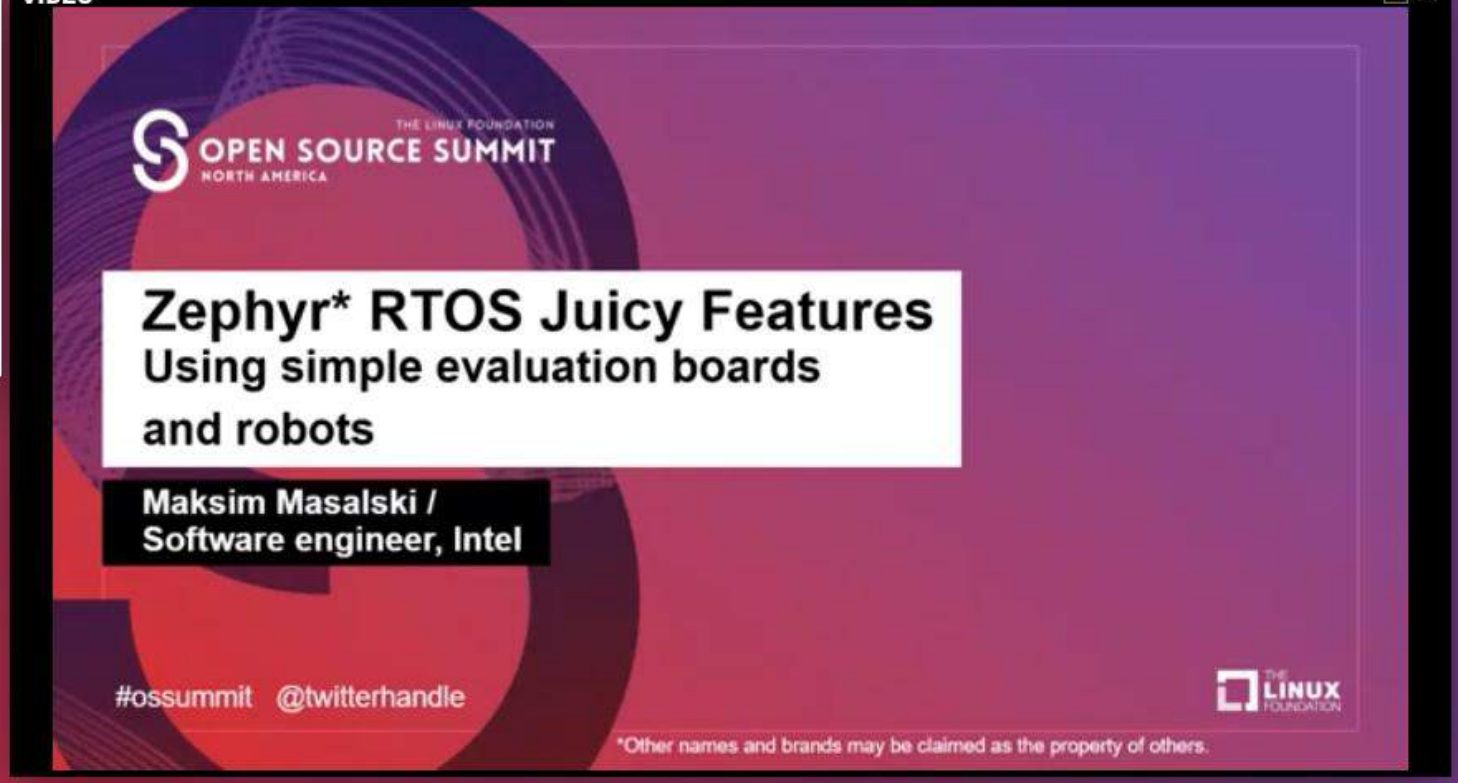
https://deumesh.intel.com/projects/robot-avatar-

VIDEO



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https://devmesh.intel.com/projects/robot-avatar-

VIDEO

Agenda

Part I Zephyr* Introduction
- The Zephyr Project Overview
- Key points of the Zephyr RTOS

Part II Robotics
- How do you write code for a robot?
- Micro:bit* board description
- Robotics expansion platforms
- Line-following robot
- Run samples on Zephyr
- Reverse engineering of the MakeCode* program
- Create Zephyr application
- Building an application
- Setup Zephyr application
- Coding Zephyr application
- Build and upload Zephyr binary
- Running application

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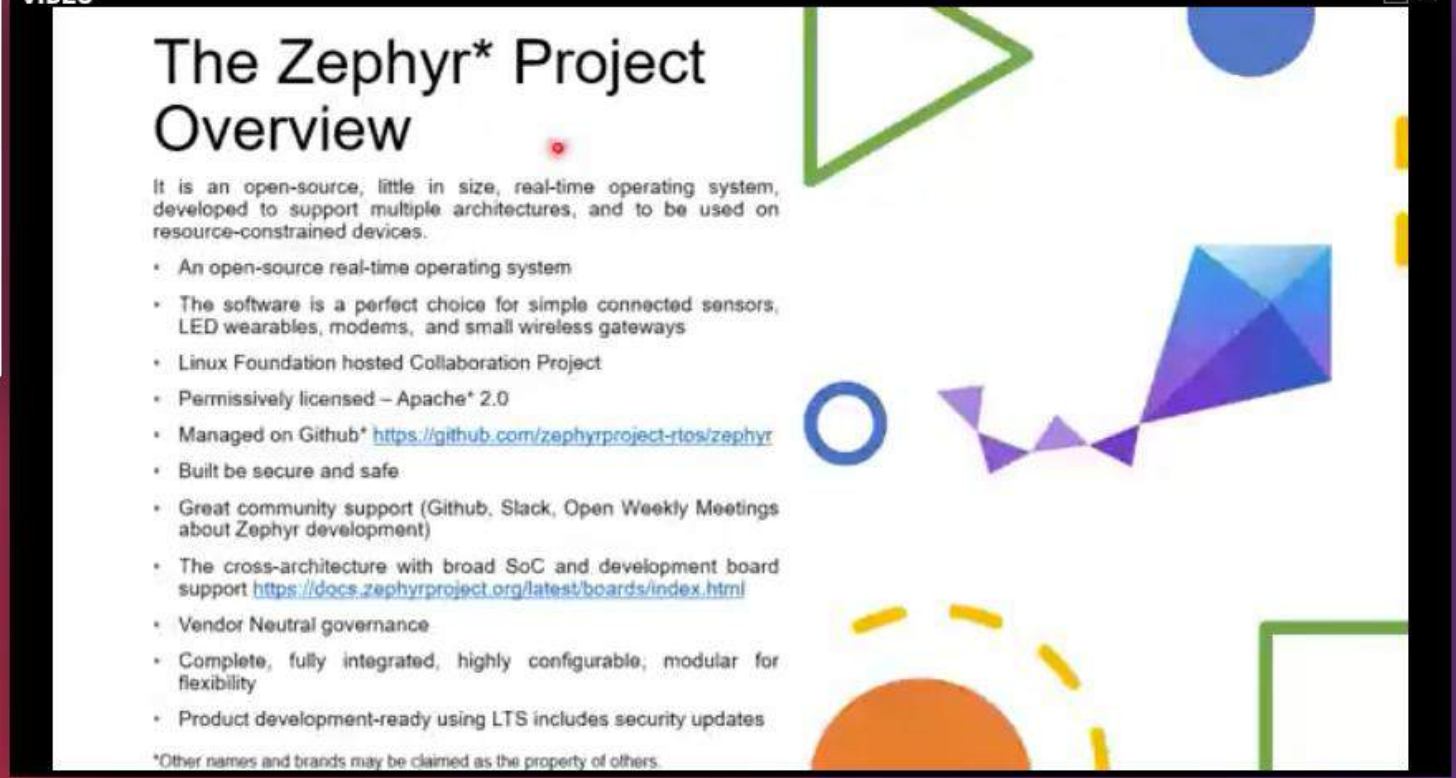

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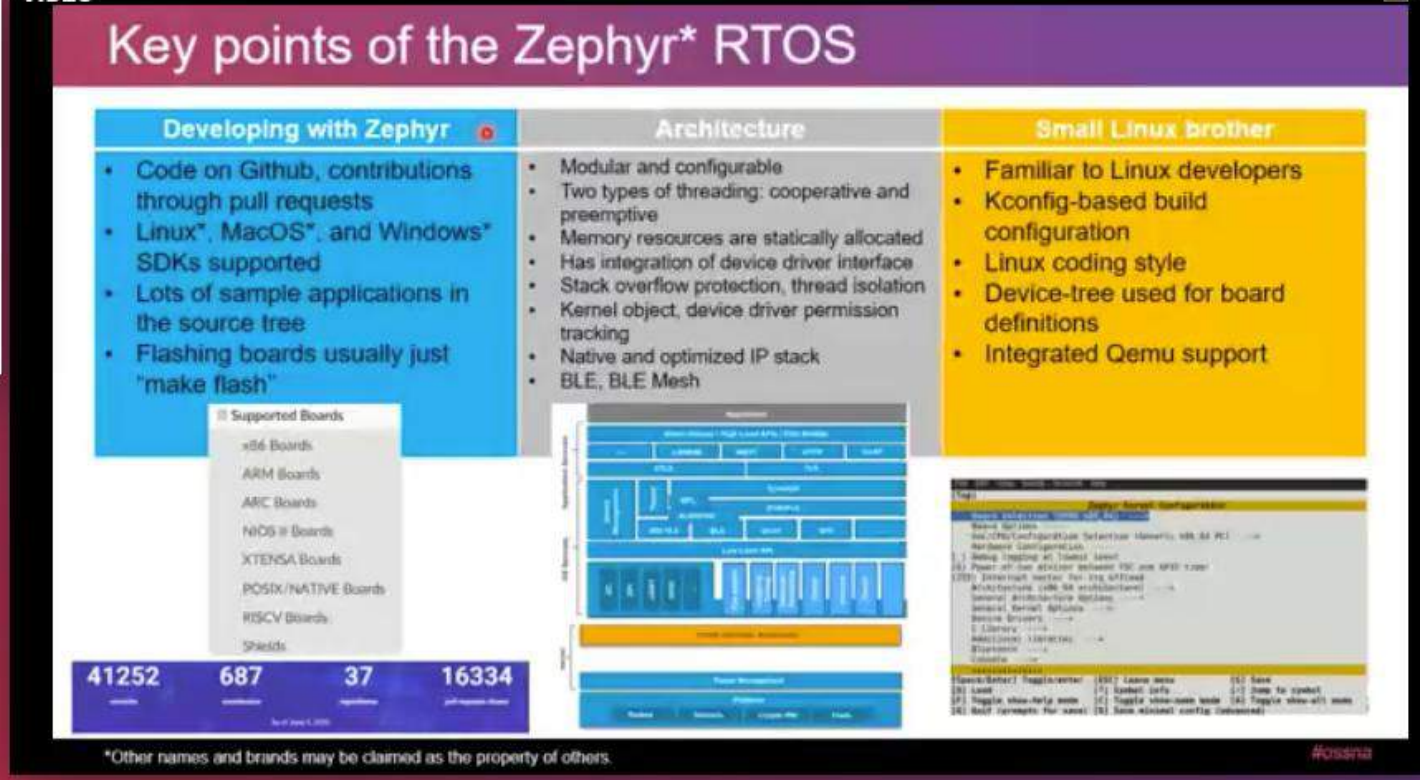

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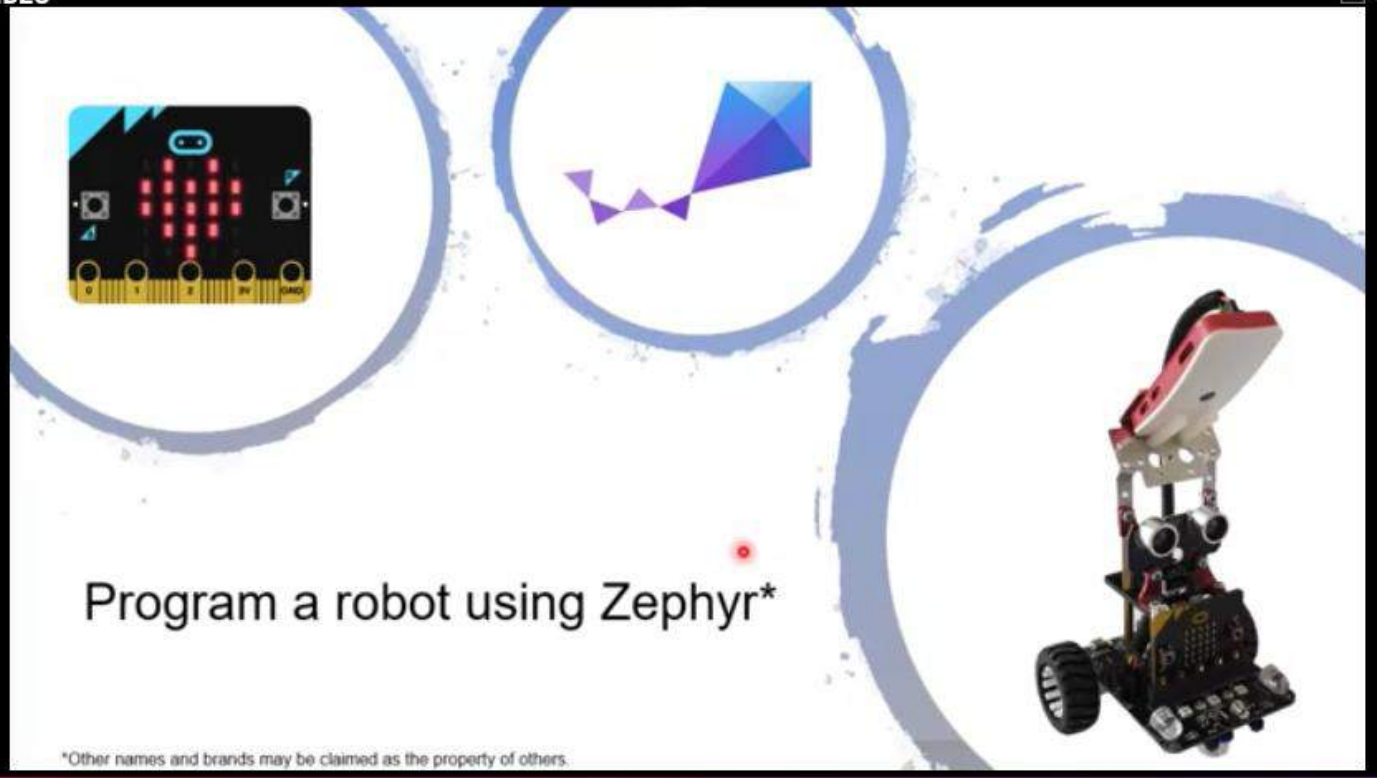
VIDEO



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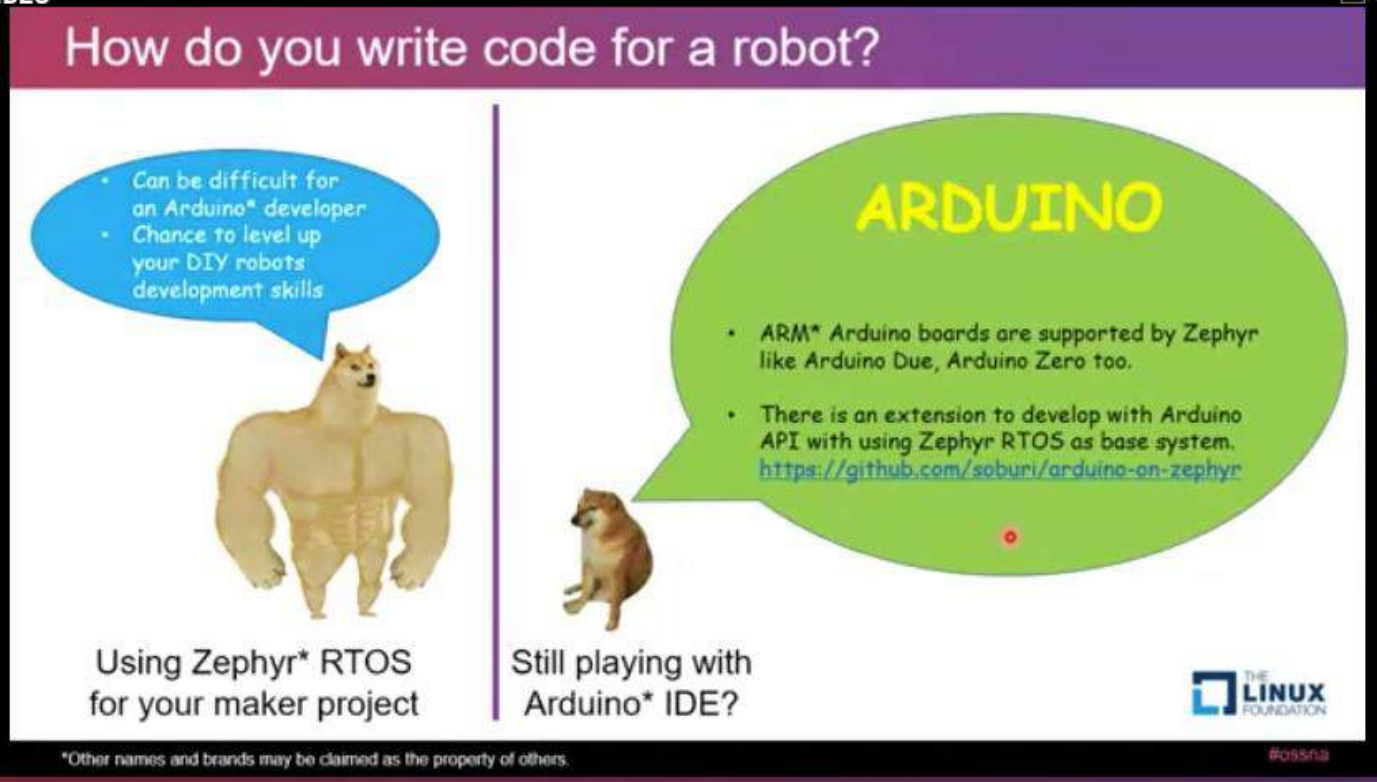

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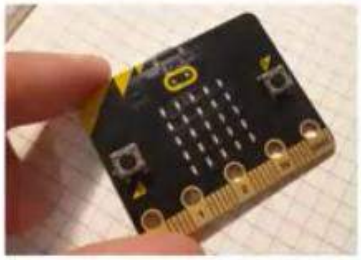
Micro:bit* board description



- Has enough built-in features like gyroscope, accelerometer, 2 buttons, temp sensor, LED matrix
- Doesn't take much space at your desk
- In the evening, you can use it to teach kids coding using simple programming languages like Scratch*, MakeCode*, or even Python*
- When kids go to sleep, run Zephyr on it and play with robots, and IoT prototypes
- Cheap enough to by one more, if you burn it during robotics experiments

Technical data:

1. Size 4 x 5cm (1.6 x 2 inch)
2. Has 2 programmable buttons
3. 3 digital/analogue input/output rings
4. 25 individually programmable LEDs
5. 32-bit ARM* Cortex* M0 CPU 16K RAM 16Mhz with Bluetooth* LE
6. Accelerometer, compass, temperature sensor
7. 20 pin edge connector
8. Micro USB* connector

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Robotics expansion platforms

A big number of expansion boards and platforms makes it simple to create a robot of any type and purpose. Just insert micro:bit into the platform and you can control it.

And finally, drive your robot by Zephyr*!

Micro:bit* has next expansion platforms:

1. Drones
2. Robotic Arms
3. Various car chassis
4. Biped robots

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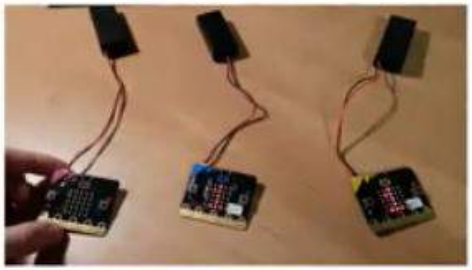
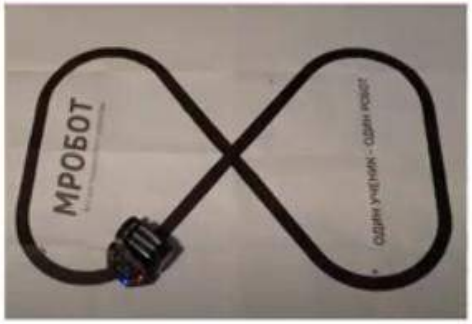
Run samples on Zephyr*



- If you have three micro:bit boards you can try to run the Bluetooth® Mesh sample from the Zephyr code repo.
- Detailed Bluetooth Mesh project description here: https://docs.zephyrproject.org/latest/samples/bluetooth/mesh_demo/README.html



- The most popular and easiest-to-implement are line-follower robots.
- I will guide you how to program line-following function of the robot using Zephyr RTOS.
- Video of the robot following a line: https://www.youtube.com/watch?v=tIvoHQjo8a4

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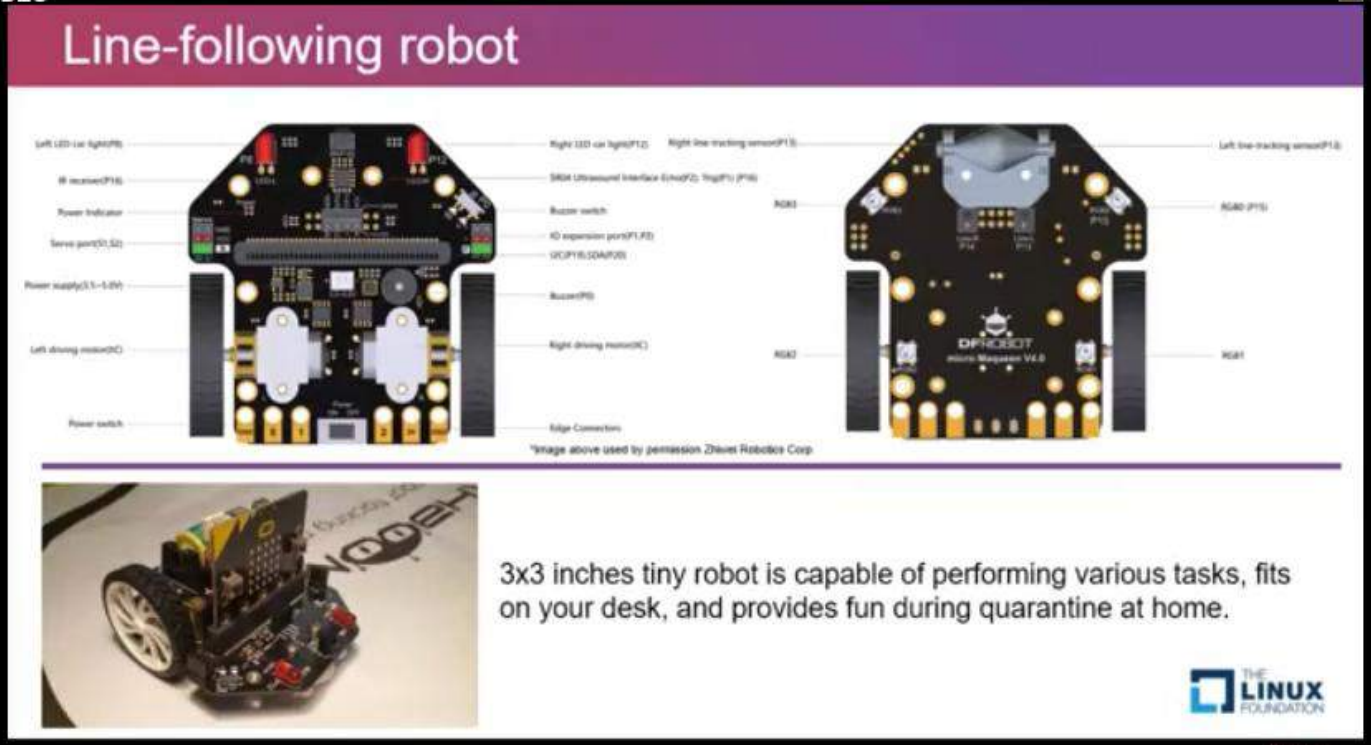

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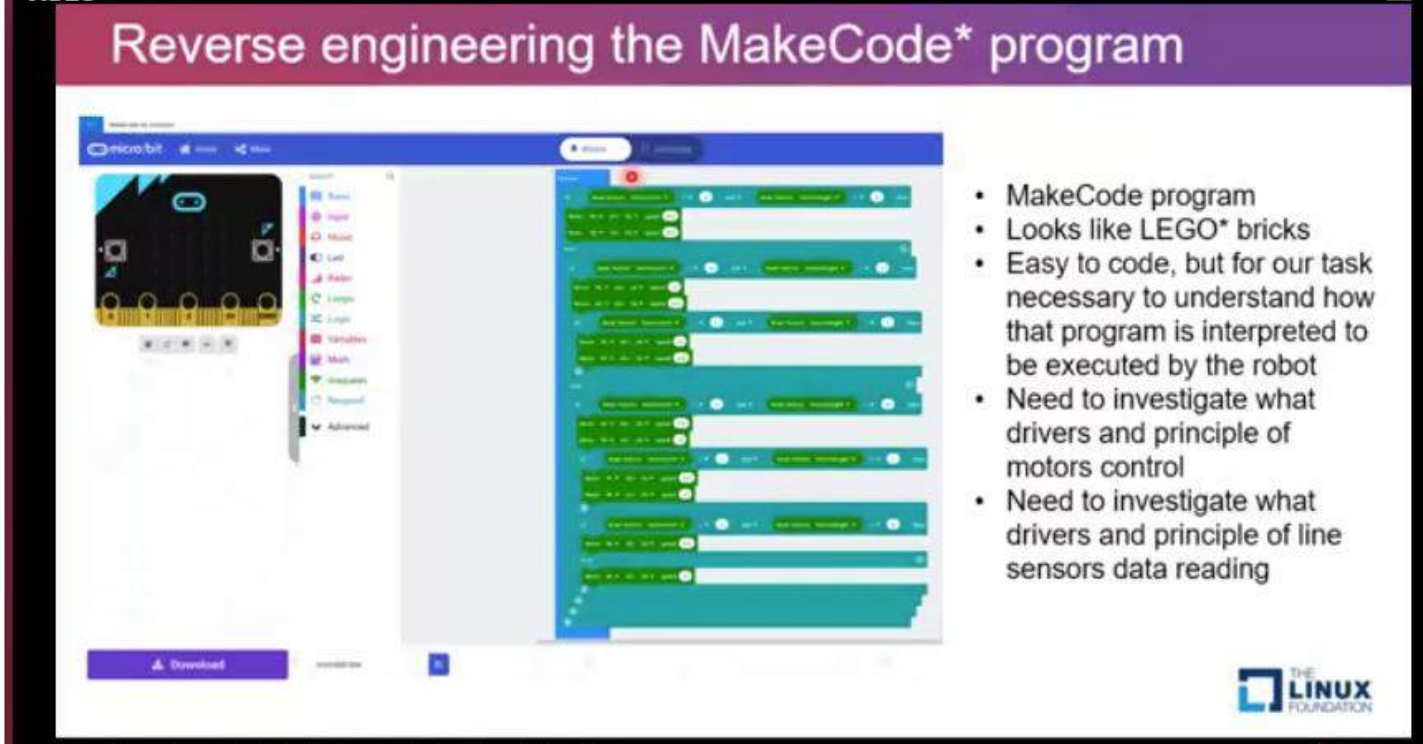

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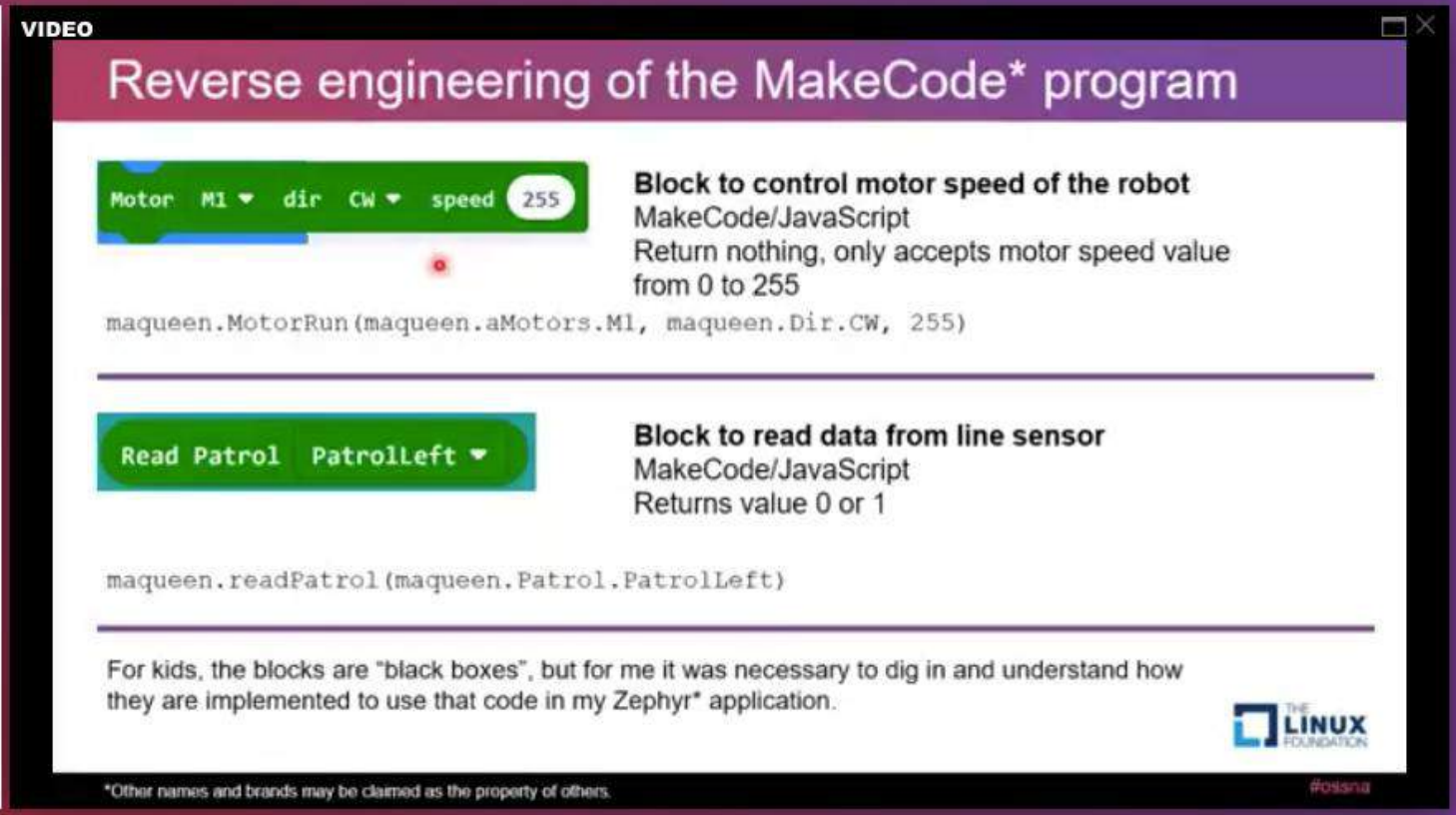

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Reverse engineering of the MakeCode* program

Found library on Github*
- Typescript file (.ts) had all definitions and control code for motor and also code for reading data from the sensors.

Motor driver information:
- Motor driver is I2C
- In code found correct device address value (0x10)
- In code found commands responsible for setting motors speed value

Line sensor information:
- Robot has two line sensors.
- Line sensors are binary. They use infrared LED to measure the amount of the reflected light from the surface.
- Found pins on the micro:bit board responsible for reading sensor data (pin 22, pin 23). One pin for each sensor.

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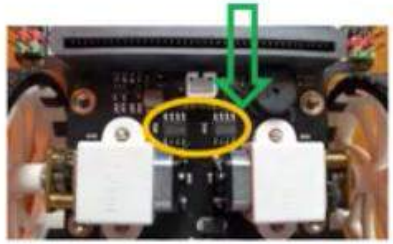
Two motor drivers.
One for each motor.
Both controlled by one I2C chip.



Line sensors working principle:

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Does Zephyr support time sensitive networks?

Yes, gPTP, 802.1Qav in upstream
https://www.zephyrproject.org/wp-content/uploads/2020/01/Zephyr-industrial-networking.pdf

What's the model of this robot used?

I used DFRobot Maqueen robot

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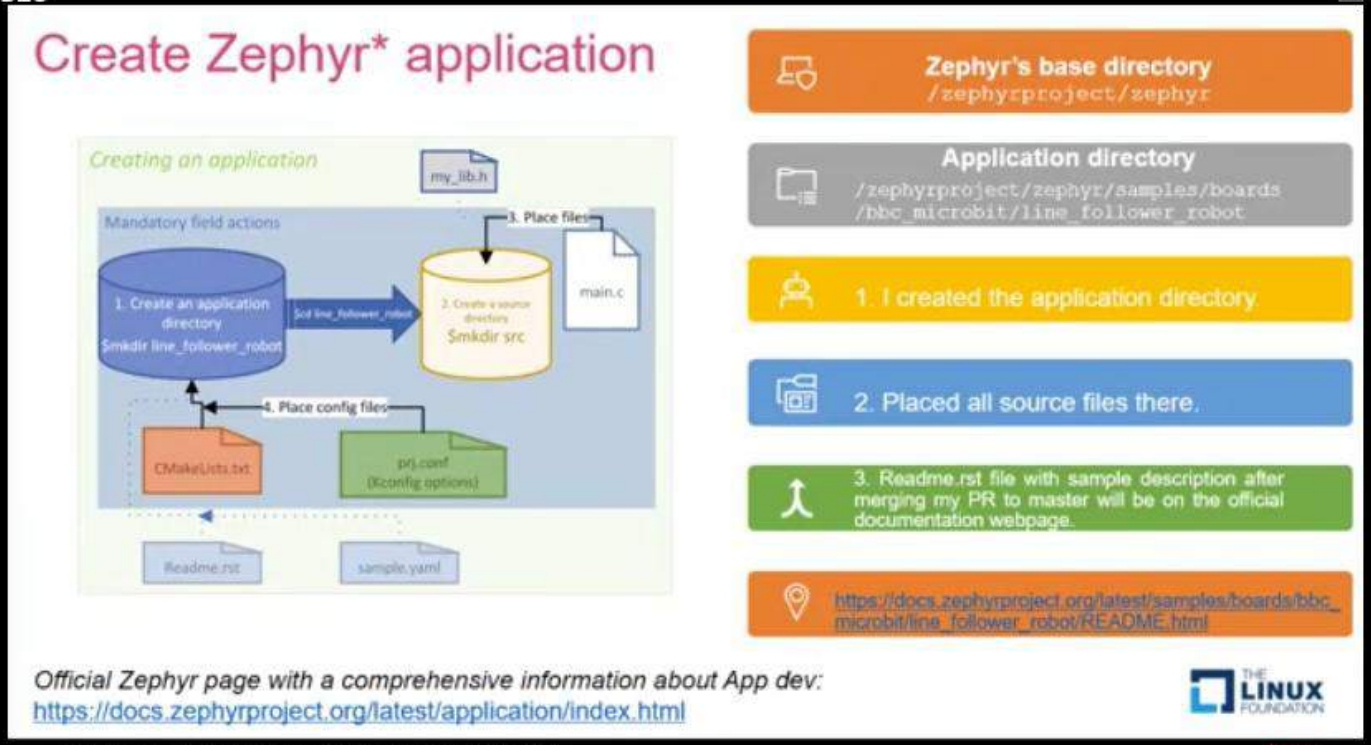

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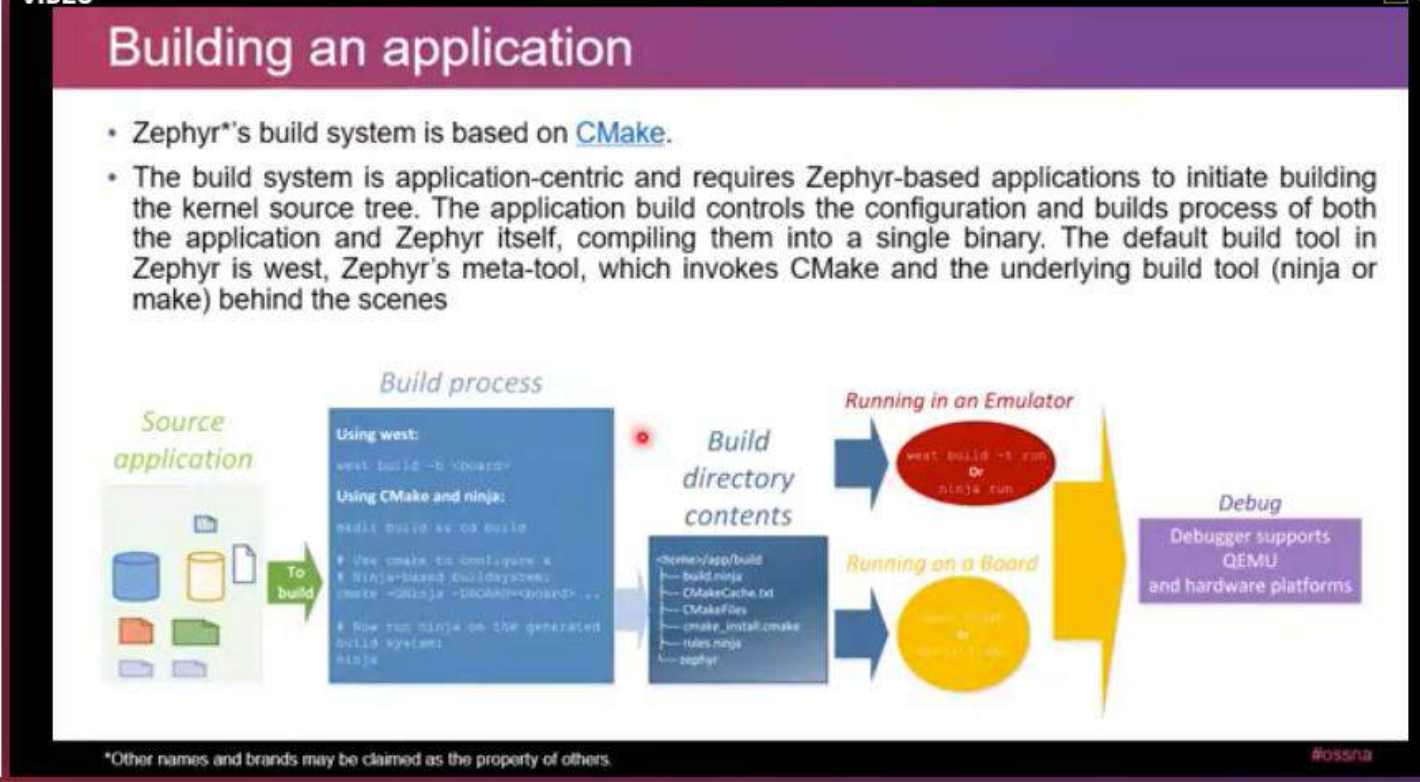

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Why put your application into the Zephyr tree? Is that recommended for all projects, or was it just because this was a first-of-its-kind demo?

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Setup Zephyr* application

prj.conf

To setup current application necessary to enable vital configuration options. For my application I enabled I2C and GPIO using prj.conf file:

```
CONFIG_GPIO=y
CONFIG_I2C=y
CONFIG_PRINTK=y
```

CMakeLists.txt

```
# SPDX-License-Identifier: Apache-2.0

cmake_minimum_required(VERSION 3.13.1)

find_package(Zephyr REQUIRED HINTS $ENV{ZEPHYR_BASE})
project(robot)

FILE(GLOB app_sources src/*.c)
target_sources(app PRIVATE ${app_sources})
```

Sample.yaml

That file has information for Sanitycheck testing system.

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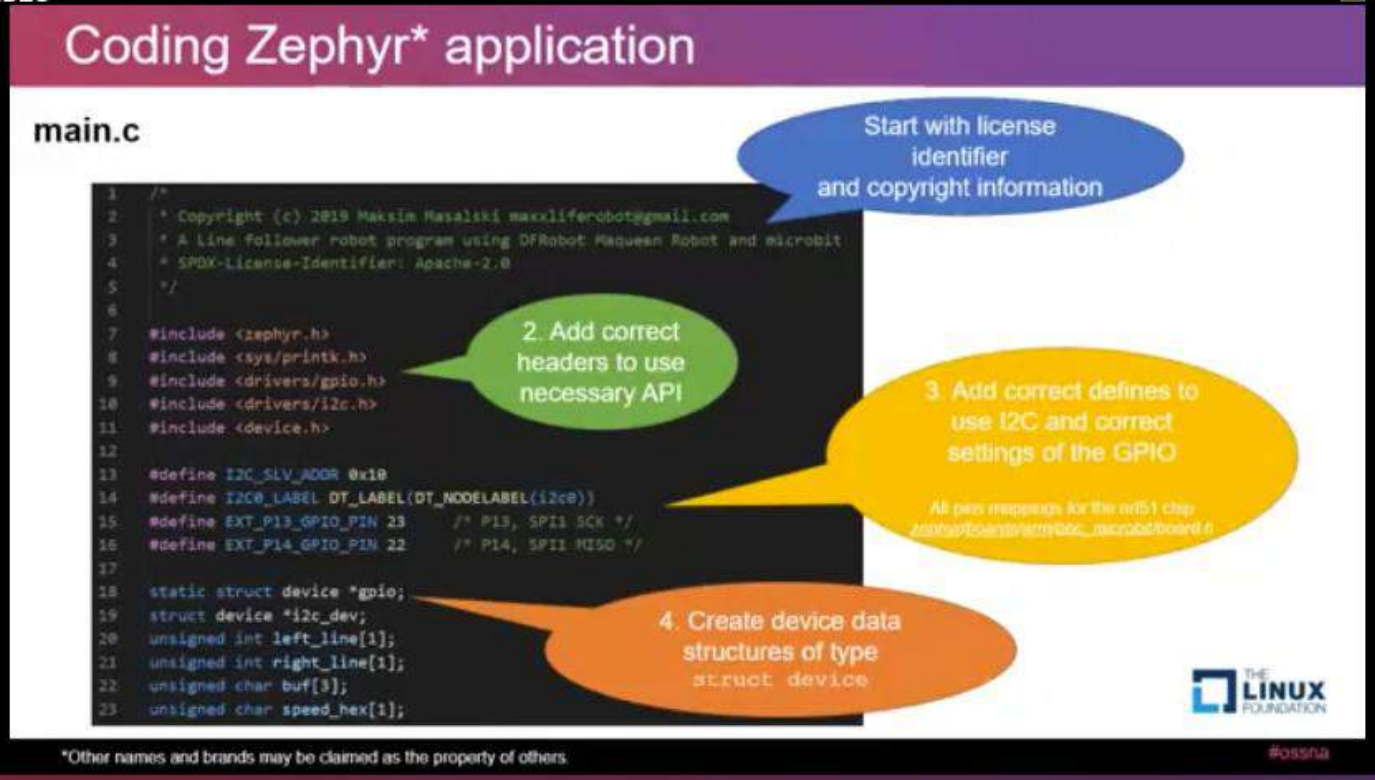

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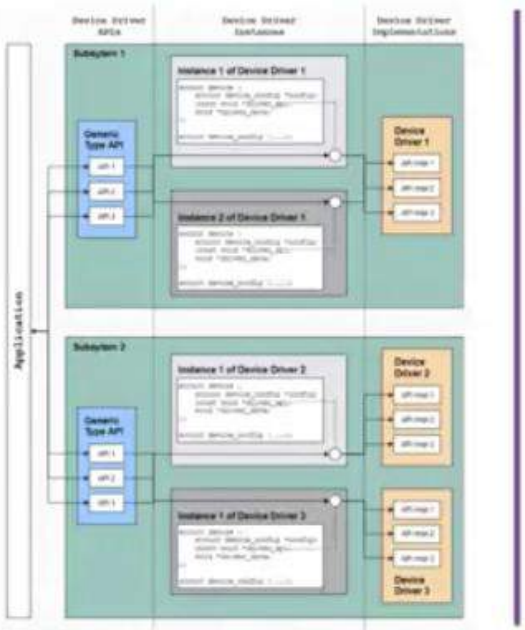
Device Driver Model



Standard Drivers

- Interrupt controller
- Timer
- Serial communication
- Entropy

Driver Data Structures

The device initialization macros populate some data structures at build time which are split into read-only and runtime-mutable parts. At a high level we have:

```
struct device {
        const char *name;
        const void *config_info;
        const void *driver_api;
        void * const driver_data;
};
```

Official Zephyr page with a comprehensive information about Device drivers:*
https://docs.zephyrproject.org/latest/reference/drivers/index.html

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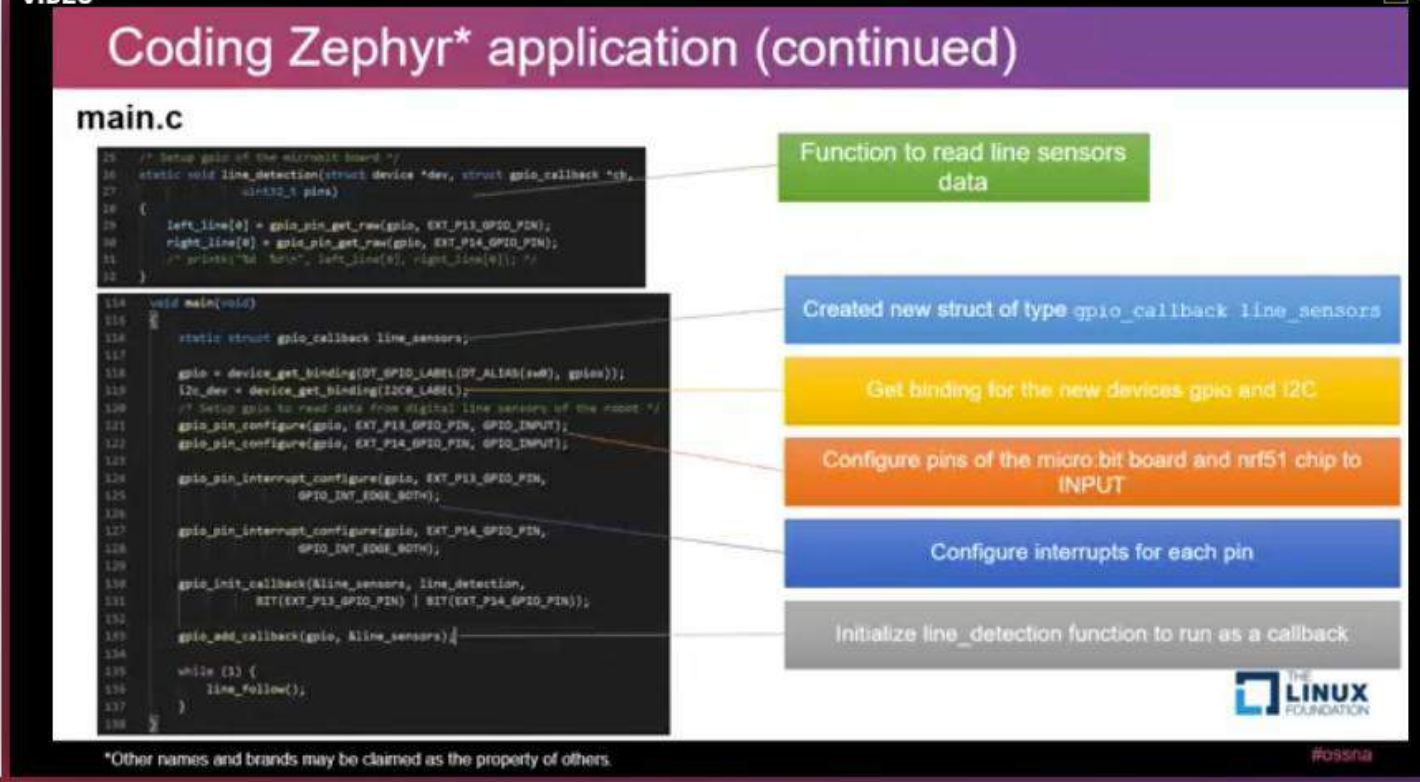

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Coding Zephyr* application (continued)

main.c

Writing function to control motors.

```
41  /* Function to control motors of the DFRobot Maqueen Robot */
42  /* Send value > 0 motor rotates forward */
43  /* Send 0 motor stop */
44  /* Send value < 0 motor rotates backward */
45  void motor_left_control(int left_speed)
46  {
47      if (left_speed < 0) {
48          left_speed = left_speed * (-1);
49          /* Command bits to control I2C motordriver of the robot */
50          buf[0] = 0x00;
51          buf[1] = 0x01;
52          buf[2] = decimal_to_hex(left_speed);
53      } else {
54          buf[0] = 0x00;
55          buf[1] = 0x00;
56          buf[2] = decimal_to_hex(left_speed);
57      }
58      /* Left motor write data*/
59      /* Address of the I2C motordriver on the robot is 0x10 */
60      i2c_write(i2c_dev, buf, 3, 0x10);
61  }
```

Function to control one motor

If function accepted negative value change direction of the rotation.

Make package to send using buf[] array

Else, if function accepted positive value, rotate wheel forward

Send buf[] array to the I2C device

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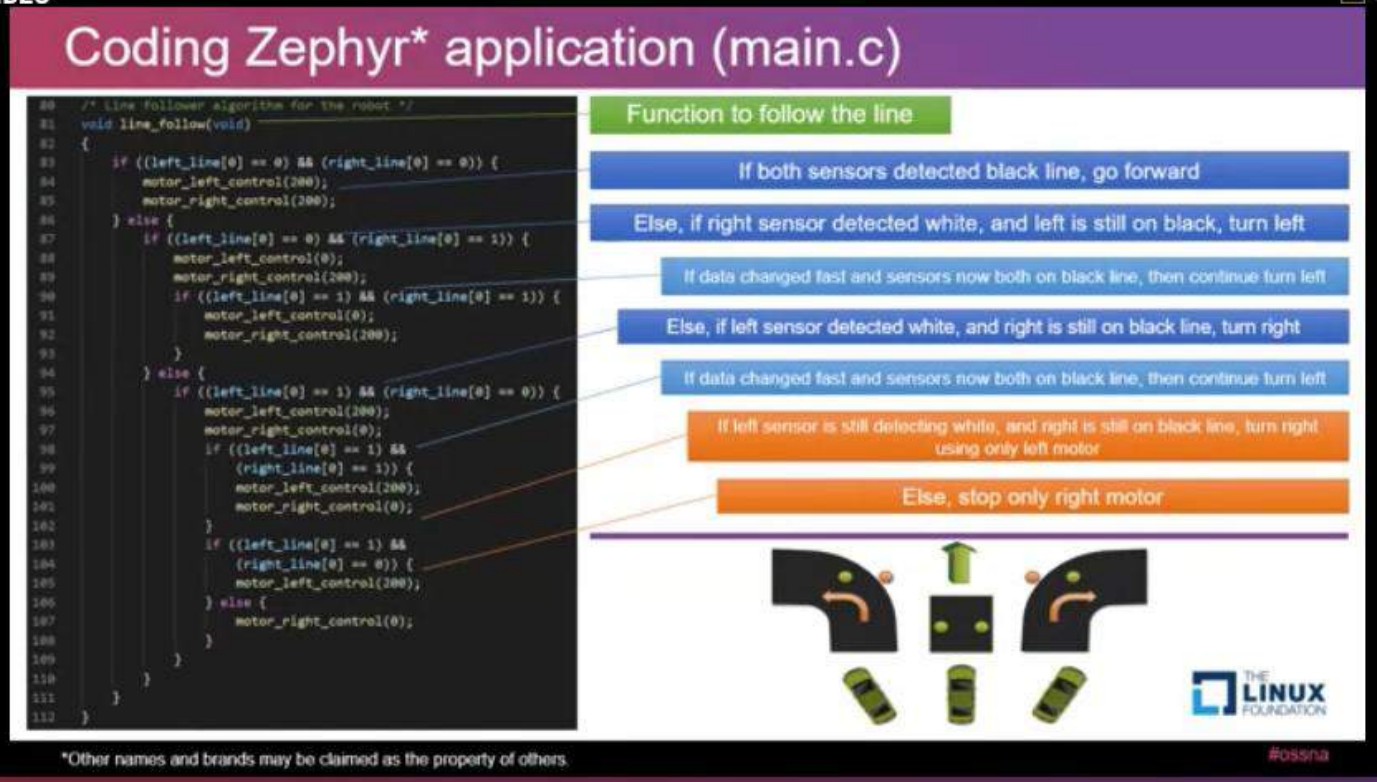

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Q&A WITH SPEAKER SPEAKER BIO

I used DFRobot Maqueen robot

Thank you! I will share them to all participants, or you can ping me maksim.masalski@intel.com

Why put your application into the Zephyr tree? Is that recommended for all projects, or was it just because this was a first-of-its-kind demo?

I wanted to merge my application into upstream tree on Github.

Any recommended IDE that can be used with Zephyr? Because main developers like to use IDE for development and debugging

I'm using VIM, recently started to use VS Code. You can use Eclipse https://docs.zephyrproject.org/latest/application/index.html (Eclipse debugging article)

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Build and upload Zephyr* binary

1. Clone the Zephyr repo from Github* and setup development system as described below: https://docs.zephyrproject.org/latest/getting_started/index.html

2. Connect micro:bit to the computer using micro-USB cable.

3. Build application using `$west build` command

```
[maksim@maksim-nuc zephyr]$ pwd
/home/maksim/zephyrproject/zephyr
[maksim@maksim-nuc zephyr]$ west build -p -b bbc_microbit samples/boards/bbc_microbit/line_follower_robot/
```

```
[126/131] Linking C executable zephyr/zephyr_prebuilt.elf
Memory region         Used Size  Region Size  %age Used
           FLASH:       17484 B       256 KB      6.67%
            SRAM:        5248 B        16 KB     32.03%
        IDT_LIST:          88 B         2 KB      4.30%
[131/131] Linking C executable zephyr/zephyr.elf
```

4. Flash Zephyr image to the micro:bit board using `$west flash` command

```
[maksim@maksim-nuc zephyr]$ west flash
-- west flash: rebuilding
ninja: no work to do.
-- west flash: using runner pyocd
-- runners.pyocd: Flashing file: /home/maksim/zephyrproject/zephyr/build/zephyr/zephyr.hex
[====================] 100%
0003119:INFO:loader:Erased 18432 bytes (18 sectors), programmed 18432 bytes (18 pages), skipped 0 bytes (0 pages)
```

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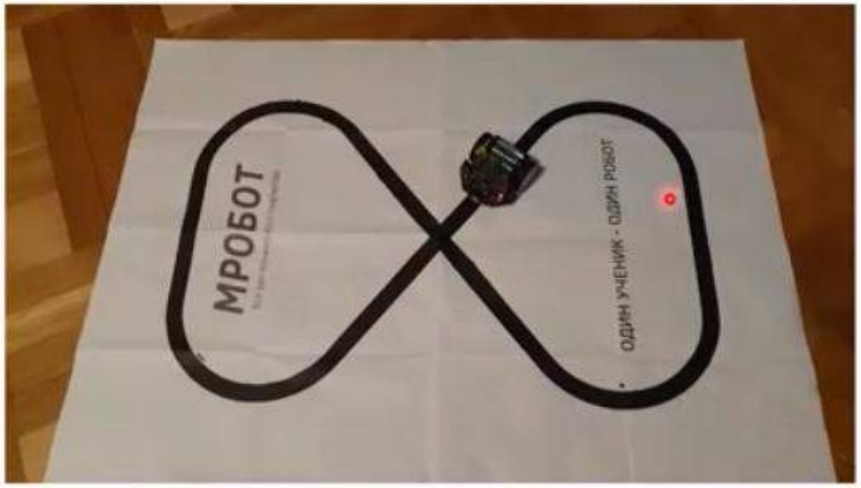
Running the application

Turn on the robot, and place it on the track, it will follow the line as shown in the video below:
https://www.youtube.com/watch?v=tIvoHQjo8a4



Join the Zephyr* project:
https://github.com/zephyrproject-rtos/zephyr

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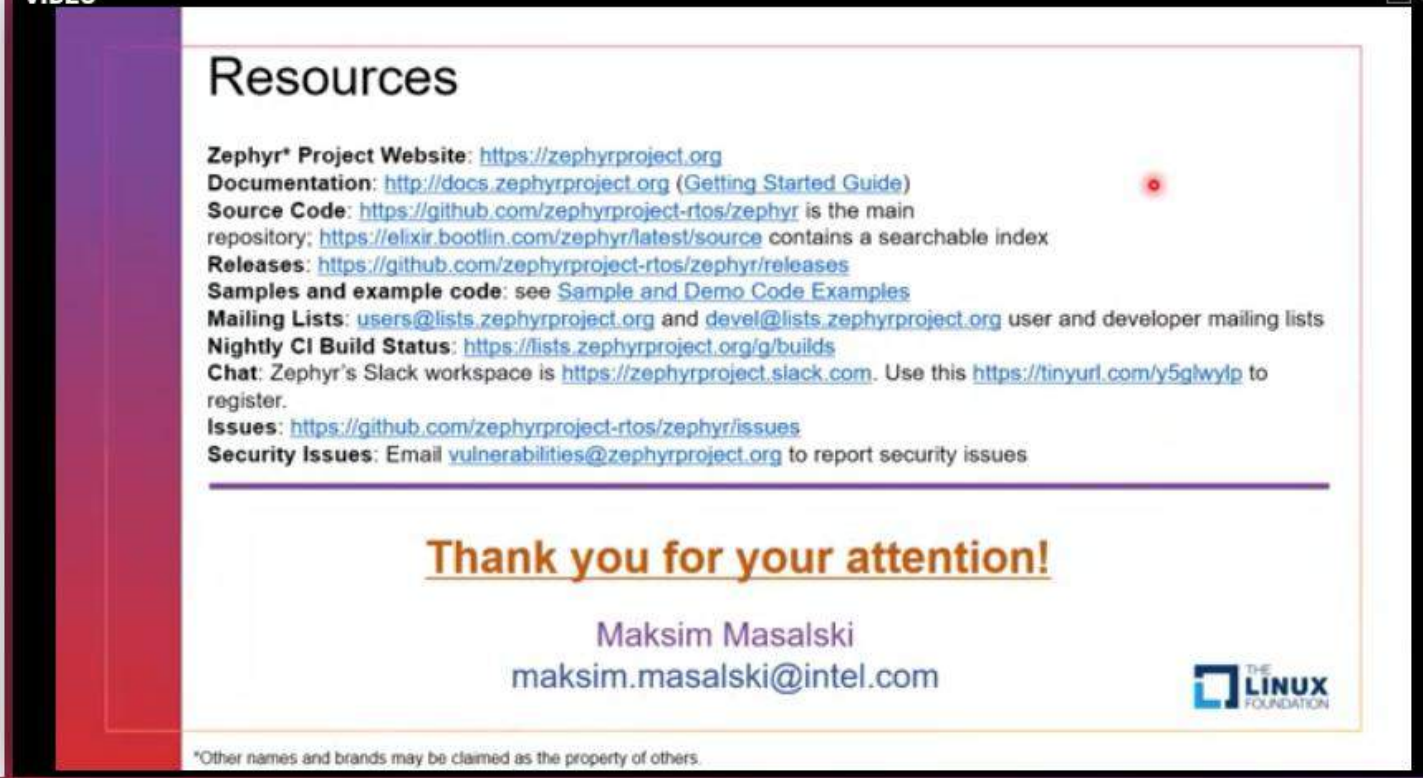

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