

onlinexperiences.com/scripts/Server.nxp

Zephyr Mini-Summit

OPEN SOURCE SUMMIT
NORTH AMERICA

THE LINUX FOUNDATION

Embedded Linux Conference
North America

VIDEO



ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

SLIDES

Zephyr Mini-Summit: Agenda

- Zephyr overview - John Round
- Intro to West - Marti Bolivar
- Overview of Bluetooth - Martin Woolley
- Security Issues - David Brown
- Safety Certification - Kate Stewart
- Use Case - Michael Gieda
- Q&A

Linaro

THE LINUX FOUNDATION

#ossna

refresh icon

video icon

document icon

list icon

comment icon

person icon

Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO



SLIDES

Vision Statement

The Zephyr Project strives to deliver the **best-in-class RTOS** for connected resource-constrained devices, built to be secure and safe.

Linaro
THE LINUX FOUNDATION

#ossna

refresh video list comment user



VIDEO



ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

SLIDES

Zephyr Project

- **Open source** real time operating system
- **Vibrant Community** participation
- Built with **safety and security** in mind
- **Cross-architecture** with broad SoC and development board support.
- **Vendor Neutral** governance
- **Permissively licensed** - Apache 2.0
- **Complete**, fully integrated, highly configurable, **modular for flexibility**
- **Product** development ready using LTS includes security updates
- **Certification** ready with Auditable

THE LINUX FOUNDATION PROJECTS

Open Source, RTOS, Connected, Embedded
Fits where Linux is too big



#ossna



Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO



SLIDES

Zephyr Supported Hardware Architectures

ARC
Synopsys

arm
Cortex-M, Cortex-R & Cortex-A

intel
X86 & x86_64

Nios® II
Processor

RISC-V
32 & 64 bit

tensilica
Xtensa

Coming soon: **SPARC*** **OpenPOWER™** Linaro
 THE LINUX FOUNDATION

#ossna

Navigation icons: back, forward, search, etc.



VIDEO

**ABSTRACT**

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

SLIDES

Board Support – 200+ and growing

<http://docs.zephyrproject.org/boards/boards.html>

#ossna





VIDEO

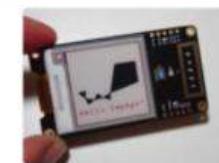
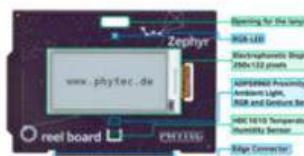
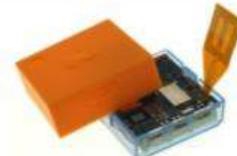


ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

SLIDES

Development Boards Shipping with Zephyr Today



#ossna

Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO

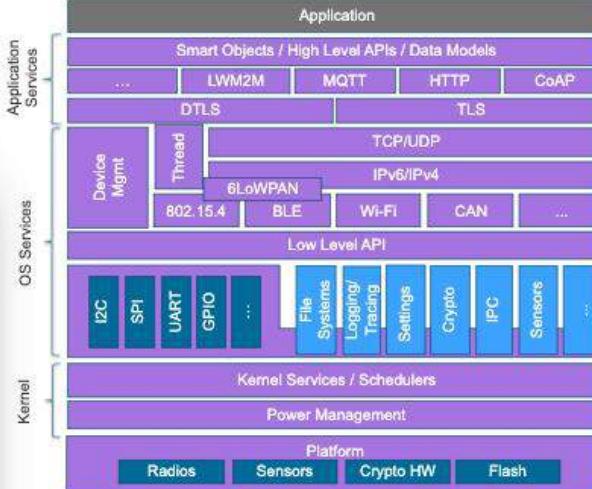


ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

SLIDES

Architecture



Fully featured OS allows developers to focus on the application

- Highly Configurable, Highly Modular
- Cooperative and Preemptive Threading
- Memory and Resources are typically statically allocated
- Integrated device driver interface
- Memory Protection: Stack overflow protection, Kernel object and device driver permission tracking, Thread isolation
- Bluetooth® Low Energy (BLE 5.1) with both controller and host, BLE Mesh
- 802.15.4 OpenThread
- Native, fully featured and optimized networking stack

Linaro

THE LINUX FOUNDATION

#ossna

Navigation icons: back, forward, search, etc.



VIDEO



ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

SLIDES

Growing a Diverse Community!

Lifetime project participation

Authors

- 2016/2: 80
- 2020/6: 699

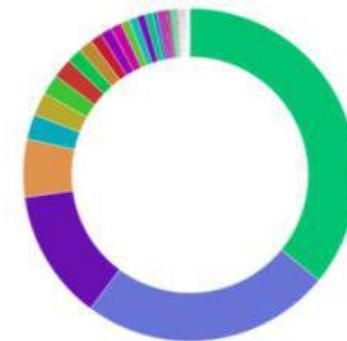
Commits

- 2016/2: 2,806
- 2020/6: 41,693

Boards

- 2016/2: 4
- 2020/6: 200+

Company Participation over the last 12 months



#ossna



VIDEO



ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

SLIDES

Upstream Commits in Last Year

10,000+



5000+



2000+



500+



>50



#ossna



VIDEO



SLIDES

Zephyr Project Governance



Goal: Separate business decisions from meritocracy, technical decisions

Governing Board

- Decides project goals and strategic objectives
- Makes business, marketing and legal decisions
- Prioritizes investments and oversees budget
- Oversees marketing such as PR/AR, branding, others
- Identifies member requirements

Technical Steering Committee

- Serves as the highest technical decision body consisting of project maintainers and voting members
- Sets technical direction for the project
- Coordinates X-community collaboration
 - Sets up new projects
 - Coordinates releases
 - Enforces development processes
 - Moderates working groups
- Oversees relationships with other relevant projects

Community

- Code base open to all contributors, need not be a member to contribute.
- Path to committer and maintainer status through peer assessed merit of contributions and code reviews
- Ecosystem enablement



#ossna



VIDEO



SLIDES

Zephyr Project Members



and more...



#ossna



VIDEO

**ABSTRACT**

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

SLIDES

Zephyr Participation Information

Orientation:

- <https://www.zephyrproject.org/community/>
- <https://docs.zephyrproject.org/latest/index.html>

Github:

- <https://github.com/zephyrproject-rtos/zephyr>

Mail Lists:

- <https://lists.zephyrproject.org/g/main>

Slack:

- <https://tinyurl.com/y5glwylp>



#ossna



VIDEO



SLIDES

Outline: Presenter: Marti Bolivar



- Zephyr and west developer
- What we're doing today:
 - Overview of what's available in west
 - Good starting points for experimenting and getting help
- Helpful if you've already gone through the Zephyr Getting Started Guide for v2.3.0, but not required:
https://docs.zephyrproject.org/2.3.0/getting_started/index.html



VIDEO



SLIDES

What is west?



Zephyr's "meta-tool" or "swiss army knife," used for many common development workflows.

An extensible command line tool for managing a Zephyr workspace:
<https://docs.zephyrproject.org/2.3.0/guides/west/index.html>

Recommended but not required:
<https://docs.zephyrproject.org/2.3.0/guides/west/without-west.html>

Developed in its own git repository:
<https://github.com/zephyrproject-rtos/west>

onlinexperiences.com/scripts/Server.nxp

Zephyr Mini-Summit

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO SLIDES

West “proper” vs. Zephyr uses

Zephyr™

West “proper”

- Workspace commands (`init`, `update`, etc.)
- Configuration command (`config`)
- APIs for adding extension commands (external plug-ins)

In the west repository

Zephyr’s west usage and extensions

- Zephyr module integration
- Extension commands (`build`, `flash`, `debug`, etc.)

In the zephyr repository

refresh video document list comment user



VIDEO



SLIDES

Creating a workspace: west init



```
$ west init -m https://github.com/zephyrproject-rtos/zephyr \
--mr v2.3.0 zephyrproject
```

Results (simplified)



Vocabulary

- **zephyrproject:** the **west workspace's** top level directory, or **topdir**. The **.west** directory marks the topdir.
- **zephyr:** the **manifest repository** (in this example)
- **.west/config:** the workspace **local configuration file**; tells west that "zephyr" is the manifest repository
- **west.yml:** the **manifest file**; says what other git repositories should be pulled in via **west update**

Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO SLIDES

Manifest file, west.yml

Zephyr™

ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

```
1 manifest:
2   defaults:
3     remote: upstream
4
5   remotes:
6     - name: upstream
7       url-base: https://github.com/zephyrproject-rtos
8
9   projects:
10    - name: fatfs
11      revision: 9ee6b9b9511151d0d64a74d532d39c6f2bbd4f16
12      path: modules/fs/fatfs
13    - name: mcuboot
14      revision: ba7748d0923077488fd8d7864db8d0af0a4b4657
15      path: bootloader/mcuboot
16      # ... 35 other modules not shown (zephyr v2.3.0)
17
18   self:
19     path: zephyr
20     west-commands: scripts/west-commands.yml
```

Simplified contents of zephyr/west.yml in v2.3.0.

- **remotes:** where projects can be fetched
- **projects:** a list of git repositories in the workspace
- **self:** configures the manifest repository (zephyr) itself

refresh video list comments user

Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO SLIDES

Manifest file semantics



`zephyrproject-rtos/zephyr`

`west.yml`

`manifest:`

`projects:`

`- ...`

`- ...`

`- ...`

`zephyrproject-rtos/<project>`

`zephyrproject-rtos/<project>`

`zephyrproject-rtos/<project>`

Every element of the projects list is another Git repository that is included in the upstream Zephyr project distribution.

Navigation icons: back, forward, search, etc.

Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO SLIDES

Updating a workspace: west update

\$ west update # run inside the "zephyrproject" workspace

Results (simplified)

```
zephyrproject
├── bootloader
│   └── mcuboot
├── modules
│   └── fs
│       └── fatfs
├── .west
│   └── config
└── zephyr
    └── west.yml
```

Vocabulary

- **Modules:** third-party code with Zephyr integration, can be integrated into Zephyr applications, device drivers, etc.
- Includes things like file systems, vendor HALs, etc.
- A small number west projects live outside the modules directory. Currently just the mcuboot bootloader and some additional developer tools repositories

refresh video notes search user

Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO SLIDES



ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

Other workspace commands

Zephyr™

Some additional [workspace management commands](#):

list	print information about projects in the west manifest
manifest	slice and dice the west manifest
diff	"git diff" for one or more projects
status	"git status" for one or more projects
forall	run a command in one or more local projects

For a complete list of commands, including extensions, run:

```
$ west help
```

Navigation icons: back, forward, search, etc.

Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO SLIDES



ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

Zephyr extension commands

Some additional [Zephyr development extension commands](#):

build	compile zephyr applications
flash	flash a compiled application to a board
debug	flash an application and enter a debugger (usually GDB)
debugserver	flash an application and start a debug server
attach	attach a debugger to a board without flashing

refresh video notes search user

Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO SLIDES

Most common extension issue

If you see this when running an extension like west build:

```
west: error: argument <command>: invalid choice: 'build'  
(...)
```

Then you're not in your workspace, so the extension can't be found.

See this item on the troubleshooting page:
<https://docs.zephyrproject.org/2.3.0/guides/west/troubleshooting.html#invalid-choice-build-or-flash-etc>

↻ ⏴ ⏵ 🔍 🗂️ 💬 🙁

Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO SLIDES

West configuration files

Zephyr™

ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

- “INI-like” (Python configparser syntax)
- We saw .west/config earlier; that’s the workspace configuration file
- You can also set user- and system-wide configuration values
- Run `west config` to manage your configuration
- See also: <https://docs.zephyrproject.org/2.3.0/guides/west/config.html>

refresh video presentation notes comment user

Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO SLIDES

Help and troubleshooting

Documentation: [West page in the Zephyr guides](#) and [Troubleshooting west](#). Also:

\$ west help
List all commands and one line help for each (including extensions).

\$ west <command> help
Help for a specific <command>, like `west help init`

\$ west -v <command>
Enable verbose output for <command>, like `west -v init`

↻ ⏴ ⏵ 🔍 🗃 💬 🙁

VIDEO



An Overview of Bluetooth® Technology in Zephyr

Martin Woolley

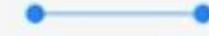
Senior Developer Relations Manager | Bluetooth SIG, Inc.

Twitter: @bluetooth_mdw



Bluetooth Today

Topology



Point-to-Point



Broadcast



Mesh

Radio



Bluetooth BR/EDR

Bluetooth Low Energy (LE)

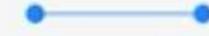


Stack Configurations



Bluetooth and Zephyr

Topology



Point-to-Point



Broadcast



Mesh

Radio

Bluetooth BR/EDR

Bluetooth Low Energy (LE)

Experimental

Bluetooth SIG Qualifications

<https://docs.zephyrproject.org/latest/guides/bluetooth/bluetooth-qual.html>

Modular Design and Feature Selection

```
CONFIG_BT=y  
CONFIG_BT_OBSERVER=y  
CONFIG_BT_BROADCASTER=y  
CONFIG_BT_DEBUG_LOG=y  
  
CONFIG_BT_MESH=y  
CONFIG_BT_MESH_RELAY=n  
CONFIG_BT_MESH_GATT_PROXY=n
```

Bluetooth Mesh

GAP Peripheral

```
CONFIG_BT=y  
CONFIG_BT_SMP=y  
CONFIG_BT_PERIPHERAL=y  
CONFIG_BT_GATT_DIS_PNP=n  
CONFIG_BT_DEVICE_NAME="NCLEC"  
CONFIG_BT_GATT_DIS=n  
# enable the possibility of LE Secure Connections  
CONFIG_BT_TINYCRYPT_ECC=y
```

```
CONFIG_BT=y  
CONFIG_BT_CENTRAL=y  
CONFIG_BT_DEBUG_LOG=y
```

GAP Central



Gap Peripheral Device

```
// 1. Advertising

static const struct bt_data ad[] = {
    BT_DATA_BYTES(BT_DATA_FLAGS, (BT_LE_AD_GENERAL | BT_LE_AD_NO_BREDR)),
    BT_DATA(BT_DATA_NAME_COMPLETE, DEVICE_NAME, DEVICE_NAME_LEN),
};

err = bt_le_adv_start(BT_LE_ADV_CONN, ad, ARRAY_SIZE(ad), NULL, 0);
```



Gap Peripheral Device

```
// 2. Defining GATT Services and Characteristics

#define BT_UUID_CUSTOM_SERVICE BT_UUID_DECLARE_128(0x3E, 0x09, 0x99, 0x10, 0x29, 0x3F, 0x11,
0xE4, 0x93, 0xBD, 0xAF, 0xD0, 0xFE, 0x6D, 0x1D, 0xA0)

static struct bt_gatt_attr attrs[] = {
    BT_GATT_PRIMARY_SERVICE(BT_UUID_CUSTOM_SERVICE),
    BT_GATT_CHARACTERISTIC(BT_UUID_INPUT, BT_GATT_CHRC_WRITE, BT_GATT_PERM_WRITE,
NULL, write_input, NULL),
    BT_GATT_CHARACTERISTIC(BT_UUID_OUTPUT, BT_GATT_CHRC_READ, BT_GATT_PERM_READ,
read_output, NULL, NULL),
};

static struct bt_gatt_service custom_service = BT_GATT_SERVICE(attrs);

bt_gatt_service_register(&custom_service);
```



Gap Peripheral Device

```
// 3. Security

static struct bt_conn_auth_cb pairing_cb_display = {
    .passkey_display = pairing_passkey_display,
    .passkey_confirm = auth_confirm,
    .cancel = auth_cancel,
};

bt_conn_auth_cb_register(&pairing_cb_display);

int rc = bt_conn_security(default_conn, BT_SECURITY_FIPS);
```

For education on Bluetooth LE security, download the
Bluetooth LE Security Study Guide

<https://www.bluetooth.com/bluetooth-resources/le-security-study-guide/>



VIDEO



Mesh Networks



Node Composition

```
// 1. Models Supported
static struct bt_mesh_model sig_models[] = {
    BT_MESH_MODEL_CFG_SRV(&cfg_srv),
    BT_MESH_MODEL_HEALTH_SRV(&health_srv, &health_pub),
    BT_MESH_MODEL(BT_MESH_MODEL_ID_GEN_ONOFF_SRV, generic_onoff_op, &generic_onoff_pub, NULL),
    BT_MESH_MODEL(BT_MESH_MODEL_ID_GEN_LEVEL_SRV, generic_level_op, &generic_level_pub, NULL));

// 2. The models each element contains
static struct bt_mesh_elem elements[] = {
    BT_MESH_ELEM(0, sig_models, BT_MESH_MODEL_NONE),
};

// 3. The elements in this node (one only here)
static const struct bt_mesh_comp comp = {
    .elem = elements,
    .elem_count = ARRAY_SIZE(elements),
};
```



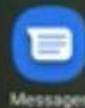
VIDEO



08:37

78%

Search



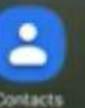
Messages



Beacon Tools



BBC Sport



Contacts



nRF Logger



Audio Recorder



Calculator



Gboard



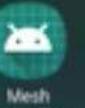
nRF Mesh



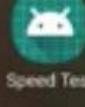
File Manager



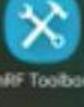
Bdisk



Mesh Controller



Speed Test



Edge Touch



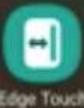
TheAdvertiser



nRF Connect



Vodafone



VIDEO



08:37 X

4% 78%

Search



VIDEO



08:37 ::

4% 78%

Search



Each running Bluetooth mesh with the generic on/off server and Light HSL server models



Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

VIDEO

08:37 11% 78%

DST: 0xC001

C1 C2 C3 C4

R1 R2 R3 R4

ALL

ON OFF

Connecting...

DISCONNECT

Each subscribed to three addresses representing all nodes, row number and column number

DISCONNECT

Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

VIDEO

address → DST: 0xC001

C1 C2 C3 C4

R1 R2 R3 R4 ALL

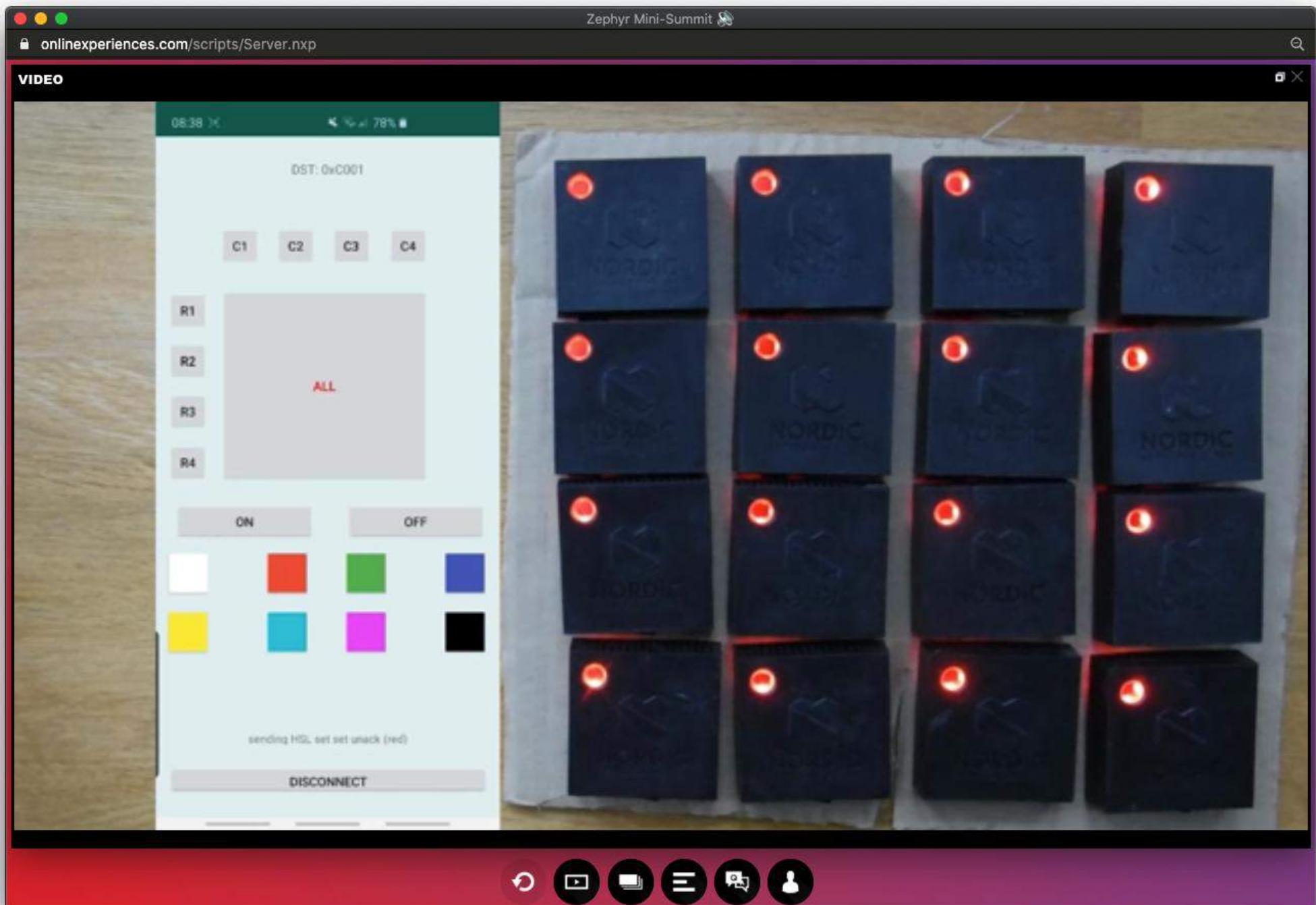
ON OFF

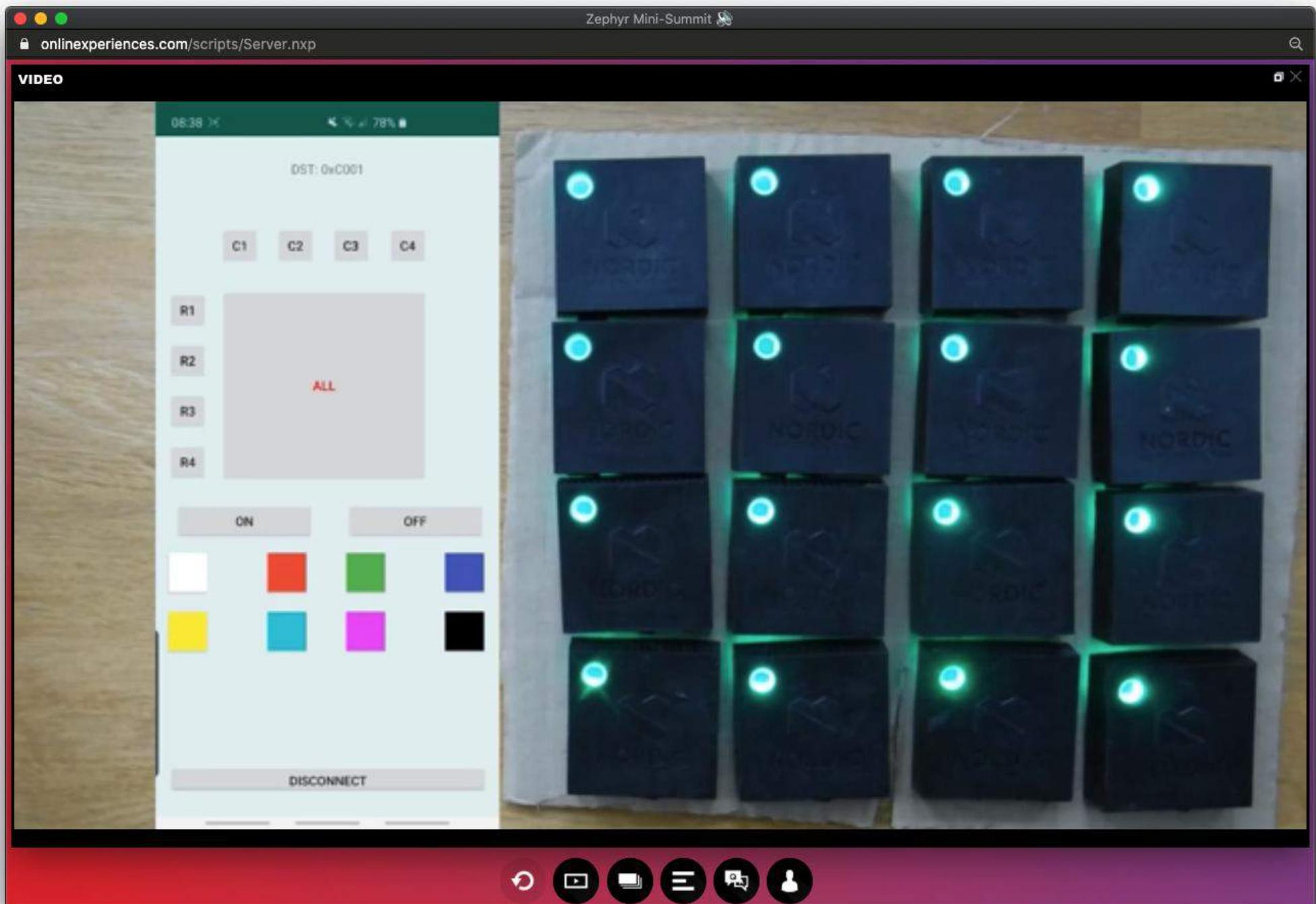
WHITE RED GREEN BLUE
YELLOW CYAN MAGENTA BLACK

sending generic on off set unack (1)

DISCONNECT

The image shows a video player interface with a control panel on the left and a physical hardware setup on the right. The control panel includes fields for 'address' (with a red arrow pointing to it), 'columns' (C1-C4), 'rows' (R1-R4), and a 'color' selection section with options for white, red, green, blue, yellow, cyan, magenta, and black. It also shows a message 'sending generic on off set unack (1)' and a 'DISCONNECT' button. The hardware on the right consists of a 4x4 grid of 16 small black boards, each with a blue LED at its top center. The boards are arranged in four rows and four columns, matching the layout of the control panel.





Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

VIDEO

08:38 78%

DST: 0xC013

C1 C2 C3 C4

R1

R2

R3

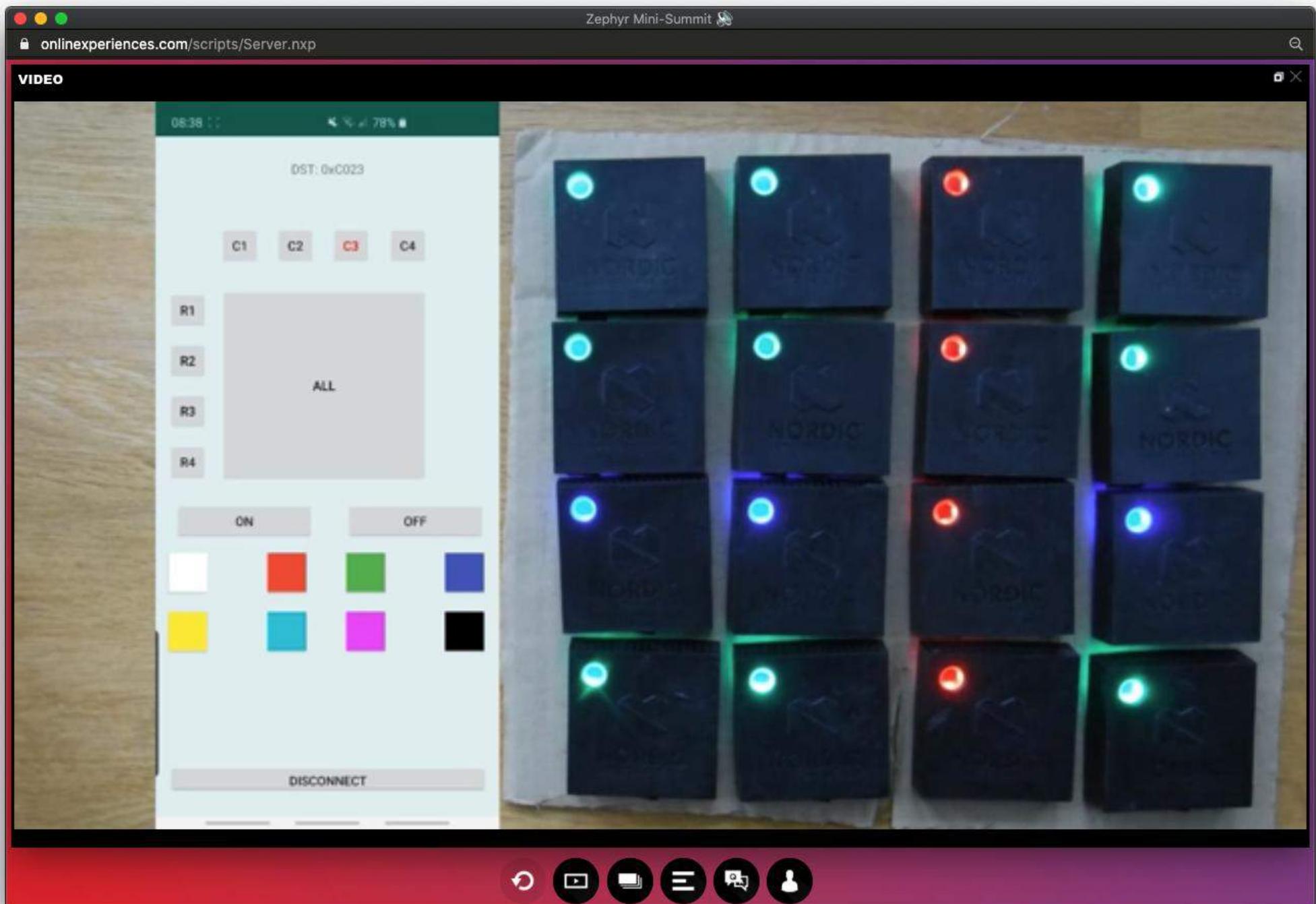
R4

ALL

ON OFF

DISCONNECT

The image shows a screenshot of a video player application window titled "Zephyr Mini-Summit". The URL in the address bar is "onlinexperiences.com/scripts/Server.nxp". The video player interface has a red border and a dark background. On the left, there is a control panel with buttons for columns C1 through C4 and rows R1 through R4, along with an "ALL" button. Below these buttons are two sets of color swatches: "ON" (white, red, green, blue, yellow, cyan, magenta, black) and "OFF" (black). At the bottom of the panel is a "DISCONNECT" button. To the right of the control panel is a grid of 16 small, black, rectangular objects, likely Zephyr Mini-Summit modules, arranged in a 4x4 pattern. Each module has a small blue LED on top that is currently illuminated. The background of the entire interface is a light-colored wood grain.



VIDEO



Bluetooth SIG Developer Resources



Bluetooth SIG Resources - hands-on education

[Study Guide](#)

An Introduction to Bluetooth Low Energy Development

Provides foundation-level information and hands-on labs that walk you through assembling a Bluetooth Low Energy device.

[LEARN MORE](#)[Study Guide](#)

An Introduction to Bluetooth Mesh Networking

Learn the theory and practice of Bluetooth mesh device firmware development, and develop a working mesh network.

[LEARN MORE](#)[Study Guide](#)

An Introduction to the Bluetooth Mesh Proxy Function

Learn how to create applications for smartphones and other platforms which can monitor and control nodes in a Bluetooth mesh network.

[LEARN MORE](#)[Study Guide](#)

The Bluetooth LE Security Study Guide

Learn about fundamental security concepts, the security features of Bluetooth Low Energy, and gain some hands-on experience using those features in device code.

[LEARN MORE](#)

<https://www.bluetooth.com/bluetooth-resources/?keyword&types=study-guide>



VIDEO



Thank You for Listening



Twitter: @bluetooth_mdw



Unthinkably Connected



Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO

SLIDES

Thank You for Listening

Twitter: @bluetooth_mdw

Bluetooth

Unimicromy Connected

ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

Open Source Summit
THE LINUX FOUNDATION
NORTH AMERICA

Overview of Bluetooth®

Martin Woolley / Bluetooth

#ossummit @d3zd3z

THE LINUX FOUNDATION

刷新

返回

搜索

更多

消息

个人资料



VIDEO



ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

SLIDES

A presentation slide with a red and purple circular background. At the top left is the Open Source Summit logo. In the center is a large white box containing the title "Zephyr Security" in bold black font. Below the title is a black bar with the text "David Brown, Linaro". At the bottom left is the hashtag "#ossummit" and the handle "@d3zd3z". In the bottom right corner is the Linux Foundation logo. The slide also features a small "Linaro" logo in the top right corner.

Zephyr Security

David Brown, Linaro

#ossummit @d3zd3z

Linaro

THE LINUX FOUNDATION



Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO



ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

SLIDES

Security Subcommittee (Team)

- Members get a seat
- Architect: elected role, responsible for overall project security
- Chair: elected, responsible for running security subcommittee
- Meets every other week

Linaro

THE LINUX FOUNDATION

#ossna



Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO



SLIDES

Security Team Accomplishments

- CII Gold (see next slide)
- Registered as CNA
- Documenting project security goals
- Developing/documenting Vulnerability Process
- Specifics: Improving random/entropy subsystem

Linaro

THE LINUX FOUNDATION

#ossna

refresh video document list comment user

Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO



ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

SLIDES

CII Gold

- Core Infrastructure Initiative Best Practices Program
- Awards badges based on “project commitment to security”
- Mostly about project infrastructure: is project hosting, etc following security practices
- Zephyr achieved gold Feb, 2019

Linaro

THE LINUX FOUNDATION

#ossna



Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO



ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

SLIDES

Project Security Documentation

- Project Security Overview
- Started with documents from other projects
- Built around Secure Development, Secure Design, and Security Certification
- Ongoing process, rather than something to just be accomplished

Linaro

THE LINUX FOUNDATION

#ossna



onlinexperiences.com/scripts/Server.nxp

Zephyr Mini-Summit

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO



ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

SLIDES

Vulnerability Process

- Recently received bulk a vulnerability report
- Highlighted need to document process
- Added [vulnerability reporting](#) to project docs

• Process:

- Embargo period
- Stages issue goes through
- Working with maintainers to see issues fixed
- Public disclosure at end

Linaro

THE LINUX FOUNDATION

#ossna



Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO

SLIDES

PSIRT, and CVE CNA

- PSIRT is Subset of Security Subcommittee
- CNA: CVE Numbering Authority
- Registered with MITRE as the numbering authority for the project. We issue our own CVEs
- Must satisfy MITRE documentation and process requirements

Linaro

THE LINUX FOUNDATION

#ossna

refresh video presentation notes person



VIDEO



ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

SLIDES

Recent Report

- [NCC Group reported ~26 issues](#)
- Critical, High and Medium made into JIRA tickets
- These have now been fixed
- Embargo is past, everything updated now in the [vulnerability report](#) page
- Most resulted in 1 or more CVEs being reported



#ossna



Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO

ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

SLIDES

Results from Report

- Most issues were fixed in reasonable time
- One issue, recommendation is to disable
- Increased embargo from 60 to 90 days
 - Zephyr isn't an end product, vendors need time to incorporate fixes into products
 - Zephyr needs alert system to notify vendors
- Continue to improve process

Linaro

THE LINUX FOUNDATION

#ossna

refresh video notes search user

Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO



ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

SLIDES

Vulnerability Alert System

- For Embargo to work, certain parties need to be notified early
- Created [Vulnerability Registry](#) for vendors to register to receive these alerts
- Goal: Zephyr to fix issues within 30 days to give vendors 60 days before publication of vulnerability

Linaro

THE LINUX FOUNDATION

#ossna





VIDEO

**ABSTRACT**

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

SLIDES

Zephyr Safety Certification

Kate Stewart / The Linux Foundation

#ossummit



Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO

SLIDES

Code Repositories

Backports & Keeping Configurations in Sync

```
graph LR; CC[Community Contributions via DCO] --> Dev[Development]; Dev --> LTS[Long Term Support \"Stable\" Releases]; LTS --> Aud[Auditable]; Dev --> Backport[Backports & Keeping Configurations in Sync]; Backport --> Aud; Safety[Safety & Security Processes] --> Aud; Cert[Certifiable Releases] --> Aud
```

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

ABSTRACT

Development

Long Term Support "Stable"

Auditable

Community Contributions via DCO

Releases

LTS Releases

Safety & Security Processes

Certifiable Releases

#ossna

THE LINUX FOUNDATION

onlinexperiences.com/scripts/Server.nxp

Zephyr Mini-Summit

OPEN SOURCE SUMMIT
NORTH AMERICA

THE LINUX FOUNDATION

Embedded Linux Conference
North America

VIDEO



SLIDES

Zephyr OS: Long Term Support (LTS - 1.14)

It is:

- **Product Focused**
- **Current with latest Security Updates**
- **Compatible with New Hardware:** We will make point releases throughout the development cycle to provide functional support for new hardware.
- **Tested:** Shorten the development window and extend the Beta cycle to allow for more testing and bug fixing
- **Supported for 2 years**

It is not:

- **A Feature-Based Release:** focus on hardening functionality of existing features, versus introducing new ones.
- **Cutting Edge**

THE LINUX FOUNDATION

#ossna

refresh icon

video icon

document icon

list icon

comment icon

person icon

onlinexperiences.com/scripts/Server.nxp

Zephyr Mini-Summit

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO



SLIDES

Zephyr OS: Long Term Support (LTS - 1.14)

[Zephyr 1.14.0](#)

This is an LTS maintenance release with fixes, as well as Bluetooth specification changes for the Bluetooth protocol stack included in Zephyr.

Security Vulnerability Related

The following security vulnerabilities (CVS) were addressed in this release:

- Fixes CVE-2018-18808. The Bluetooth BNEP/LE specification up to and including version 1.1 permits a sufficiently low encryption key length and does not support an adequate authentication. As a result, Zephyr can decrypt traffic and listen arbitrary ciphertext without the key-exchanging.
- Bluetooth**
- Issues Fixed**

[Zephyr LTS 1.14.2 \(Maintenance Release\)](#)

This is an LTS maintenance release with fixes.

Security Vulnerability Related

The following security vulnerabilities (CVS) were addressed in this release:

- CVE-2018-18808
- CVE-2018-18801
- CVE-2018-18802
- CVE-2018-18809
- CVE-2018-18810
- CVE-2018-18811
- CVE-2018-18812

Issues Fixed

These GitHub issues were addressed since the previous 1.14.0 tagged release.

Delivering bug fixes and latest security updates!

THE LINUX FOUNDATION

#ossna

Navigation icons: back, forward, search, etc.

Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO



SLIDES

Zephyr OS: Auditable

An auditable code base will be established from a subset of the **Zephyr OS LTS**.

- Code bases will be kept in sync.
- More rigorous processes (necessary for certification) will be applied to the auditable code base.

Processes to achieve selected certification to be:

- Determined by **Safety Committee and Security Committee**
- Coordinated with **Technical Steering Committee**



THE LINUX FOUNDATION

#ossna

refresh icon

video icon

document icon

list icon

comment icon

person icon



VIDEO



SLIDES

Standards Considered

Coding for Safety, Security, Portability and Reliability in Embedded Systems:

- [MISRA C:2012](#), with [Amendment 1](#), following [MISRA C Compliance:2016](#) guidance
- SEI CERT C and [JPL](#) (Jet Propulsion Laboratory California Institute of Technology) used as reference

Functional Safety:

- [IEC 61508: 2010](#) (SIL 3 initially, eventually though like to get to SIL 4)
 - Broadest for robotics and autonomous vehicle engineering companies. Reference for other standards in Robotics domain.
 - [Sampled Certifications derived from IEC 61508](#): Medical: IEC 62304; Auto: ISO 26262; Railway: EN 50128

Others:

- Medical: FDA 510(K), ISO 14971, IEC 60601; Industrial: UL 1998, ??



#ossna



Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO



SLIDES

Building in Safety for LTS → Auditable

- Established **Safety Committee in 2019**, meets bi-weekly. Community that understands Safety considerations, and implications.
- Initial target was decided by Governing Board to be **IEC 61508** (it is a common basis for others standards that the members care about)
- Build on Coding Practices have been documented for the project to establish more general **Coding Guidelines**
- Passing Best Practices for **project quality** as defined by CII
 - <https://bestpractices.coreinfrastructure.org/projects/74>
- Leveraging Automation to **prevent regressions**:
 - Weekly Coverity Scans to detect bad practices in imported code
 - MISRA scans being incorporated, to evolve to conformance and address issues.
 - Looking for open source as well as commercial tooling to help here.

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

THE LINUX FOUNDATION

#ossna

refresh video document list comment user

Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO

SLIDES

Zephyr OS: Quality Development Proces

ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

- **Quality is a mandatory expectation** for software across the industry.
- Assumptions:
 - Software Quality is enforced across Zephyr project members
 - Compliance to internal quality processes is expected.
- **Software Quality** is not an additional requirement caused by functional safety standards.
- Functional safety considers Quality as an **existing pre-condition**.

Functional Safety Process

Functional Safety Standards e.g. IEC 61508

Basic Quality Management System

Quality is the foundation

THE LINUX FOUNDATION

#ossna

refresh icon

video icon

document icon

list icon

comment icon

person icon

Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO

SLIDES

Zephyr OS: Initial Certification Focus

■ In scope
■ Out of scope

- Scope will be **extended** to include **additional components** as determined by the safety committee
- Some of the modules under consideration for the next iteration include: Crypto, IPC, Flash, etc.

The diagram illustrates the Zephyr OS architecture, organized into several layers:

- OS Services:** TCP/UDP, IPv6/IPv4, CAN, BLE, Thread, 6LoWPAN, Zigbee, WiFi, File System, Logging, Debug, Crashdump, Properties, Crypto, IPC, Sensors, and others.
- Kernel:** POSIX, Device Model, Kernel Services / Schedulers, Power Management, Interrupt Handling, Common and Interface, and Platform.
- Platform:** Radios, Sensors, Crypto HW, and Flash.

Legend: Blue boxes represent **In scope** components, while grey boxes represent **Out of scope** components.

#ossna

THE LINUX FOUNDATION

Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO

SLIDES

System Configurations

Single Core MCU

App App
RTOS
Unicore SoC
Core 1

AMP

App App
RTOS
Multicore SoC
Core 1 Core 2

SMP

App App
RTOS
SoC
Core 1 Core 2

Hypervisor Guest

App App
Zephyr Linux
Hypervisor
Core 1 Core 2

Mesh

App App
RTOS
Multicore SoC
Core 1 Core 2

Supported with OpenAMP

Supported on some architectures

Supported with ACRN

Supported with Bluetooth & 15.4

Safety and security can apply to all these configurations

#ossna

Navigation icons: back, forward, search, etc.



VIDEO



SLIDES

Zephyr Project Roadmap

LTS 1

- User-space and Memory Protection Support
- Logging and Shell infrastructure
- Timer and Tick-less overhaul
- BSD Socket based networking

2019

- E2E Cloud Integration
- Sound/Audio Capabilities
- Next Gen Bluetooth Technologies
- Quality Standards Compliance
- Certifiable Code Base

LTS 2

- MISRA-C Compliance
- Commercial Compiler Support and IDE Integration
- Multi Core / SMP
- Bluetooth® Split Link Layer
- Advanced Power Management

2020

- Accelerated Path*
- Functional Safety Certification
 - Quality Standards Compliance

2021



#ossna



Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO



SLIDES

Tensorflow Lite + Zephyr: developing ML in MCUs with & without hardware!

Michael Gieda, Antmicro

#ossummit @antmicro

THE LINUX FOUNDATION

REPLAY

VIDEO

SLIDES

CHAT

PROFILE



VIDEO



ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

SLIDES

Tensorflow Lite + Zephyr: developing ML in MCUs with & without hardware!



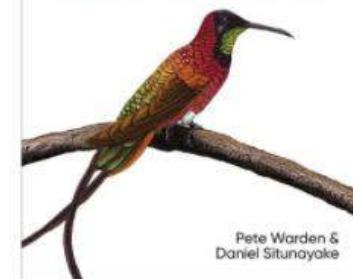
INTRODUCTION: TINYML

- TensorFlow Lite is an extremely popular edge ML framework from Google
- **Prediction: ML will be prevalent, used in tiny battery operated and no-battery devices**
- Use cases: gesture recognition, keyphrase detection, people counting etc.
- TF Lite expanded to MCUs - led by Pete Warden's team at Google
- Collaboration with Harvard, Arm, Antmicro and many others - [join our meetings!](#)

O'REILLY®

TinyML

Machine Learning with TensorFlow Lite on Arduino and Ultra-Low-Power Microcontrollers



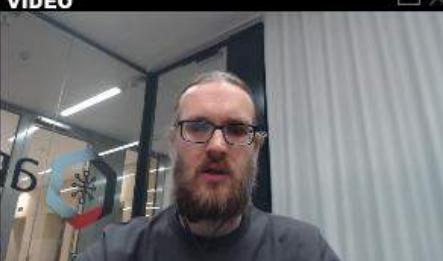
Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO



SLIDES

Tensorflow Lite + Zephyr: developing ML in MCUs with & without hardware!

antmicro

INTRODUCTION: ZEPHYR AND TF LITE

- TFL for MCUs targets many devices, vendors, architectures
- Doing ML based on sensor data needs hardware access - and drivers
- An RTOS provides consistent HW API and programming method
- Zephyr spans many architectures, is vendor-neutral
- Vibrant developer community - good for adoption

 TensorFlow

 Zephyr™

ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

refresh icon

video icon

document icon

list icon

comment icon

person icon

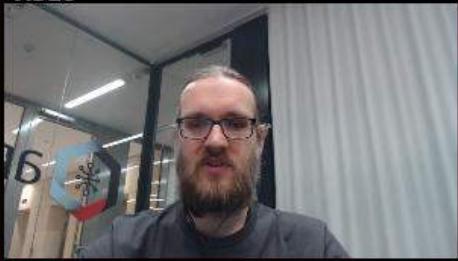
Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO



SLIDES

Tensorflow Lite + Zephyr: developing ML in MCUs with & without hardware!

antmicro

OUR WORK WITH ZEPHYR AND TF LITE

- helped TF Lite team run in Renode simulator on Arm for no-HW testing in late 2018
- then also helped add initial RISC-V support
- presented at RISC-V Summit workshop 2018 with Google
- added support for Zephyr in project with Google late 2019 - also first FPGA platform in TF Lite
- got this upstream this year!

TensorFlow

Zephyr™

antmicro

↻ ⟲ ⟳ ⏷ ⏸ 🔍

**VIDEO****ABSTRACT**

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

SLIDES

Tensorflow Lite + Zephyr: developing ML in MCUs with & without hardware!

OUR WORK WITH ZEPHYR AND TF LITE

- resulted in [awesome blog note!](#)
- generated lots of enthusiasm
- planning course with Harvard in the fall
- working on more sensors/examples (audio), as well as CI pipelines with Renode

TensorFlow Blog

All

TensorFlow Core

TensorFlow Lite

TFX

Tools

Community

TensorFlow Lite

TensorFlow Lite is an open source deep learning framework for on-device inference. Articles in this section cover deploying machine learning models on mobile and IoT devices.



RENODE™

Community - TensorFlow Lite

Running and Testing TF Lite on Microcontrollers without hardware in Renode

June 03, 2020 — A guest post by Michael Slobot of Antmicro. Every day more and more software developers are exploring the worlds of machine learning, embedded systems, and the Internet of Things. Perhaps one of the most exciting advances to come out of the most recent innovations in...



What's new in

What's new in TensorFlow Lite from DevSummit 2020

April 26, 2020 — Posted by Michael Lakin, Developer Advocate on behalf of the TensorFlow Lite team



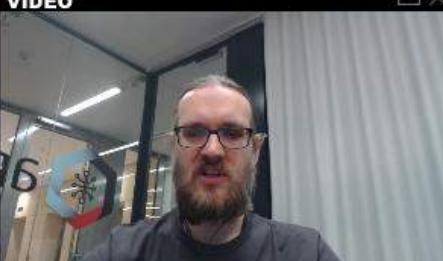
Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO



SLIDES

Tensorflow Lite + Zephyr: developing ML in MCUs with & without hardware!

antmicro

WHAT'S THE DEAL WITH RENODE?

- “Renode from @antmicro looks very neat, a bit like Docker for embedded devices” - Pete
- also called “a simulator on steroids”
- enables no-HW, rapid development cycles, CI
- very useful for a fast-changing library like TF Lite
- simulates not “just” CPUs - also sensors, connectivity - full blown use cases
- inject synthetic sensor data, deterministically execute various scenarios
- runs across Arm, RISC-V, PowerPC (new!), x86
- check the complete list of [supported boards](#)



RENODE™

↻ ⟲ 🔍 ⌂ 🗣️ 🚙

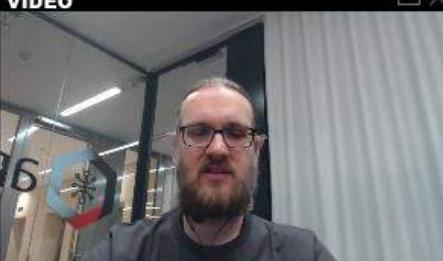
Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

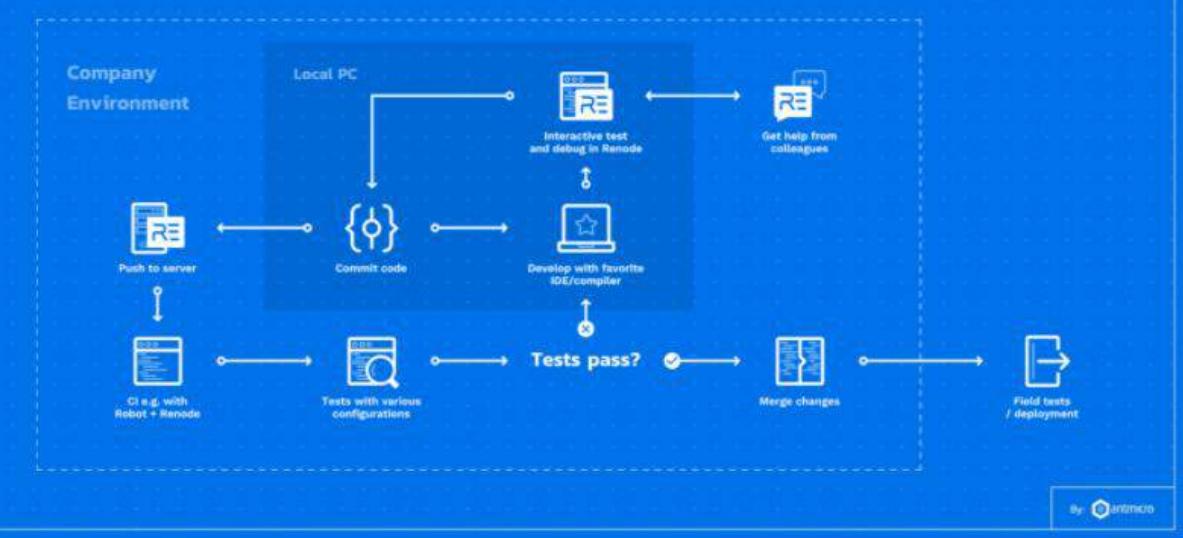
VIDEO



SLIDES

RENODE

Renode-based Continuous Integration workflow for IoT systems



Company Environment

Local PC

Remote PC (RDP)

GitHub icon

Push to server (e.g., with Robot + Renode)

Commit code

Interactive test and debug in Renode

Develop with favorite IDE/compiler

Tests pass? (checkmark)

Merge changes

Field tests / deployment

By Renode

Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO



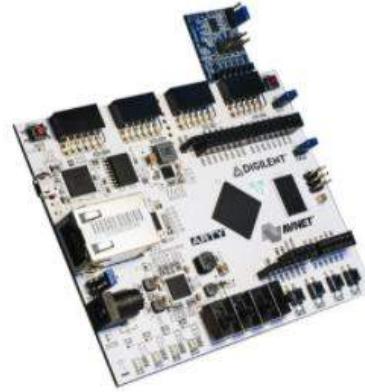
SLIDES

Tensorflow Lite + Zephyr: developing ML in MCUs with & without hardware!

antmicro

THE PHYSICAL PLATFORM FOR OUR ZEPHYR + TF LITE WORK

- Digilent Arty A7 low-cost devboard
- RISC-V soft SoC (LiteX/VexRiscv) inside
- PmodACL with ADXL345 I2C accelerometer
- FPGA gives potential to accelerate ML functions in HW, and Renode can easily co-simulate such FPGA blocks



ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

refresh icon

video icon

document icon

list icon

comment icon

person icon

Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO



SLIDES

Tensorflow Lite + Zephyr: developing ML in MCUs with & without hardware!

antmicro

RUNNING THE ZEPHYR + TF LITE DEMO

Self-contained demo repository:

```
git clone --recurse-submodules https://github.com/antmicro/litex-vexriscv-tensorflow-lite-demo
```

- see Renode's on-the-fly model adding capability
- data injection into virtual sensors from files
- see example Robot test
- example Travis CI included
- if you're lazy strapped for time like me, demo also includes precompiled binary :)

ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

refresh video presentation notes speech user

**VIDEO****ABSTRACT**

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

SLIDES

Tensorflow Lite + Zephyr: developing ML in MCUs with & without hardware!

**RESULTS**

```
Got id: 8+e5
*****
Booting Zephyr OS build v1.7.99-22021-ga6d97078a3e2
*****
Got accelerometer
RING:
* * * * *
```



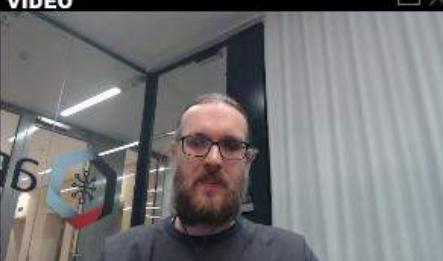
Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO



SLIDES

Tensorflow Lite + Zephyr: developing ML in MCUs with & without hardware!

GOING FORWARD: MORE PLATFORMS

- this one was added by Arm
- working on more for Harvard course!

TFLU: Add stm32f4 and build target #35854

Merged tensorflow-copy... merged 3 commits into tensorflow:master from mansnils:renode on Feb 18

Conversation 10 Commits 3 Checks 0 Files changed 13 +416 -3

mansnils commented on Jan 14

Add new TARGET=stm32f4 that is working with Renode.
Add new target that will just build the test binaries.
Add new CI script for this as well.
The purpose of this is CMSIS-NN regression.

Contributor

Reviewers rthadur, petewarden ✓

Assignees gbaned



onlinexperiences.com/scripts/Server.nxp

Zephyr Mini-Summit

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO

SLIDES

Tensorflow Lite + Zephyr: developing ML in MCUs with & without hardware!

antmicro

GOING FORWARD: PERF ANALYSIS

Executed instructions

Real time (ms)	e51	u54_1	u54_2	u54_3	u54_4
0	0	0	0	0	0
5000	0	2.5e7	2.5e7	2.5e7	2.5e7
10000	0	2.5e7	5e7	2.5e7	2.5e7
15000	0	2.5e7	7e7	2.5e7	2.5e7
20000	0	2.5e7	8.5e7	2.5e7	2.5e7
25000	0	2.5e7	1e7	2.5e7	2.5e7

Peripheral writes

Time (ms)	u54_1	u54_2	u54_3
0	0	0	0
200	1000	8000	1000
400	2000	8000	2000
600	3000	8000	3000
800	4000	8000	4000
1000	5000	8000	5000
1200	6000	8000	6000
1400	7000	8000	7000
1600	8000	8000	8000
1800	9000	8000	9000
2000	10000	8000	10000

Memory access

Time (ms)	u54_1	u54_2
0	0.5	0.5
200	0.8	1.0
400	1.2	1.5
600	1.6	1.8
800	2.0	2.2
1000	2.2	2.4
1200	2.4	2.6
1400	2.6	2.8
1600	2.8	3.0
1800	3.0	3.2
2000	3.2	3.4

Navigation icons: back, forward, search, etc.

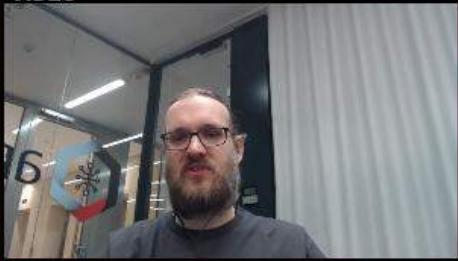
Zephyr Mini-Summit

onlinexperiences.com/scripts/Server.nxp

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Embedded Linux Conference
North America

VIDEO



SLIDES

Tensorflow Lite + Zephyr: developing ML in MCUs with & without hardware!

antmicro

ABSTRACT

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

SUMMARY

- TF Lite and Zephyr can now play nice
- Working to expand on this effort, get more edge ML engineers into Zephyr
- Renode could be used to improve / accelerate development of Tiny ML
- Want to build a constrained edge ML solution? Contact us at contact@antmicro.com - happy to hear about your use case!

 TensorFlow

 Zephyr™

refresh, video, notes, speech, user icons



THE LINUX FOUNDATION

**VIDEO****ABSTRACT**

The Zephyr Mini-Summit is designed to introduce you to the leading Open Source RTOS built with safety and security in mind. Attendees will learn why Zephyr is gaining the attention of developers, with its support for BLE, OpenThread, LTE-M/NB-IoT cellular communications, and more. Attendees will learn: Zephyr overview Intro to West Overview of Bluetooth Security Issues Safety Certification Use Case

SLIDES