Embedded Recipes

bit.ly/er23-beagle

State of the Beagle

BeaglePlay, BeagleConnect and beyond!

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Drew Fustini <drew@beagleboard.org>

BeagleBoard.org Foundation is a non-profit organization seeking to improve the state of embedded Linux and Zephyr development.

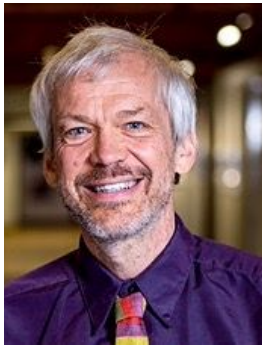
Learn more about our mission: bbb.io/about

BeagleBoard.org Foundation Leadership

Christine Long
CEO

Jason Kridner
Board Member
JK Embedded

Robert Nelson
Board Member
DigiKey

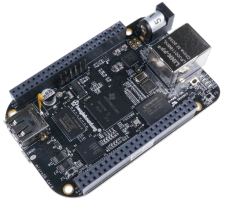


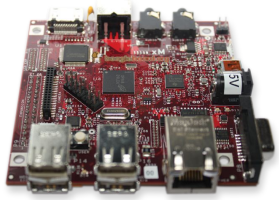
Mark Yoder
Board Member
Rose-Hulman Institute of Technology

Drew Fustini
Board Member
BayLibre

Kathy Giori
Board Member
MicroBlocks

What is BeagleBoard.org?





beagleboard.org

- Community supported by non-profit BeagleBoard.org Foundation in the United States
- Focus on embedded, reliability, longevity, control and machine learning, not just cheap computers
- Approach is open and collaborative with open hardware, detailed documentation and fully open source software
- Entrepreneurial and open community of domain experts that share our passion and approach

Visit **bbb.io/about** to learn more

bbb.io/pocketnc

open source hardware

bbb.io/oshwa

bbb.io/books

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bbb.io/jpl

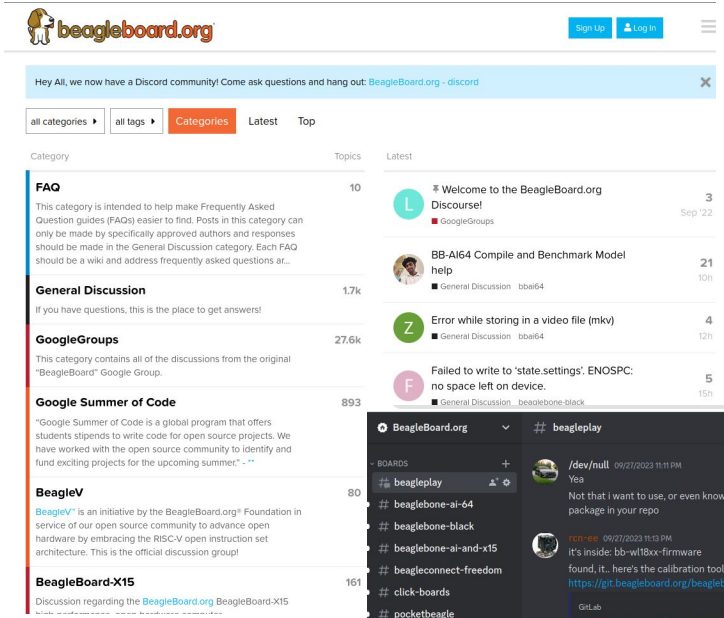
bbb.io/creator

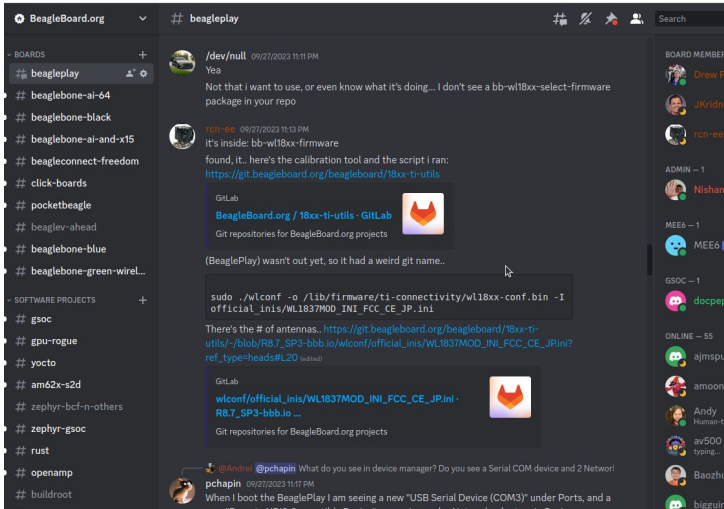
Embedded Open Source Summit 2023 (Prague)

- **Improving Embedded Linux Development with BeagleBoard.org**
- **Simplifying Zephyr Usage Through Linux Host Integration**

Join the BeagleBoard.org community

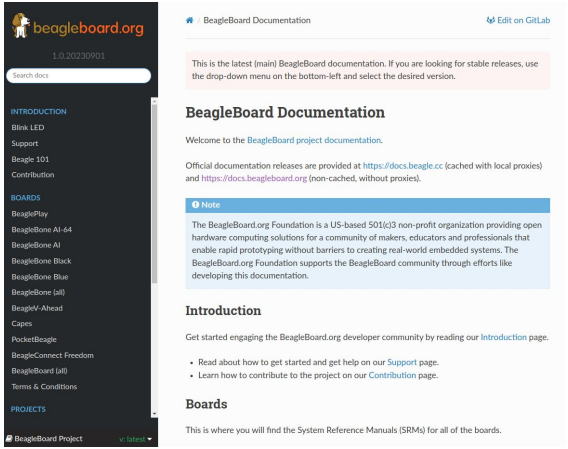
- New website: beagleboard.org
  - beagleboard.org/projects
  - beagleboard.org/blog
  - Educational Materials
    - Bootlin course updated for BeaglePlay
- BeagleBoard.org Forum
- Discord chat group
  - *#beagle on libera.chat IRC still exists*
- BeagleCast
  - bi-weekly video stream

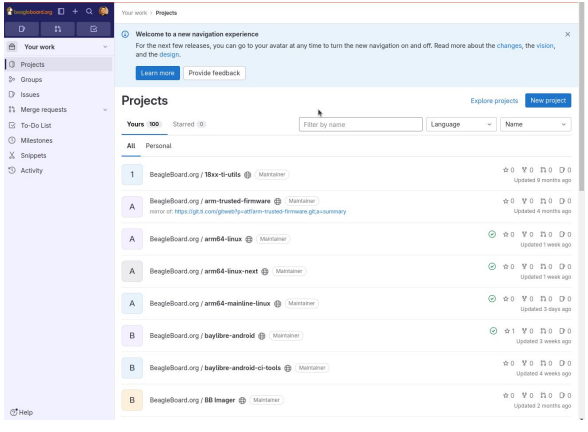


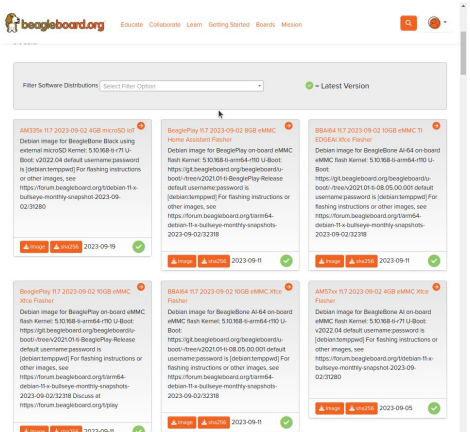


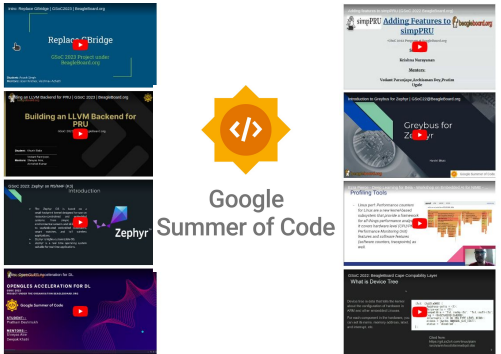
Join the BeagleBoard.org community

- GitLab instance: git.beagleboard.org
- New documentation: docs.beagleboard.org
- Software distribution images
- Google Summer of Code (GSoC)



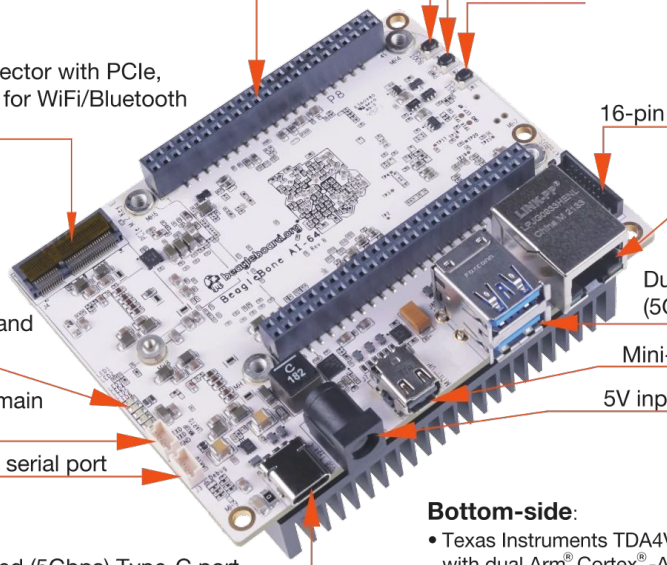






beagleboard.org

BeagleBone® AI-64



Bottom-side:

- Texas Instruments TDA4VM system-on-chip with dual Arm® Cortex®-A72, C7x DSP, and deeplearning, vision and multimedia accelerators
- 4GB DDR4 RAM
- 16GB on-board eMMC flash storage
- Micro-SD slot
- Dual CSI-2 camera connectors

BeagleBone AI-64

- Open source NPU stack on C7x DSP and MMA
- Program in Python instead of just C
- Bring TF Lite model into AI-64 using open source tool
- Edge AI tutorial

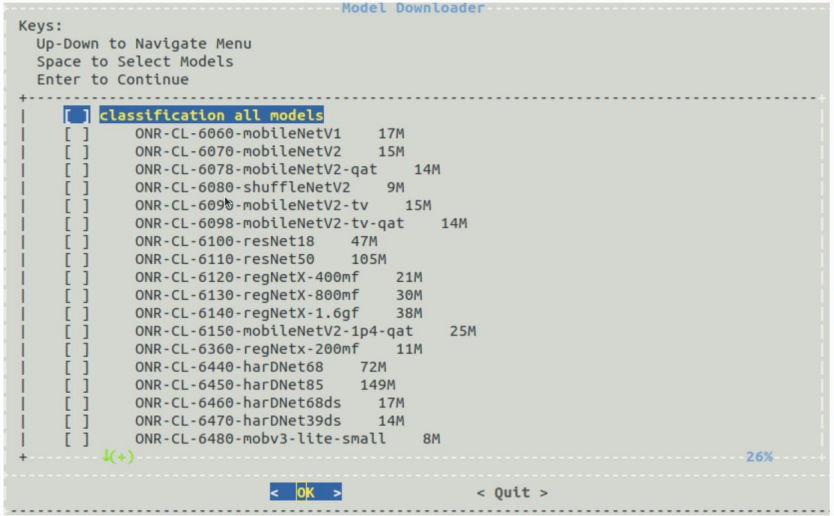


Fig. 78 *Model downloader tool menu option to download models*

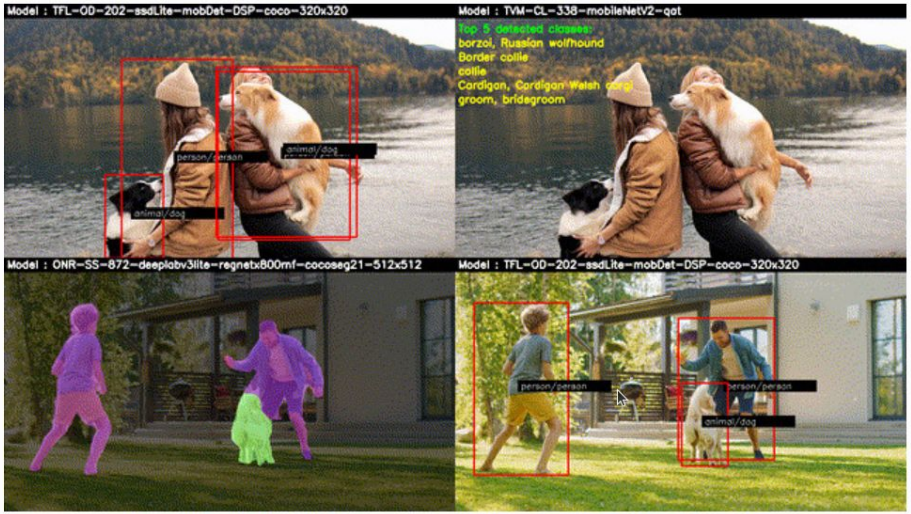
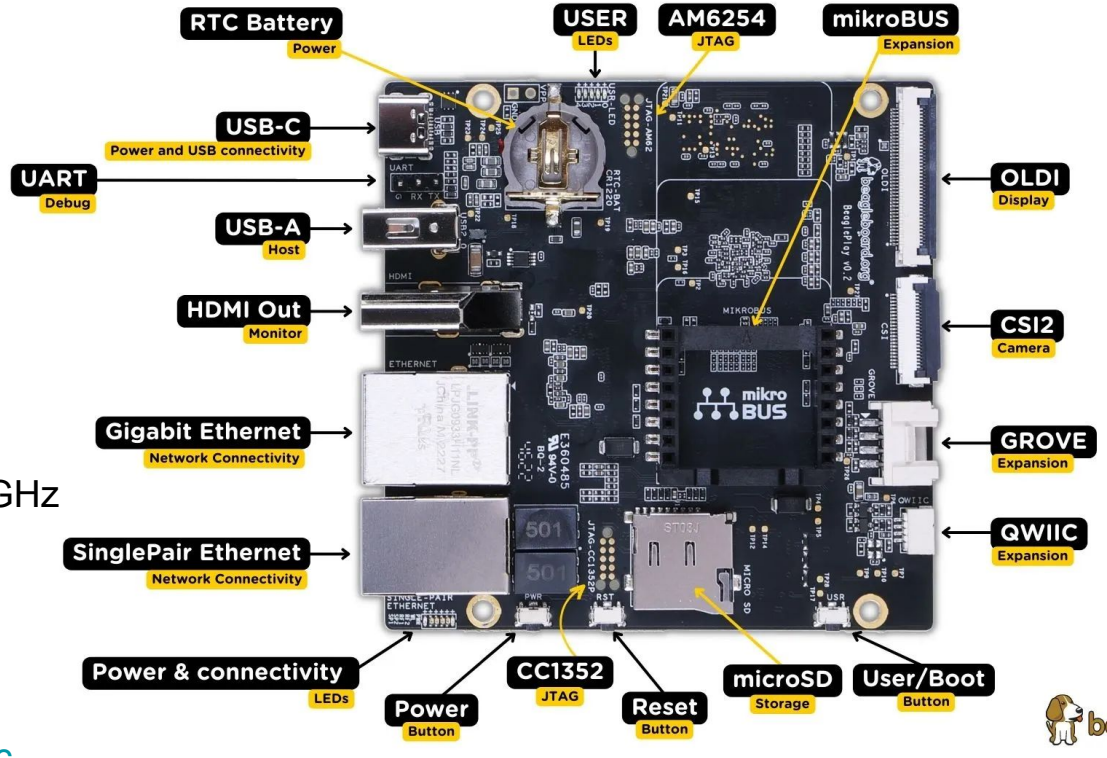


Fig. 80 *Sample output showing multi-input, mutli-inference output*

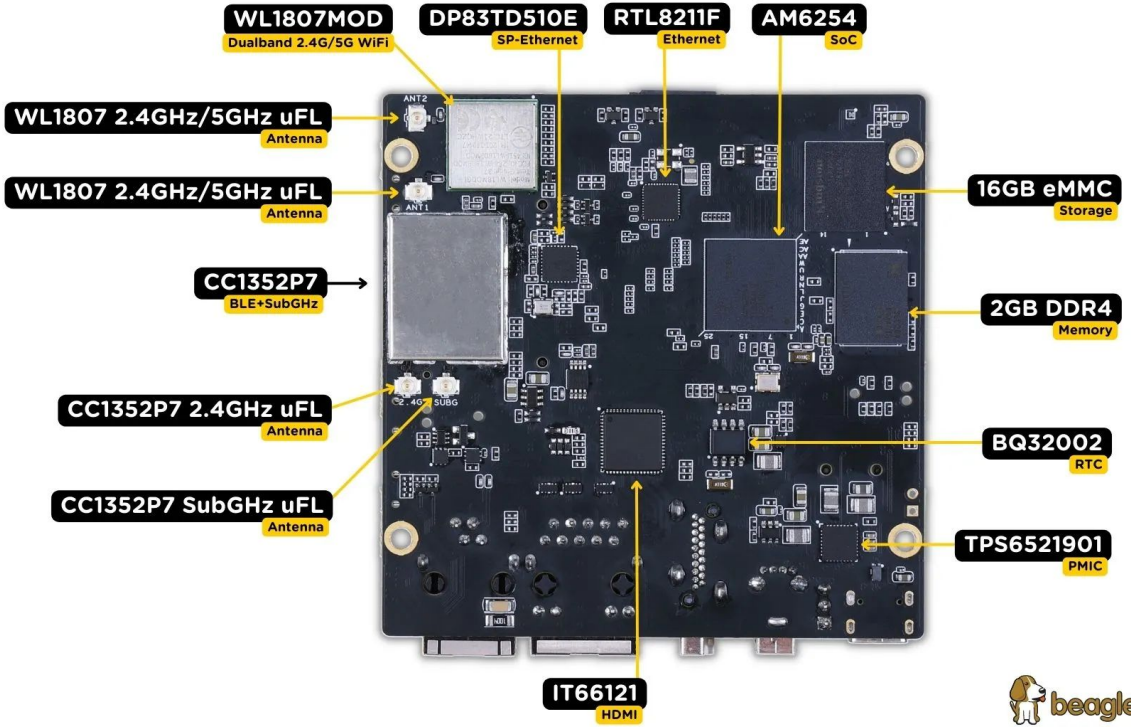
BeaglePlay

- TI Sitara AM625
  - 1.4GHz quad-core Arm Cortex-A53
  - Arm Cortex-M4F
  - PRU Subsystem
  - HDMI, USB 2.0, CSI
  - Gigabit Ethernet
  - 5GHz, 2.4GHz and sub-1GHz wireless
  - Single-pair Ethernet with power-over-data-line
  - PowerVR Rogue AXE-1-16



BeaglePlay

- 1,000s of available off-the-shelf sensors, actuators, indicators and connectivity options over mikroBUS, Grove, and QWIIC connections
- Utilize BeagleConnect technology over the sub-1GHz IEEE 802.15.4 wireless network to a BeagleConnect® Freedom up to 1km away.

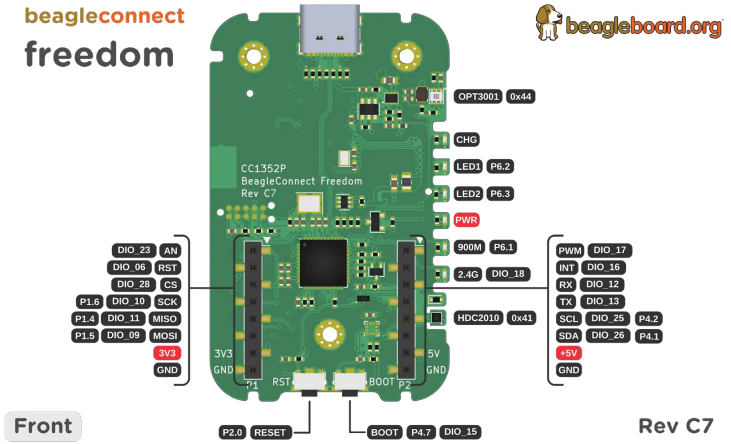


BeaglePlay

- BeaglePlay: First Experience
- Documentation and tutorials
- Android (AOSP) on BeaglePlay
    - Mattijs Korpershoek, BayLibre
- U-Boot series for BeaglePlay:

  [PATCH V6 00/20] board: ti: Add support for BeaglePlay
- Kernel series for BeaglePlay:

  [PATCH V2 0/3] arm64: dts/defconfig/binding: Add support for BeaglePlay



- **BeagleConnect Freedom:** TI CC1352 wireless microcontroller running Zephyr
- Works with BeagleConnect™ enabled sub-GHz wireless gateways,
- Can be used with over 1,000 mikroBUS-based Click boards from MikroE,
- Provides Bluetooth Low Energy (BLE)-enabled Linux computers at 2.4GHz and long-range, low-power sub-GHz IEEE 802.15.4 wireless connections at up to 1km with data rates of 1kbps,
- Includes enclosure and antenna, on-board sensors, a USB-to-UART bridge, battery charger, buzzer and user-programmable LEDs and button.

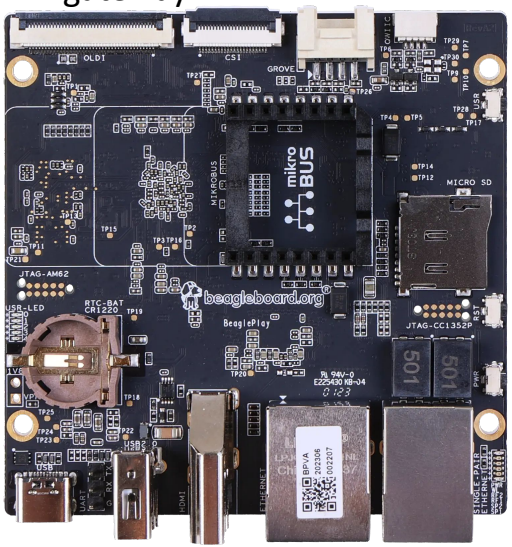
Zephyr sensor + Linux gateway

[Simplifying Zephyr Usage Through Linux Host Integration](#) Jason Kridner (EOSS 2023)

Microcontroller running Zephyr with sensor attached

Wireless network connection

Single board computer running Linux acting as gateway



Zephyr sensor + Linux gateway

Simplifying Zephyr Usage Through Linux Host Integration Jason Kridner (EOSS 2023)

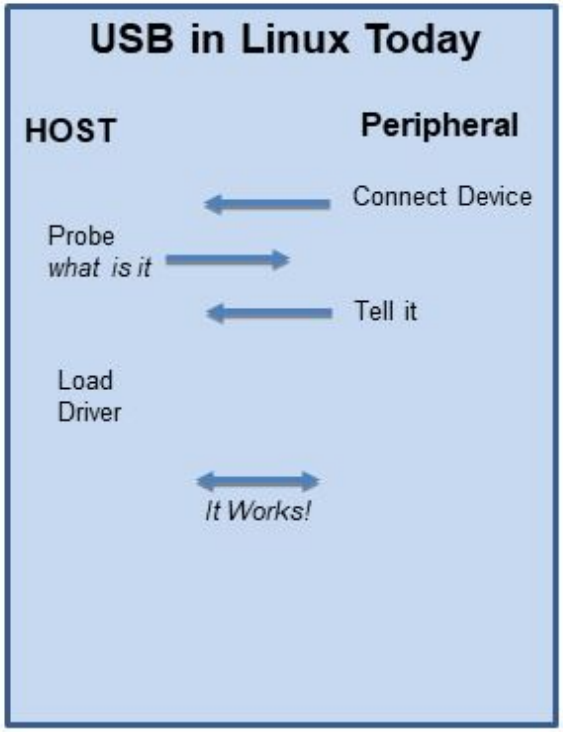
- Linux nodes can be more expensive, but offer greater remote access and redundant connectivity options
    - Terminal shell, rotated journals, virtualization, and more…
    - Large storage, high-level database queries, …
    - Common execution environment as server infrastructure
- Zephyr nodes are growing in capability, but data will touch Linux system eventually for storage, analysis and presentation
    - git.beagle.cc/beagleconnect/zephyr/zephyr

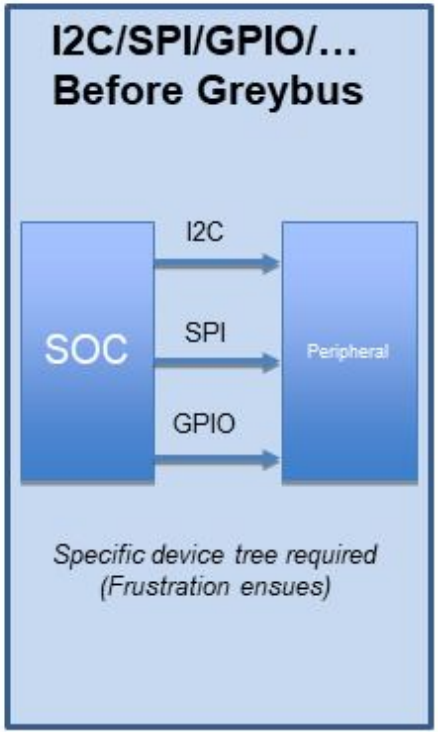
Greybus and Project Ara

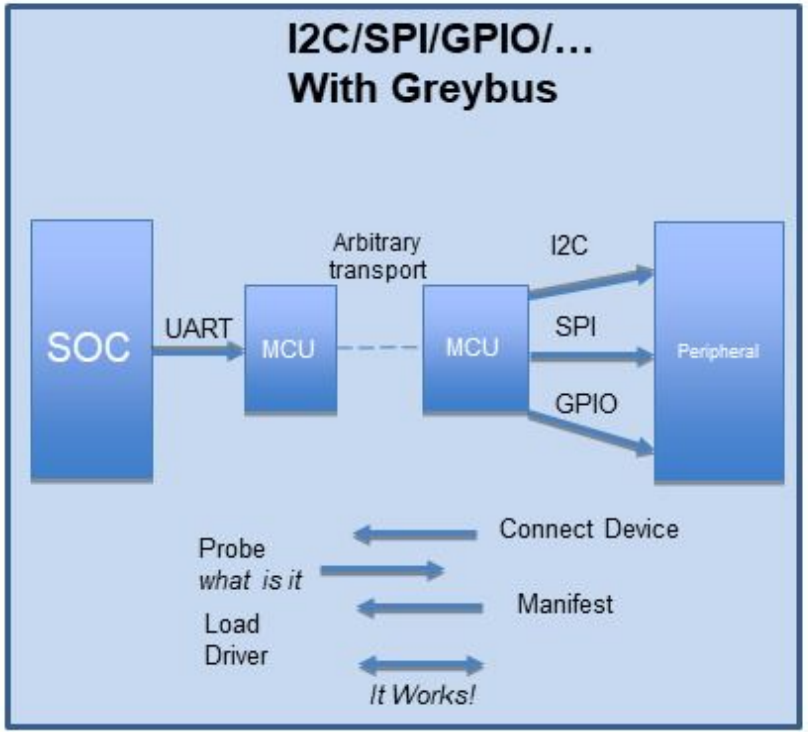
- Greybus comes from Project Ara
- Project Ara sought to create a modular mobile phone, so you could update only what you want
- Needed to make embedded busses hot pluggable
- In mainline kernel, using Unipro

Zephyr sensor + Linux gateway

[Simplifying Zephyr Usage Through Linux Host Integration](#) Jason Kridner (EOSS 2023)

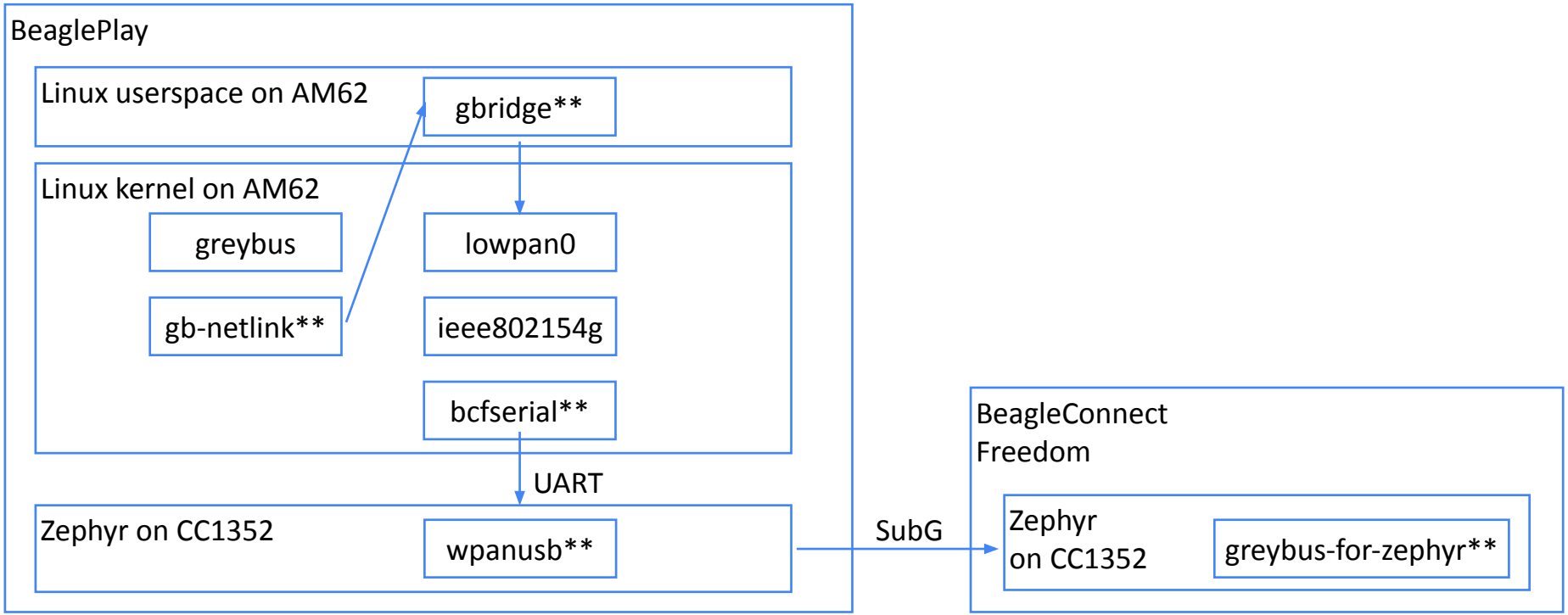






BeagleConnect and Greybus

Simplifying Zephyr Usage Through Linux Host Integration Jason Kridner (EOSS 2023)



BeagleConnect and Greybus

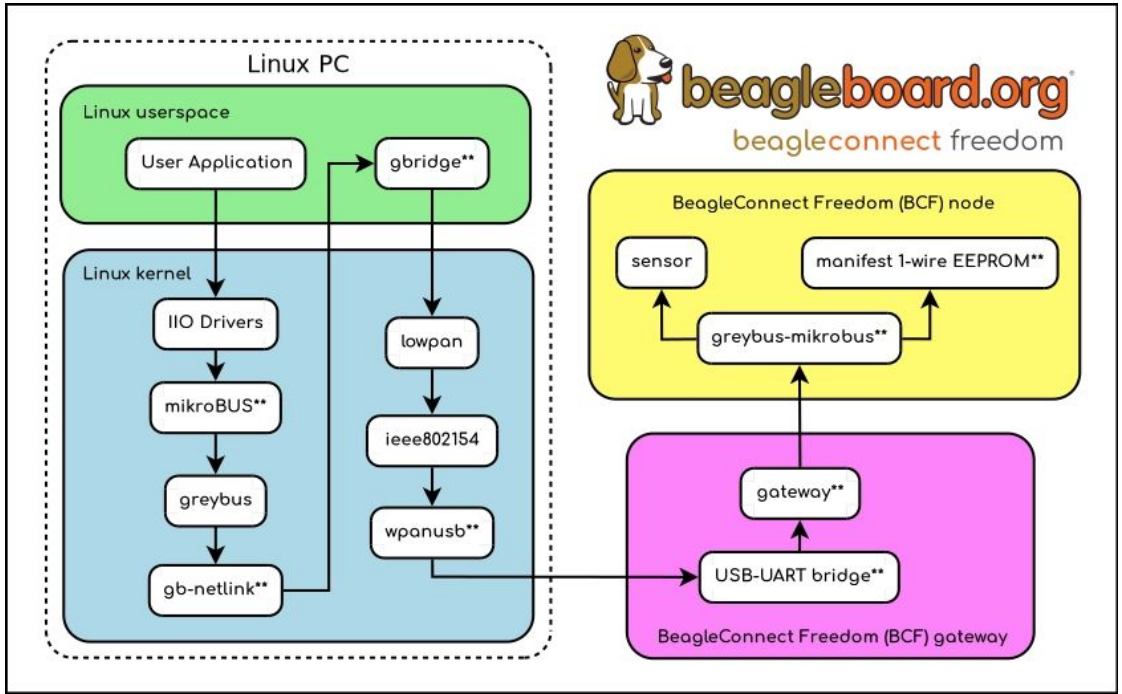
Simplifying Zephyr Usage Through Linux Host Integration Jason Kridner (EOSS 2023)

```
debian@BeaglePlay:~$ sudo modprobe opt3001
debian@BeaglePlay:~$ i2cdetect -y -r 6
     0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00:                         -- -- -- -- -- -- -- --
10: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
20: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
30: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
40: -- UU -- -- UU -- -- -- -- -- -- -- -- -- -- --
50: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
60: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
70: -- -- -- -- -- -- -- --
debian@BeaglePlay:~$ iio_info
Library version: 0.24 (git tag: v0.24)
Compiled with backends: local xml ip usb
IIO context created with local backend.
Backend version: 0.24 (git tag: v0.24)
Backend description string: Linux BeaglePlay 5.10.168-ti-arm64-r104
IIO context has 2 attributes:
     local,kernel: 5.10.168-ti-arm64-r104
     uri: local:
```

Replace GBridge in BeagleConnect

Ayush Singh for Google Summer of Code 2023

Problem: The existing architecture revolves around GBridge. Ran in userspace and interacted with gb-netlink in kernel. Design was brittle and could hang kernel.

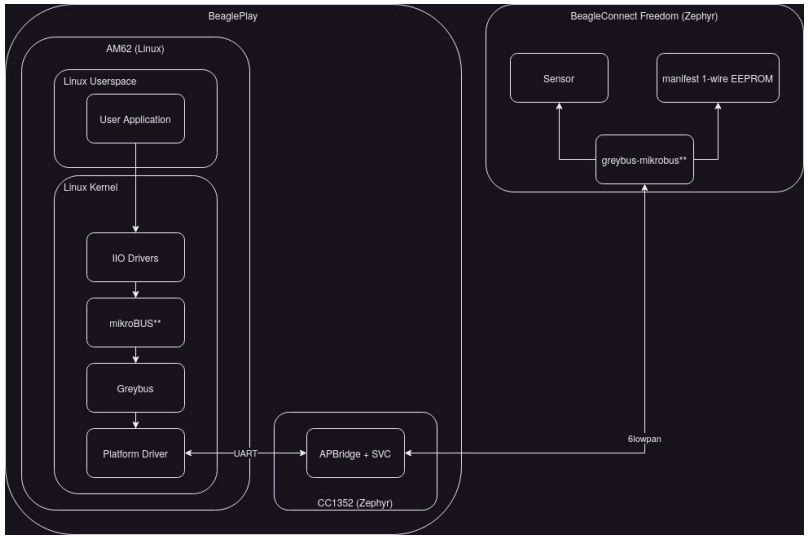


Replace GBridge in BeagleConnect

Ayush Singh for Google Summer of Code 2023

Solution

- Eliminate GBridge and merge its functionality into greybus (linux driver) and cc1352 driver.
- Allow Greybus Linux driver to directly communicate with cc1352
- Move SVC and APBridge roles into cc1352

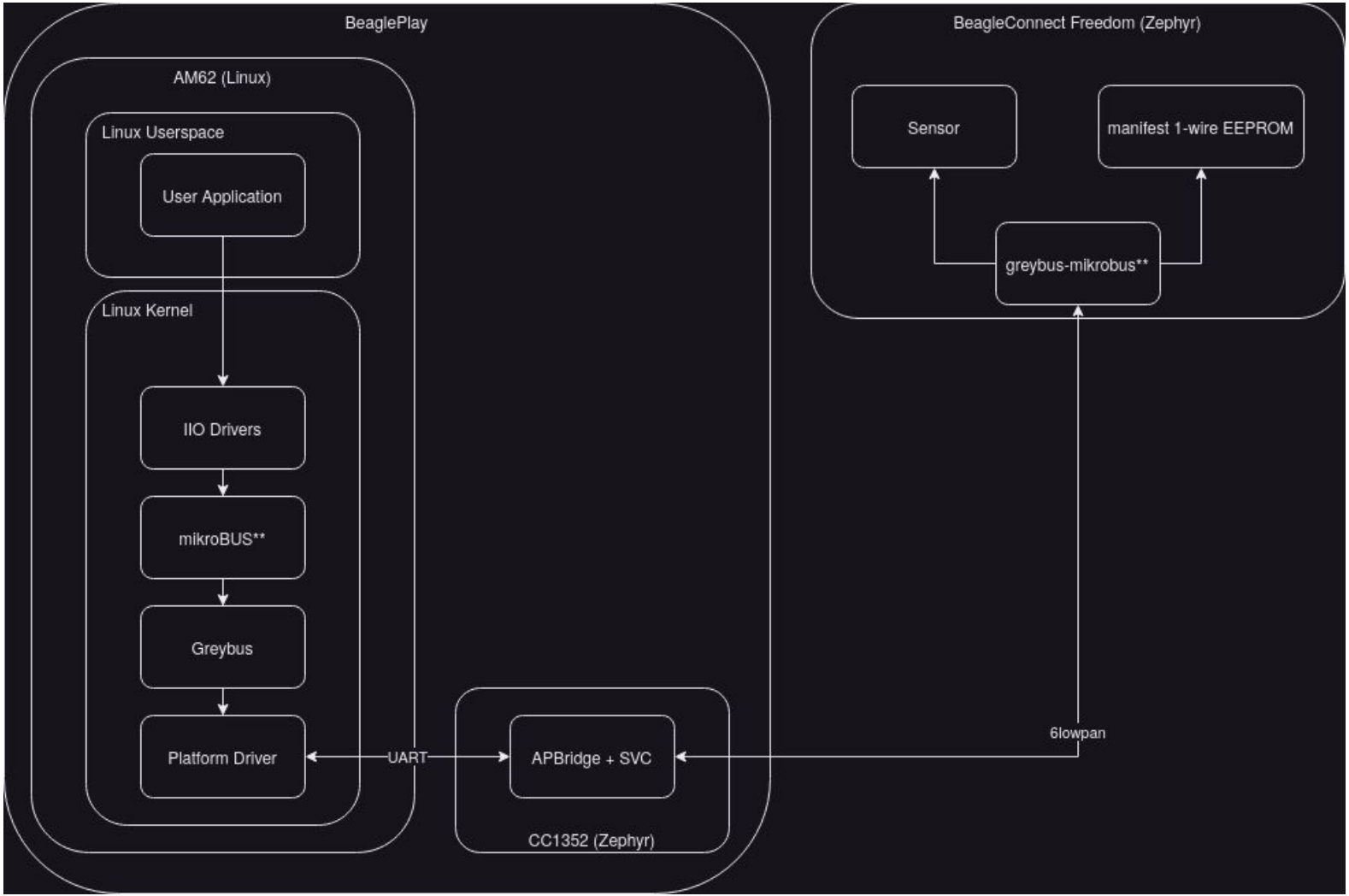


Videos

- GSoC Demo: https://youtu.be/GVuIB7i5pjk
- BeagleCast Episode 5 - Talking Rust,
- Greybus and Gbridge with Ayush Singh

Software

- Zephyr: cc1352-firmware
- Linux driver
- [PATCH v5 0/3] greybus: Add BeaglePlay Greybus Driver


BeaglePlay
AM62 (Linux)
Linux Userspace
User Application
Linux Kernel
IIO Drivers
mikroBUS**
Greybus
Platform Driver
UART
APBridge + SVC
CC1352 (Zephyr)
6lowpan
BeagleConnect Freedom (Zephyr)
Sensor
manifest 1-wire EEPROM
greybus-mikrobus**

BeagleV Ahead

T-Head TH1520 (quad-core Xuantie C910 processor)

4GB LPDDR4

16GB eMMC

WiFi/Bluetooth

Ethernet

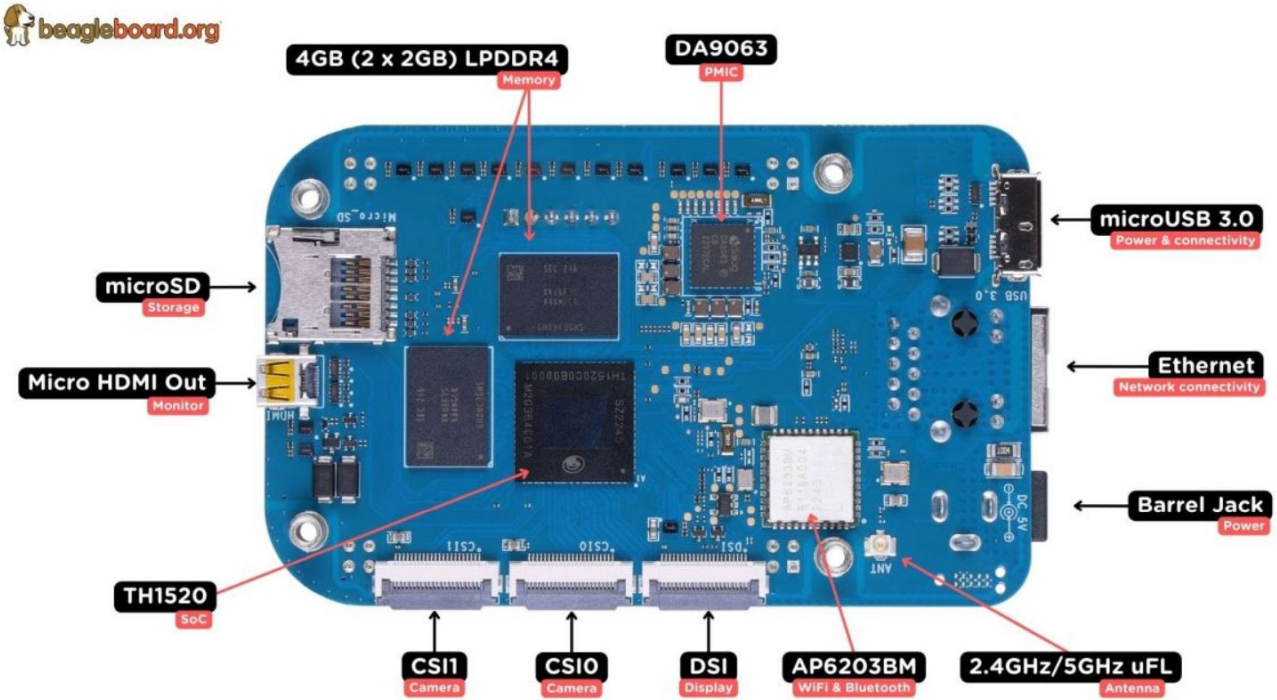
microUSB 3.0

HDMI

mikroBUS

2 x CSI connector

DSI connector



BeagleV Ahead

T-Head TH1520 (quad-core Xuantie C910 processor)

4GB LPDDR4

16GB eMMC

WiFi/Bluetooth

Ethernet

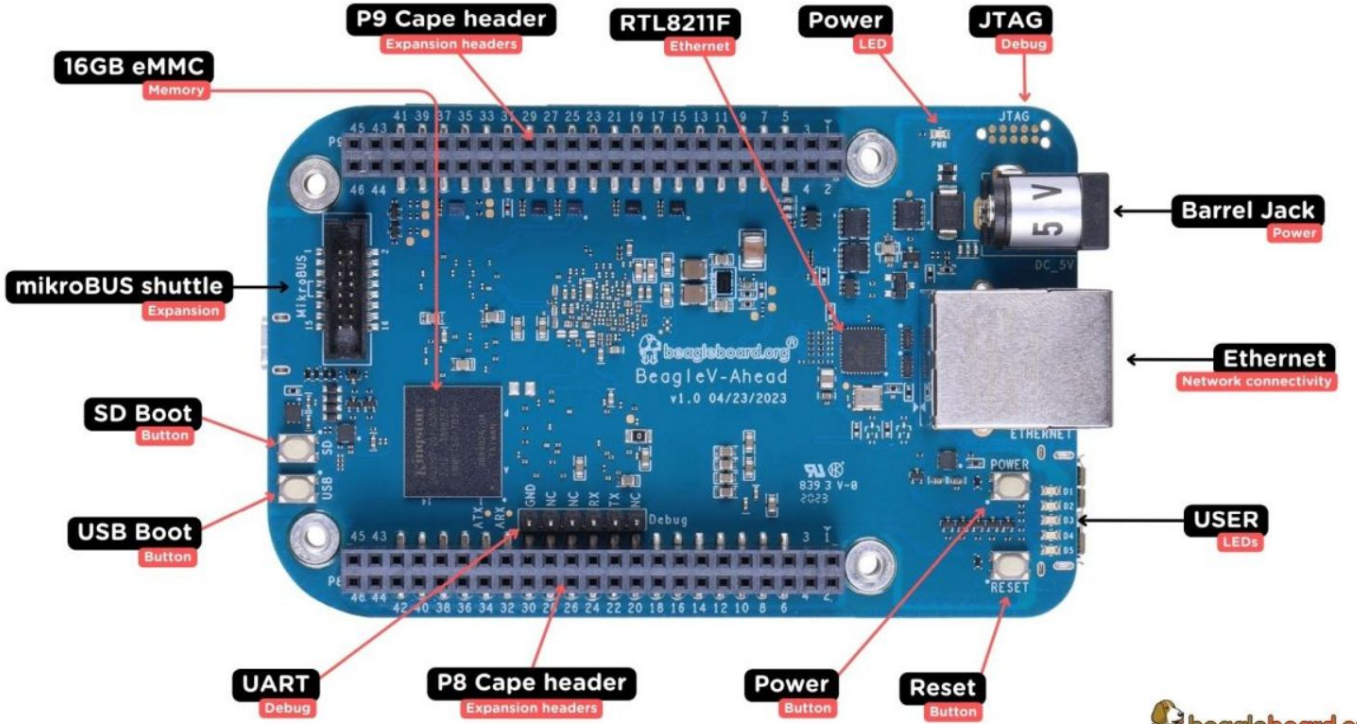
microUSB 3.0

HDMI

mikroBUS

2 x CSI connector

DSI connector



BeagleV Ahead

beagleboard.org

Upstream Linux TH1520 patch series

BeagleV

Log In

Maintainer Git Repos:

Palmer Dabbelt - (RISCV) - kernel/git/palmer/linux.git - palmer kernel tree 4 - (v6.7.x-rc)
Conor Dooley - (dt) - kernel/git/conor/linux.git - conor's fork of linux.git 3 - (v6.6-rc)

RFC for Mainline:

Version	SubSystem	lore
RFC 0	THEAD Clock	[PATCH 0/3] Add T-HEAD th1520 soc clock support - Yangtao Li 4
RFC 2	dwmac driver	[PATCH net-next v2 0/3] add the dwmac driver for T-HEAD TH1520 SoC - Jisheng Zhang 5
RFC 2	riscv: errata: improve T-Head CMO	[PATCH v2 0/2] riscv: errata: improve T-Head CMO - Jisheng Zhang 3
RFC 0	riscv: dts: thead: set dma-noncoherent to soc bus	[PATCH] riscv: dts: thead: set dma-noncoherent to soc bus - Jisheng Zhang 1
RFC 0	riscv: mm: update T-Head memory type definitions	[PATCH] riscv: mm: update T-Head memory type definitions - Jisheng Zhang 2
RFC 0	Reset	[RFC PATCH 0/3] Introduce reset driver for T-HEAD th1520 SoC 2

Maintainer Git Repos:
RFC for Mainline:
Staged for Mainline:
Mainline Status: