

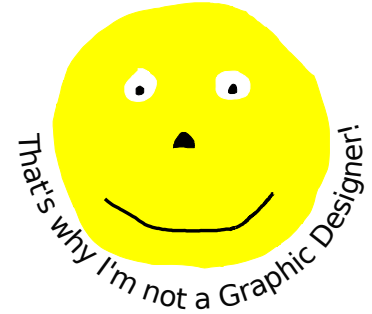
OE4T

OpenEmbedded for Tegra

A look at OE4T, when Yocto meets Nvidia.

About me

- Embedded Linux Engineer since 2021
- Smart Displays and now Vision Devices
- Areas of expertise:
 - bootloader
 - Linux kernel
 - user-space
 - Yocto
- Not a maintainer, but a heavy OE4T user



About OE4T

- Official Yocto Project for Jetson
 - Community Project with support from NVIDIA
- Layers:
 - **meta-tegra** – BSP Layer for Jetson platform
 - **meta-tegra-community** - additional community recipes
 - **tegra-demo-distro** – reference distro for meta-tegra



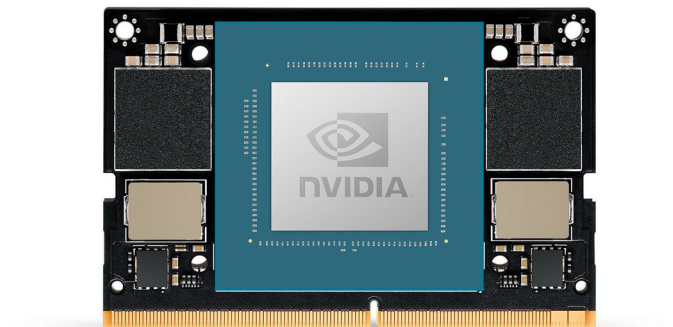
Hardware

Use-Case

- GPU Compute, AI and machine learning applications
 - Nvidia GPU with Tensor Cores and CUDA support
- Camera based Applications
 - Multiple CSI Ports
- Combined
 - Shared buffers between ISP, GPU and CPU

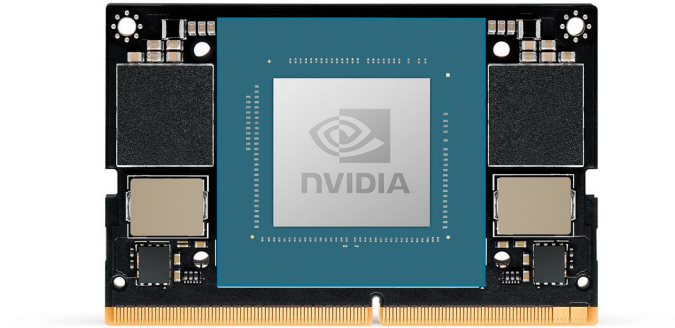
Jetson Orin Nano

- Jetson Orin Nano 4GB
 - 34 TOPS
 - 512-core NVIDIA Ampere GPU
 - 6x Cortex A78AE @ 1.7GHz
- Jetson Orin Nano 8GB
 - 67 TOPS
 - 1024-core NVIDIA Ampere GPU
 - 6x Cortex A78AE @ 1.7GHz



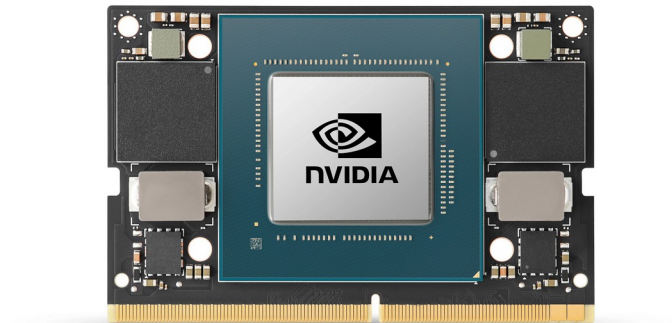
Jetson Orin Nano 2

- Release planned for 2027 H1
- Delivers 2x the inference performance of its predecessor in the same form factor and consumes 40% less power at the same performance.



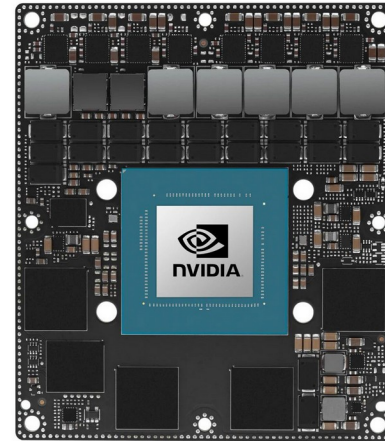
Jetson Orin NX

- Jetson Orin NX 8GB
 - 117 TOPS
 - 1024-core NVIDIA Ampere GPU
 - 8x Cortex A78AE @ 2GHz
- Jetson Orin NX 16GB
 - 157 TOPS
 - 1024-core NVIDIA Ampere GPU
 - 8x Cortex A78AE @ 2GHz



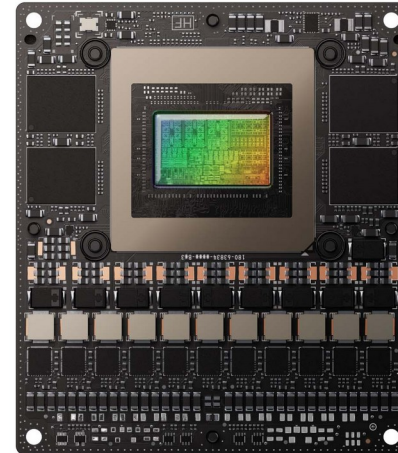
Jetson AGX Orin

- Jetson AGX Orin 32GB
 - 241 TOPS
 - 1792-core NVIDIA Ampere GPU
 - 8x Cortex A78AE @ 2.2GHz
- Jetson AGX Orin 64GB
 - 275 TOPS
 - 2048-core NVIDIA Ampere GPU
 - 12x Cortex A78AE @ 2.2GHz



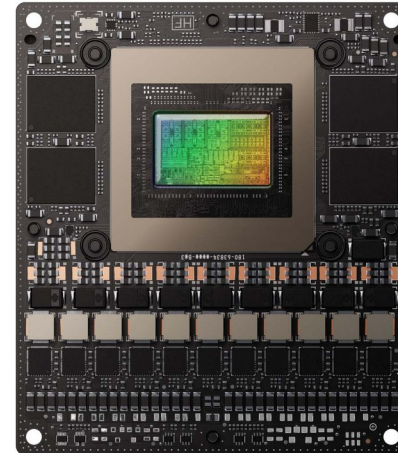
Jetson Thor

- Jetson T2000 (16GB)
 - 400 TFLOPS
 - ?x Neoverse V3AE @ ?GHz
 - Release planned for 2027 Q1
- Jetson T3000 (32GB)
 - 865 TFLOPS
 - 8x Neoverse V3AE @ ?GHz
 - Release planned for 2027 Q1



Jetson Thor

- Jetson T4000 (64GB)
 - 1200 TFLOPS
 - 1536-core NVIDIA Blackwell GPU
 - 12x Neoverse V3AE @ 2.6GHz
- Jetson T5000 (128GB)
 - 2070 TFLOPS
 - 2560-core NVIDIA GPU
 - 14x Neoverse V3AE @ 2.6GHz



Software

Getting Started

- Documentation from NVIDIA
 - <https://docs.nvidia.com/jetson/index.html>
 - Jetson Linux → Boot Architecture
 - Jetson Linux → Root File System
 - Jetson Linux → Jetson Module Adaptation and Bring-Up
- Documentation from OE4T
 - <https://oe4t.github.io/master/index.html>

Nvidia and OE4T

- **JetPack** – SDK and NVIDIA libraries like TensorRT, cuDNN, CUDA, argus, Vision Programming Interface, accelerated OpenCV
- **Jetson Linux (Linux for Tegra)** – Ubuntu based BSP provided by Nvidia, it includes SDKs, libraries and examples.
- **OpenEmbedded for Tegra**
 - **meta-tegra** – BSP Layer for Jetson platform, based on L4T
 - **meta-tegra-community** - additional community recipes
 - **tegra-demo-distro** – reference distro for meta-tegra

Bootloader

- MB1 → MB2 → UEFI
 - Configuration via dts files
- UEFI Capsule Update
- A/B Boot, Recovery Partition
- Device Tree Overlays from EEPROM
- Secure Boot and Hardware Ratcheting Support
- Network Boot Support

Linux Kernel

- Kernel Variants
 - Nobel Nvidia Tegra v6.8
 - Yocto v6.18
 - Yocto RT v6.18
- Proprietary Kernel Modules
 - Out of Tree Modules
 - Not needed for basic usage, but for GPU, VPU, ISP, etc

Storage

- SPI-NOR-Flash for Bootloader and config
- NVME/eMMC as primary storage
 - eMMC and UFS not available on all modules
- Layout defined by XML
 - A/B Layout available

Flashing/Update

- initrd-flash via USB
 - tegraflash archive created by Yocto
 - flashes all needed binaries to SPI-NOR-Flash and NVME/eMMC
 - docs: <https://oe4t.github.io/master/Flashing.html>
- Update tools
 - swupdate used by tegra demo distro
 - mender supports jetson platform
 - rauc is also available

Pitfalls

- Pinmux with Microsoft Excel Macro Sheet
 - Generates multiple dts files
- Last time buy order was one year early for TX2
- NVIDIA provides everything as source archives, no git history included
 - Handled by tegra-binaries- $\${PV}$.inc and tegra-shared-binaries.inc
 - Some recipes have patch and unpack disabled
 - Some sources have been migrated to git over the last few releases

Pitfalls

- Layout needs kernel_A partition with at least one sector
- initrd-flash is faster with bmaptool
- Slow Boot Times
- ISP configuration are closed source binary files
- Some ISP tools are only available for partners
- Hardware is Expensive

Pitfalls

- EFI variable authentication contains an allow-list
- Hardware ratcheting doesn't allow downgrades of one partition with capsule downgrade
- edk2 (UEFI) is complicated compared to u-boot
- bpmp debugfs is on with production mode fuse

Call to Action

- Repositories, Issues and Discussions Forum
 - <https://github.com/OE4T>
- Discord Community Server
 - <https://discord.gg/N82dfM4nZD>
- Monthly meetings
 - <https://github.com/orgs/OE4T/discussions/515>
- Docs
 - <https://oe4t.github.io/master/index.html>



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