

on arm

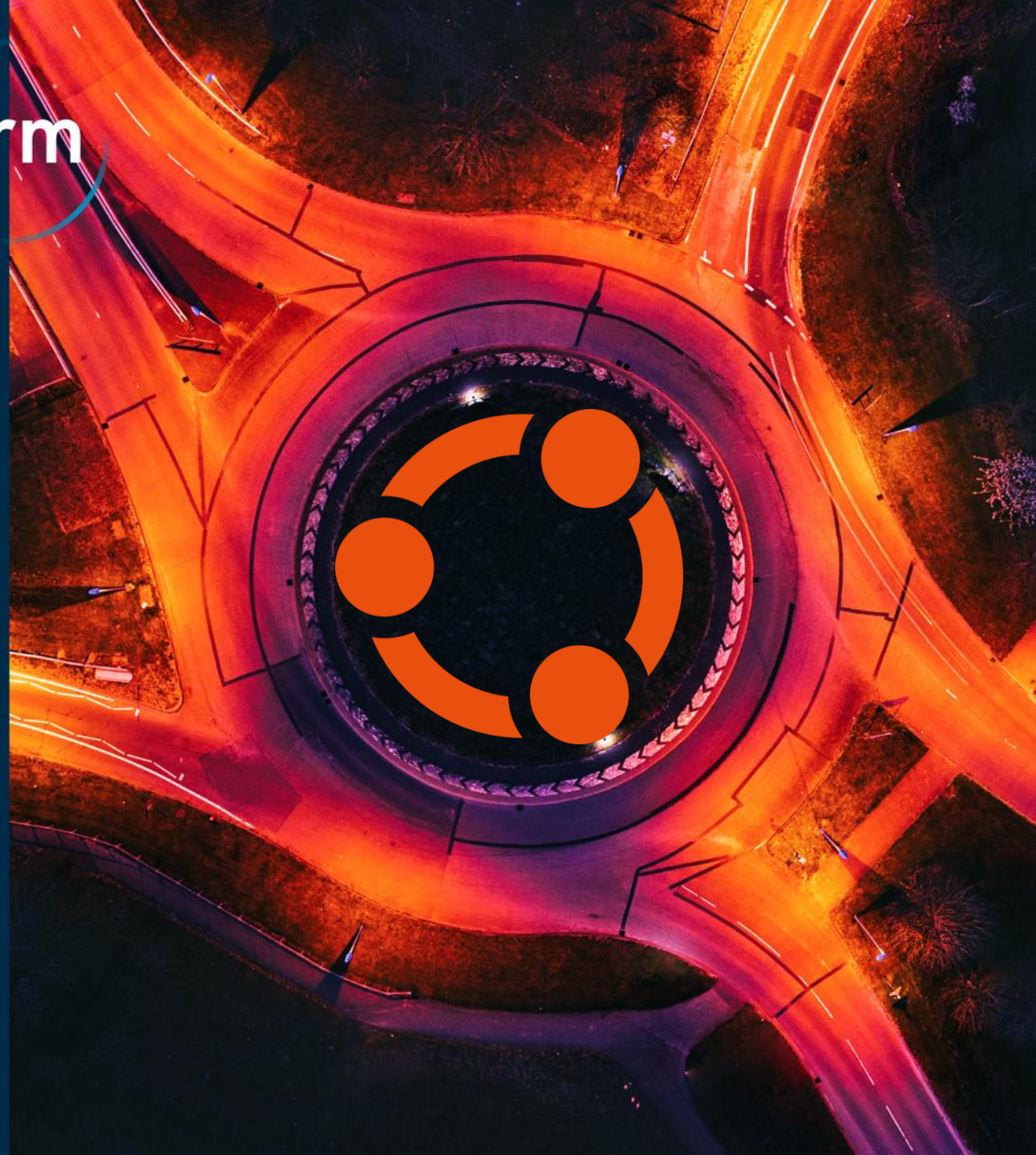
Ubuntu on Arm

Ubuntu Summit
2022

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November 8, 2022

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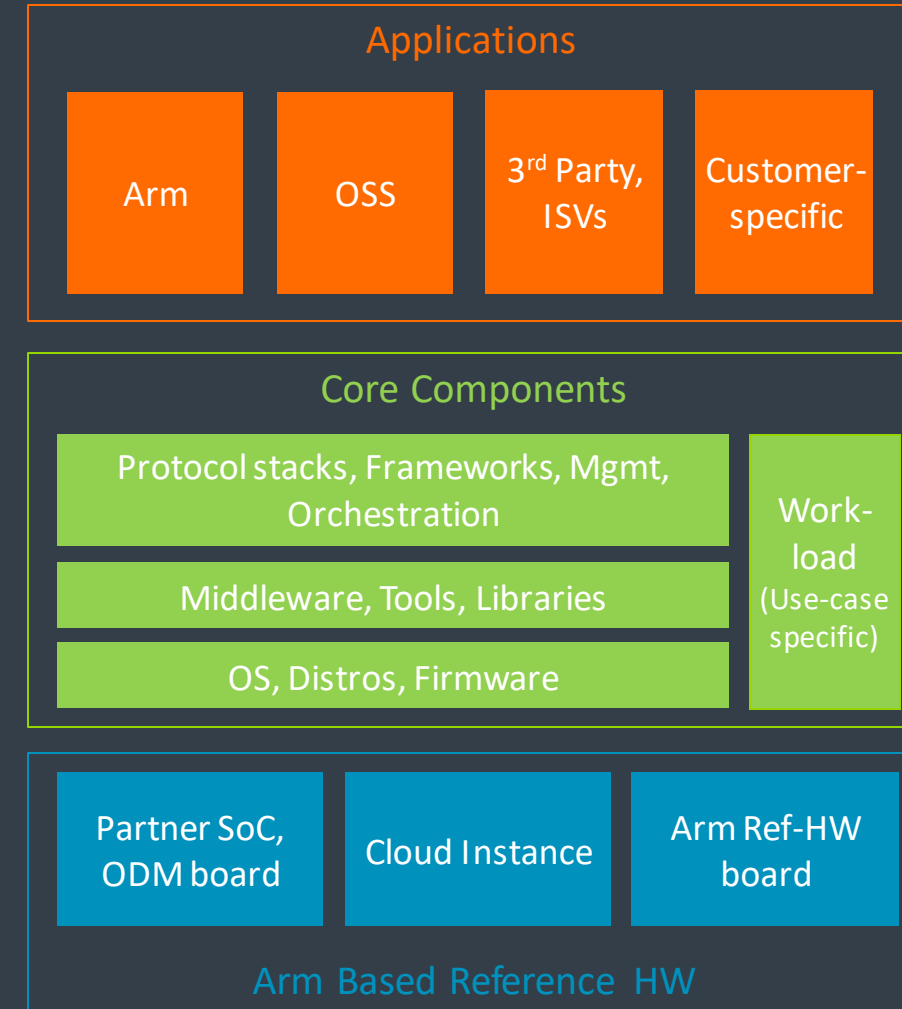
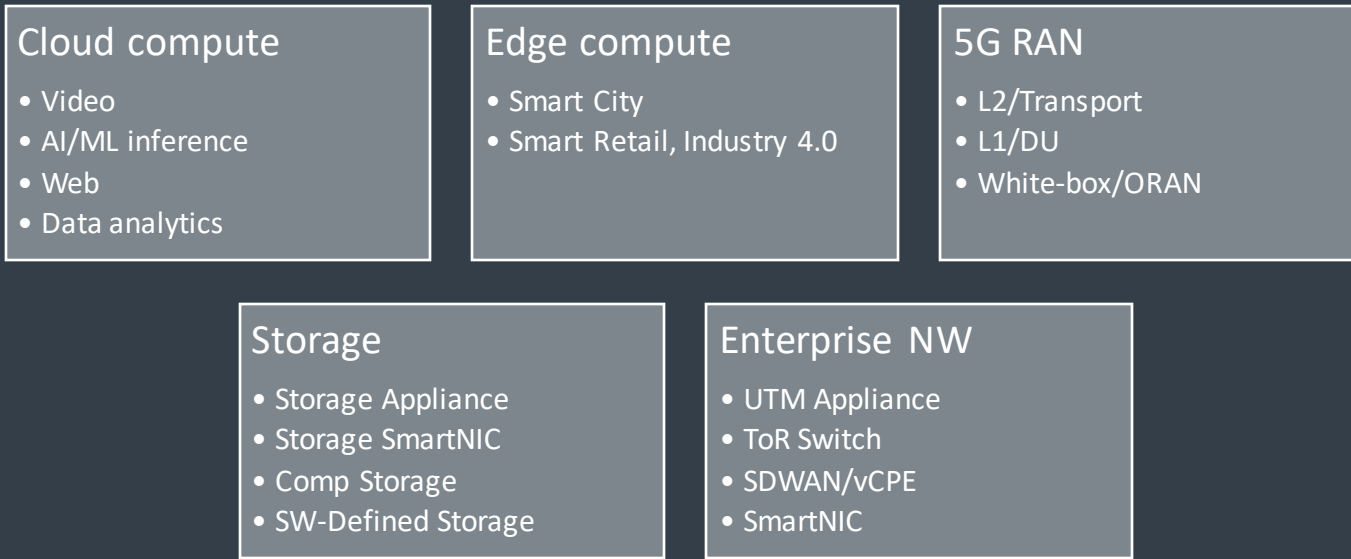
Agenda

- + Introduction
- + The Journey of Ubuntu and Arm
- + Going Forward

Introduction

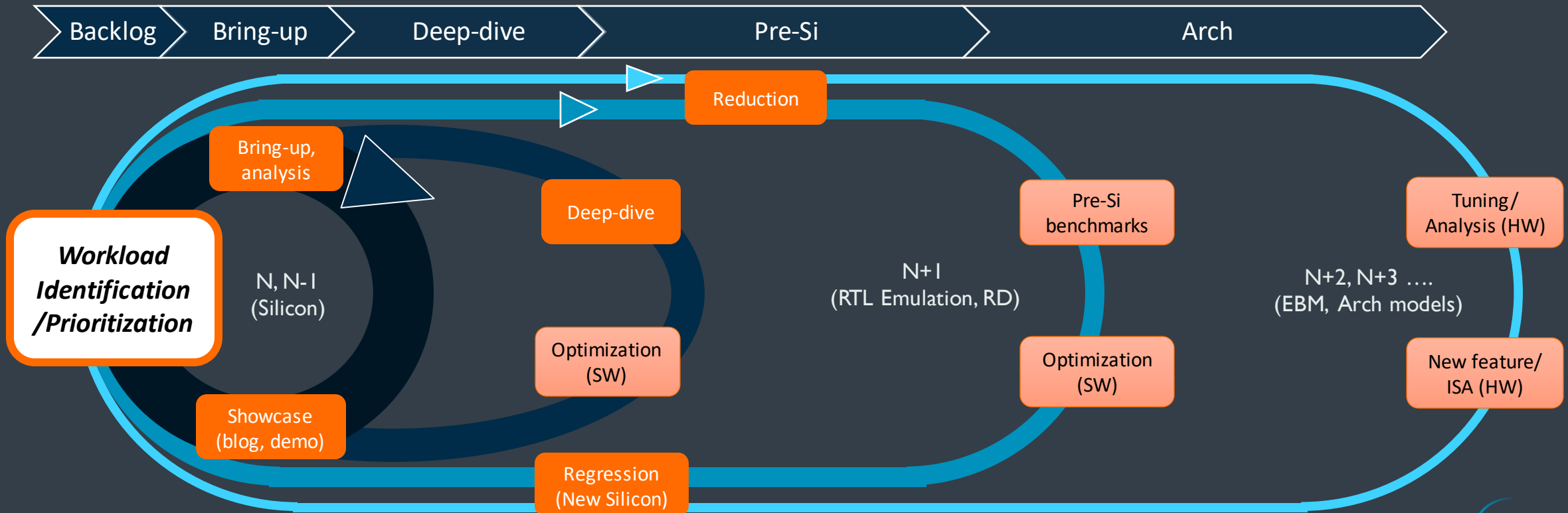
Infrastructure Performance & Solutions Engineering

- Reference integration for key segments/use-cases
 - Showcase **functionality** and capability
 - Shows end user **value-proposition**
 - Demonstrates **ecosystem** readiness
- Drive Arm-based HW deployment
- Drive System (SW and HW) Optimizations




Workloads & System Analysis

- Common set of workloads “curated” from customer feedback.
- Each phase adds additional effort – further filtering.
- This focuses on bring-up/deep-dive workloads (on silicon).



Ubuntu and Me

**Robbie Williamson**

Overview Code Bugs Blueprints Translations Answers

Twitter: @Hulk_Sm444sh
Reddit: ubuhulk

Related packages Related projects Authorized applications OCI registry credentials

User information

Launchpad Id:
robbiew

Email:
robbie.williamson@gmail.com
robbie.williamson@arm.com
robbie.williamson@ubuntu.com
robbie@ubuntu.com
Change email settings
Manage mailing list subscriptions

Jabber:
robbiew@jabber.org

OpenID login:
https://launchpad.net/~robbiew

Member since:
2008-10-02

Signed Ubuntu Code of Conduct:
Yes



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Immutable Page Info Attachments More Actions Ubuntu Wiki Login Help

RobbieWilliamson

Hello! I am Robbie Williamson.

Contact Details

- IRC: robbiew (irc.freenode.net)
- Email: robbiew@ubuntu(dot)com
- Blog: http://undacubebrutha.wordpress.com
- Twitter: undacubebrutha
- Indentix: robbiewilliamson
- G+: Robbie Williamson

Also see my Launchpad Profile.

Where to find me

I am on the following lists:

- ubuntu-devel
- ubuntu-devel-announce
- ubuntu-devel-discuss
- ubuntu-announce
- ubuntu-release
- ubuntu-server
- ubuntu-cloud
- juju

Freenode IRC:

- #ubuntu-devel
- #ubuntu-release
- #ubuntu-server
- #ubuntu-cloud
- #ubuntu-arm
- #juju
- #juju-dev
- #openstack
- #upstart
- #ltp



The Journey of Ubuntu and Arm

It All Started with Mobile...on Intel

Ubuntu Mobile and Embedded Edition

Matt Zimmerman mdz@ubuntu.com

Sat May 5 11:10:26 BST 2007

- Previous message: [Simplified procedure for Stable Release Updates](#)
- Next message: [Ubuntu Developer Summit Participation](#)
- Messages sorted by: [\[date \]](#) [\[thread \]](#) [\[subject \]](#) [\[author \]](#)

At the heart of the Ubuntu project lies a belief that open source software and technology can play a key role in enabling individuals to achieve their potential. A central goal has been the creation of a world-class, free and open source operating system that we have worked to make accessible across notebooks, desktops, thin clients and servers.

Three years on, it is clear that new types of device - small, handheld, graphical tablets which are Internet-enabled are going to change the way we communicate and collaborate. These devices place new demands on open source software and require innovative graphical interfaces, improved power management and better responsiveness.

Intel, specifically, have announced a new low-power processor and chipset architecture which will be designed to allow full internet use on these mobile Internet devices.

To fulfil the aims of our mission and in response to the technical challenges that these devices pose, we are announcing the Ubuntu Mobile and Embedded project.

We will start more detailed planning at the Ubuntu Developer Summit next week in Seville and the first release of this edition will be in October with Ubuntu 7.10. If you are interested in the project, please get involved. We will be working through our normal development processes on Launchpad, the developer mailing lists and IRC.

Finally, we are delighted to be working with Intel on this version of Ubuntu. Intel are making significant contributions of technology, people and expertise to the project. We hope that others who are interested in producing an easy-to-use and open source environment for this class of device will join us in making this a success.

--
- mdz

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Immutable PageInfoAttachmentsMore Actions: ▾Ubuntu WikiLoginHelp

Mobile

Mobile Team Home

Mobile Project Home

Mobile Project FAQ

Mobile Project Background and History

HowTos

Mobile Project Tasks

Mobile Team Meeting Info

Ubuntu Mobile

Please note, Ubuntu MID is no longer a supported platform. These pages are for historical purposes and for anyone that is currently using the old images

The Ubuntu Mobile project aims to derive an operating system for mobile internet devices using Ubuntu as a base. Sponsored by Canonical and Intel, the project has been launched at UDS-Sevilla following a preliminary announcement to the Ubuntu community.

We will extend Ubuntu by providing infrastructure for mobile development, with all of the necessary components integrated into the Ubuntu package archive, ready to install and run, or to tailor for custom mobile applications.

First MID Release

- [MID Release Images](#)

(note: the default password for the kvm image user "ume" is "ubuntu")

Resources

- Mailing list: <http://lists.ubuntu.com/mailman/listinfo/ubuntu-mobile>
- IRC: #ubuntu-mobile on [FreeNode](#)
- [Weekly meeting minutes](#) (IRC meeting every Thursday at 12:00 UTC / 9:00 PDT)
- Technical specifications: <http://blueprints.launchpad.net/~ubuntu-mobile>
- Testing Resources/Cases: <https://wiki.ubuntu.com/Testing/Cases/UMEdesktop> // [Smoke Test Results](#)
- Bug Tracking: <https://bugs.launchpad.net/ubuntu-mobile>

Then there was a Pivot...

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Search

Immutable Page

Info

Attachments

More Actions: ▾

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Login

Help

MobileTeam

This Page is obsolete. The Ubuntu Mobile Team was renamed/retasked as the Ubuntu ARM Team

See [ARM Team](#)

Ubuntu Mobile Team

The Ubuntu Mobile Team is responsible for delivering the [Ubuntu Mobile Project](#), This is built from many component projects, most of which are built by free software developers around the world. We select the best available packages for the job, and mold them into a clean, free, well-integrated system, making changes where required to meet our high standards of quality and ease of use. We work with developers in the free software community to support their interests as well as Ubuntu's.

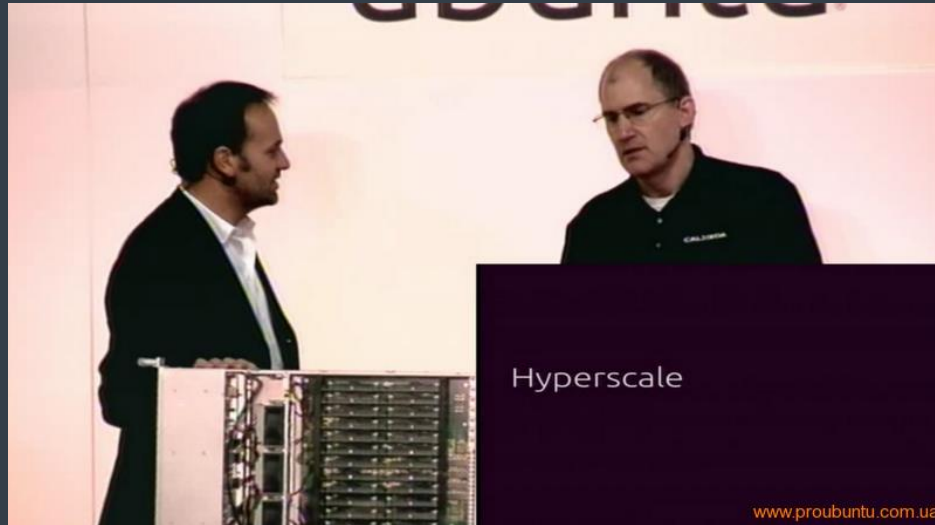
Blueprint Ideas for the upcoming P UDS

This is where we will gather blueprint ideas for both ARM in general and ARM Server projects. Not everything will become a blueprint, some will be combined, some tossed out, but all ideas are welcome.

Idea	Who	Track	Convert to Blueprint (Y/N/C)	Link to blueprint or Status
Implement an ARM Server Kernel for Server Hardware	--	ARM	Y	ubuntu-arm-p-server-kernel Will provide an ARM server tuned kernel with arrival of real ARM server hardware
Arm Server kernel build configuration and tuning	--	ARM	Y	ubuntu-arm-p-server-kernel Will start with the same settings and tunings X86 Server kernel uses, tune from there
Explore Codezero Embedded Hypervisor Virtualization on A9 http://www.l4dev.org/	davidm	ARM		ubuntu-arm-p-virtualization-solutions
Server Performance Testing including * Storage * Main workloads	robbiew	Server & Cloud	Y	servercloud-p-arm-server-performance
ARM Hard float	adconrad	ARM	Y	ubuntu-arm-p-server-benchmark-and-performance Archive will open with P, will review at feature freeze status for LTS
Orchestra on ARM	robbiew	Server & Cloud	Y	servercloud-p-arm-deployment
juju on ARM	robbiew	Server & Cloud	Y	servercloud-p-arm-service-orchestration
Openstack on ARM	robbiew	Server & Cloud	Maybe(?)	openstack + LXC is known to work on ARM. Needs reconfirmation, but I don't think we need a specific spec to handle this
KVM on ARM	Davidm	ARM	Y	ubuntu-arm-p-virtualization-solutions A15 feature, will pull in work from Linaro and ARM until chips arrive
Server System management on ARM - IPMI	Robbiew	Server & Cloud	Y	servercloud-p-arm-system-management need refresh to latest version that supports ARM
Server Documentation updates for ARM	Robbiew	Server & Cloud		
QA Develop automation tests that can run without kvm support (i.e. on raw hardware).	GrueMaster	Other	Y	other-p-qa-baremetal-testing
Revisit Server QA tests from Oneiric, enhance and update as needed.	mahmoh	Other		Original Oneiric Blueprints: server-o-arm-image-validation server-o-arm-image-qa
Testing/Hardening of viable ARM server storage options	cmagina	Server & Cloud	Y	servercloud-p-arm-storage-testing
Marvell Kernel optimizations	Marvell	--		
Support 64K kernel pages in the kernel and in executables	al stone	--	--	--

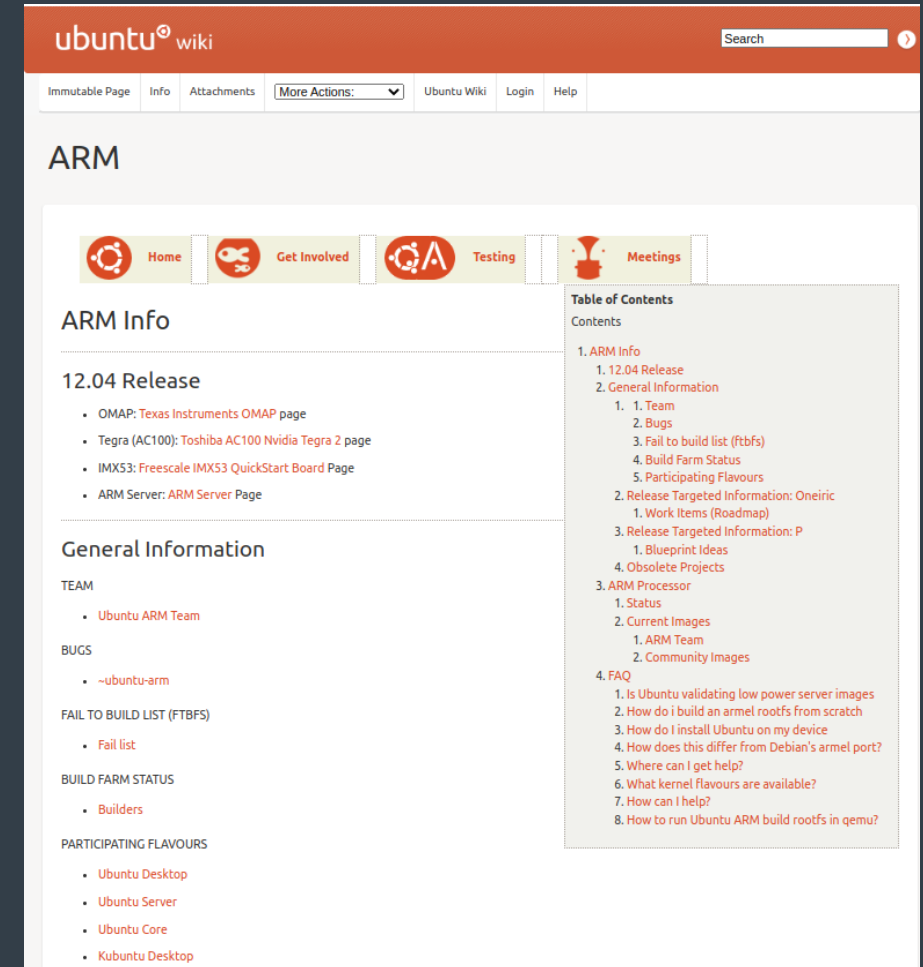


Canonical Had a Vision...Ubuntu Led the Way



Q: Why does Canonical think Ubuntu on ARM Servers will be important?

A: The key factors are cost and resource consumption. While in many ways the two are tied together, ARM servers present all of us with the opportunity to "go green" effectively. We will be able to get the server densities we would like to see, and need to continue to grow our businesses, but do so while actually reducing our energy, cooling and space requirements -- at worse, we flatten the demand over time instead of having it continue to grow at the pace it has. The key to this, though, is that less energy, less cooling and less space translates directly to lower operating costs in the data center. Couple that with servers that cost less to purchase, and ARM servers become an increasingly obvious choice. If we now factor in the Ubuntu cost model across tens of thousands -- or more -- of these servers, Customers can afford to buy and maintain the kind of computing power they could only dream of before.



A Wild Ride from 12.04 to Now

ubuntu® wiki

Installing Precise (12.04.2) using netboot onto a Marvell ArmadaXP Development Board

Before You Begin

You will need the following:

1. A management device for serial access to the board.
2. DHCP available for the board which will provide internet access (to access the Ubuntu package archive).
3. A TFTP Server accessible from the board and optionally a PXE Server setup for PXE boot emulation.

Downloading the Installer

Download the Marvell ArmadaXP `linux` and `initrd` and place them on an available TFTP Server.

Booting the Installer

Access the Marvell ArmadaXP serial console, for example with `screen /dev/ttyUSB0 115200` on a management machine with a USB serial adaptor attached to it.

Power on the board.

Interrupt U-Boot by pressing `Ctrl-C`.

TFTP Boot

Type the following at the U-Boot prompt:

```
dhcp
tftpboot 0x2000000 0
tftpboot 0x100000 0
setenv bootargs "console=ttyS0 0x2000000 0x1000000"
boot
```

This will boot into the installer.

PXE Boot

Type the following at the U-Boot prompt:

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Calxeda

Installing Ubuntu Precise (12.04.2), Saucy (13.10) and Trusty (14.04) using netboot for Calxeda ECX-1000 (Highbank) and ECX-2000 (Midway)

Before You Begin

You will need the following:

1. A management device for console access.
2. DHCP available which will provide internet access (to access the Ubuntu package archive).
3. A TFTP Server accessible from the system.

Downloading the Installer

Download the Calxeda Highbank kernel and installer `initrd` and place them on an available TFTP Server.

For Precise, use this [kernel](#) and [initrd](#).

For Saucy Highbank, use this [kernel](#) and [initrd](#).

For Saucy Midway, use this [kernel](#) and [initrd](#).

For Trusty Highbank, use this [kernel](#) and [initrd](#).

For Trusty Midway, use this [kernel](#) and [initrd](#).

Booting the Installer on Highbank

Power on the chassis and access the console via IPMI (e.g. `ipmitool -H 10.0.0.101 -U admin -P admin -I lanplus sol activate`).

Power on the system processor (e.g. `ipmitool -U admin -P admin -H 10.0.0.101 chassis power on`).

Interrupt U-Boot by pressing Enter when prompted to stop autoboot. In some instances you will need to press "y" to stop autoboot.

Type the following at the U-Boot prompt, replacing the IP address with the IP address of your TFTP Server:

```
dhcp
tftpboot ${kernel_addr_r} 10.0.0.10:/vmlinuz
tftpboot ${ramdisk_addr_r} 10.0.0.10:/initrd.gz
setenv bootargs "console=ttyAMA0"
```

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Mustang

Ubuntu 14.04 installation instructions for x-gene Mustang reference board (ARM64)

Before You Begin

You will need the following:

1. An Applied Micro Mustang reference board (get yours [here](#)).
2. A management device for console access.
3. DHCP available which will provide internet access (to access the Ubuntu package archive).
4. A TFTP Server accessible from the system.

Note: There is a known issue with Mustang networking after install correlated with link speeds less than 1000Mbps. See LP: #1433290.

Download netboot images

Download netboot images from [x-gene netboot images](#) and place them in a directory on your tftp server. Subsequent instructions assume you have placed these files in the directory `sgene` in your tftp server root. Please modify as required if you chose a different path.

Hardware Requirements

Requires a board with A3 silicon, running firmware based on the APM's 1.13.28 release or newer.

Launch Ubuntu installer

- Boot your system to u-boot prompt ("Mustang#")
 - Power up the X-C1 board, while powering up, hit "Enter" or "Return" key to stop the boot process at the u-boot prompt ("Mustang#")
- Configure your system to autoboot to Ubuntu
 - Mustang# setenv script_addr_r 0x40000000
 - Mustang# saveenv
 - Mustang# boot
- (Optional): Enable on-board network
 - Mustang# setenv netdev eth0
 - Mustang# saveenv

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CaviumThunderXCRB

Ubuntu 16.04 installation instructions for Cavium ThunderX CRB

Before You Begin

You will need the following:

1. Cavium THUNDERX 1-Socket or 2-Socket Customer Reference Board (per 2 x chips)
2. A management device for console access
3. DHCP set up to provide internet access (to access the Ubuntu package archive)
4. A TFTP Server accessible from the system
5. Boards should have following **Firmware** components:
 - **UEFI version:** AHI Aptio Label 11 (released May 12 2016) or newer
 - **BMC Firmware:** 1sxb_82693_20150901.img or newer
 - **CPLD image:** version 0ad or newer for 1socket CRB, 0db or newer for 2 socket CRB
6. **NOTE:** It is very important to ensure that systems are running with above recommended firmware levels for Ubuntu installation to work. Please contact your Cavium representative if you are unable to confirm or need help upgrading to the recommended firmware versions.

Ubuntu 16.04 Installation Instructions

Since ThunderX CRBs are UEFI based, they can be installed using the same instructions as a typical UEFI server. Please refer to [ARM/Server/Install/UEFI/BIOS](#) for further details.

ARM/Server/Install/CaviumThunderXCRB (last edited 2016-07-22 00:02:13 by /rishi)


ubuntu® Enterprise Developer Community Download

Downloads Desktop Server IoT Cloud

Ubuntu Server for ARM

Ubuntu 22.04.1 LTS includes support for the very latest ARM-based server systems powered by certified 64-bit processors.

Develop and test using over 50,000 software packages and runtimes — including Go, Java, Javascript, PHP, Python and Ruby — and deploy at scale using our complete scale-out management suite including MAAS and Juju. Ubuntu delivers server-grade performance on ARM, while fully retaining the reliable and familiar Ubuntu experience.



Ubuntu Server

This is the iso image of the Ubuntu Server installer.

[Download Ubuntu 22.04.1 LTS](#)

[Download Ubuntu 22.10](#)

[Alternative and previous releases](#)

Arm Thanks You!!!

Key Compute Libraries Optimized Using Ubuntu

Workload	Use-cases	Arm Value-add	Read more ...
OpenJDK (SpecJBB)	Run-time	Major improvements in throughput, SLA	Blog , OCI Blog
.Net	Run-time	Major improvements in .Net 7 *	Azure Blog , Dash
PHP	Run-time/web	Upto 2x improvements, 17% better website perf	AWS Blog
H.264 encoding	Video-streaming	10% better performance, 36% cost savings	Blog , Altra OCI blog
H.265 encoding	Video-streaming	25% better socket performance, efficiency *	Blog , Ampere Blog
VP9, AV1	Video-streaming	Ongoing optimization work	Coming soon
Zstandard	Data Compression	15-20% better performance, 50% lower cost	Blog
Snappy	Data compression	40% higher performance, 75% lower cost	Blog
OpenSSL AES-GCM	Crypto processing	2x higher performance**	Blog
MLPerf	AI/ML inferencing	30-80% higher performance **	Blog
Apache Arrow	Data/File-format	60% better performance, 80% lower cost	Internal report (NDA)
Synchronization	All workloads	+15% mySQL, +20% DPDK using right primitives	White-paper

Key Compute Workloads Optimized Using Ubuntu

Workload	Use-cases	Arm Value-add	Read more ...
Nginx	Web-server, gateways	20% cost savings, 54% better performance	Blog , White-paper
Mongo-DB	Data-analytics	117% better performance, 30% cost savings	Blog
Cassandra	Data-analytics	45% cost savings	Blog
Kafka	Data-analytics	30% cost savings	Blog , Whitepaper
ElasticSearch	Search engine	15-25% better performance, 50% cost savings	Blog
Memcached	Key-value store	50% better performance, 80% cost savings	Blog
Etc	Key-value store	20% better performance, 40% cost savings	Blog
Redis	Key-value store	35% better performance, 20% cost savings	Blog , Oracle , Ampere
KeyDB	Key-value store	45-65% better performance	KeyDB Blog
Pelikan	Key-value store	3x higher performance with tuning *	Pelikan Blog

Comparison between Graviton2 vs. Cascade-Lake and Rome instances on AWS

*Tau T2A (Ampere Altra) instances on GCP

Key Compute Workloads Optimized on Ubuntu (contd..)

Workload	Use-cases	Arm Value-add	Read more ...
Spark	Big-data analytics	55% better performance, 60% cost savings	Blog
Hadoop	Big-data analytics	Up to 40% better performance	Report (NDA)
Spark SQL	Big-data analytics	Up to 49% better performance	Blog , AWS Blog
mySQL	SQL Database	30-40% better *	Report (NDA) , Amp Blog
Clickhouse	SQL Database	32% better performance **	Blog
XGBoost, LightGBM	Big-data analytics ML	Up to 50% higher performance **	Blog

Up Next

Workload	Use-cases	Scope of work
PostgreSQL	SQL Database	Sysbench OLTP and TPC-C
Hadoop SQL	Big-data analytics	Hive Query

Key Web Services Optimized on Ubuntu

Workload	Use-cases	Arm Value-add	Read more ...
Wordpress	Content-delivery, hosting	17% better performance, 34% cost savings	AWS Blog
Magento	E-commerce	60% better performance	Magento Blog
VoD Edge cloud	Media-streaming	Up to 70% better perf/Watt, linear scaling*	Ampere Blog
Deathstarbench	Various synthetic services	23% better perf, 34% lower latency*	Ampere Blog

Up Next

Workload	Use-cases	Scope of work
AcmeAir	Airline-reservation	Benchmark request/sec processed with synthetic microservice.
NDbench	Media-storage	Benchmark noSQL data-stores (Cassandra) with Netflix NDbench tool
LiveKit	Media-streaming	WebRTC based framework – measure jitter, latency, bandwidth in different use-case scenarios (e.g. webinar, video-conf)

Key I/O Workloads Optimized on Ubuntu

Workload	Use-cases	Arm Value-add	Read more ...
NVMeoF/NVMeoTCP	Storage appliances, SmartNICs	75% smaller footprint, 60% lower CPU utilization	(NDA) Perf report Blog , Ampere FIO
Snort + Vectorscan	Deep-packet-inspection, NLP	70% headroom 150% better socket performance	Blog
5G RAL	L1-U/DU processing	Up to 8x performance with vector-engines	Blog

Up Next

Workload	Use-cases	Scope of work
Rook/Ceph + ISA-L	Storage clusters	Ceph with ISA-L compression, encryption, hash, de-dup
OpenEBS	Storage clusters	Benchmark OpenEBS, compare with Ceph

Key Solution PoCs Created and Shown on Ubuntu

Workload	Use-cases	Arm/Partner Value-add	Read more ...
Android-in-Cloud	Cloud-Gaming, App-development	Native development, 0% translation/porting overhead	Anbox demo Ampere/Anbox WP , Anbox Blog
Virtual RAN+MEC	5G Cloud-RAN	ORAN-compliant/Virtualized L1-Upper, L2/L3/Transport stack	MWC 2021 (Altra), (NXP), Blog MWC 2022 Demo
Virtual RAN – GPUs	5G Cloud-RAN	Arm servers + Nvidia GPU for L1, AI processing.	Blog GTC 2021 session
5G Small-cell in-a-box	Private 5G	OSS/Community stack, small footprint Edge gateways.	Demo video
Secure containers	5G vRAN	Securely hosted 5G functions using Kata	CNCF Webinar
SMARTER stack	Smart Cities	Cloud-native orchestration, cluster inferencing, data-collection.	APM Demo video (int) Solution-Brief
Edge-analytics	Smart Cities	Edge data management, analytics federated ML	Edge-Delta Blog , Splunk Blog
Twitter + Spark-stream	Real-time data-analytics	Streaming analytics with real-time big-data ML algorithms	Blog , ML Blog

Going Forward

Arm on Arm Initiatives | Linux Laptop space

Work In Progress

GPU driver support | Soundwire support |
Bluetooth |

Patches on-list

Touchscreen | Backlight Control |
External Display support | Audio
Enhancement

Gearing for Merge

USB Type C Basic Support |
Touchpad | Integrated Display |
Backlight Control

Lenovo
Collaboration
on X13s

- Conducive Form factor (16 GB RAM | 512 GB Storage), apt for native Arm development

Linaro
Collaboration
Development
Pipeline

- [Custom Debian Installer](#) | 6.0 Custom Kernel
- Foundational Kernel support for native Linux OS deployment



Firmware
updates

- Firmware redistribution upstreamed in [Linux Firmware repo](#)
- GPU firmware => Work In Progress

Looking
Ahead

- Ubuntu up and running | kernel fork 6.0
- GPU support | Performance enhancements

Keep Up The Great Work!



CANONICAL + ubuntu

An Introduction to real-time Linux

May, 23 2022 at 8:00 PM CET, 30 mins

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Edoardo Barbieri
Real-time Kernel Product Manager

Multiarch Support is the Future...Again

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MultiarchSpec

- **Launchpad Entry:** [package-selection-foundations-in-multiarch-support](#)
- **Created:** [SteveLangasek](#)
- **Contributors:** [SteveLangasek](#)
- **Packages affected:** dpkg, apt, gcc, glibc, binutils, linux-libc-dev, update-manager, software-properties-gtk, synaptic?

Summary

Integrate support for cross-architecture installation of binary packages (particularly i386→amd64, but also other combinations) in dpkg and apt.

Release Note

Ubuntu 11.04 introduces support for installing packages from multiple architectures on a single system. This makes a wider array of 32-bit applications available to users of 64-bit Ubuntu.

Rationale

The current handling of 32-bit software on the amd64 architecture is unwieldy in the extreme. A handful of libraries are packaged as "biarch" packages, building -i386 variants using gcc -m32; most do not, and as a result are only available if they're included in ia32-libs, a monstrous source package that has to be updated to be kept in sync with each change to one of the component libraries, and now contains so many libraries that its "source" package (consisting primarily of copies of the i386 binary packages) weighs in as a 550MB tarball. Furthermore, many of these libraries have to be patched to specially handle running in a 64-bit environment because they load various plugins from a system path that is already occupied by the 32-bit library, resulting in added complexity in the code due to special-casing.

In all cases, the libraries (and some executables) have to be repackaged as amd64 packages, because dpkg and apt do not support sensible handling of cross-installation of i386 packages. This consumes archive space and developer time on an ongoing basis.

User stories

- Phil wants to run VMware Server on his 64-bit Ubuntu install, but it is only available as a 32-bit package. He enables use of the 32-bit repositories on his system in the Software Sources configuration, then selects the vmware-i386 package from the Add/Remove menu. The dependencies on the i386 library packages are automatically resolved, including libpam-modules, and the packages are installed for him.
- Denise is developing software for the ARM platform, cross-compiling it from her x86-64 desktop system. She installs all of the build-dependencies as armel packages, builds her package, and tests it directly on her desktop running it under qemu via binfmt-misc.
- Shawn installed his system using the 32-bit version of Ubuntu, but his hardware is 64-bit and he wants to switch over. He manually installs the amd64 versions of dpkg and apt, replacing the i386 versions and changing which architecture is used as the default; then he installs the amd64 ubuntu-minimal package; then he installs the amd64 ubuntu-desktop package. Over time the remaining i386 packages are replaced automatically on upgrade.

Table of Contents

Contents

1. Summary
2. Release Note
3. Rationale
4. User stories
5. Assumptions
6. Design
7. Filesystem layout
8. Binary package control fields
9. Extended semantics of per-architecture package relationships
10. Dependencies involving Architecture: all packages
11. Architecture-independent files in multiarch packages
12. The future of bi-arch packages
13. apt sources
14. Implementation
15. Code Changes
16. Migration
17. Test/Demo Plan
18. Unresolved issues
19. Co-installable -dev packages
20. Co-installable packages for executables
21. Autodetection of supported ABIs
22. Architecture-independent packages that can only be generated on one architecture
23. Partial architectures
24. Architecture-specific Conflicts/Replaces
25. Binary NMUs
26. Related bugs
27. Self agenda and discussion
28. Allow official packages to have cross-architecture deps
29. Permit packages without Multi-Arch set to satisfy foreign dependencies
30. Require separate -common packages for all multiarch packages
31. Reuse bracket notation for multiarch dependency declarations
32. Permit flag days for interpreters, reducing the number of packages to touch



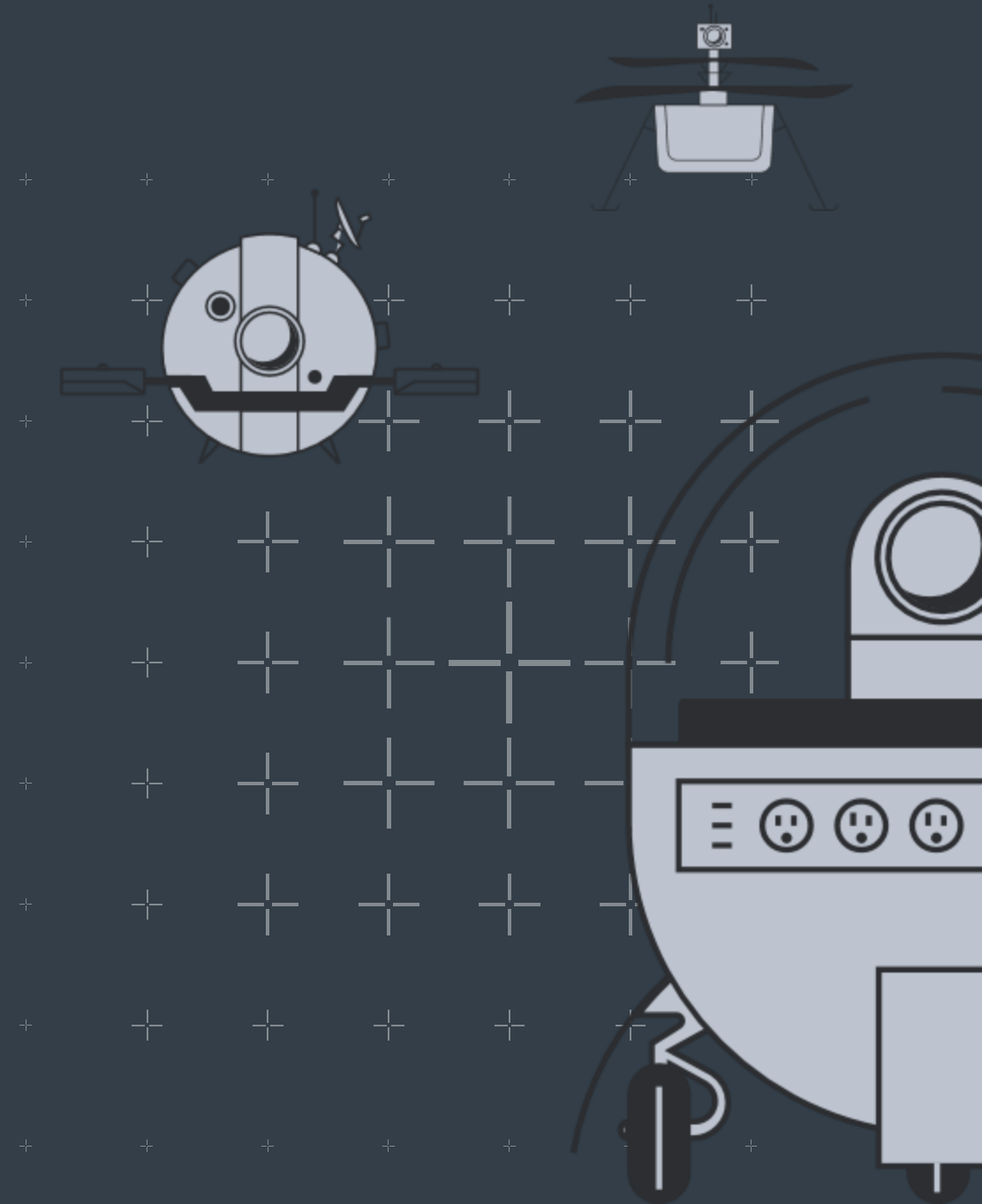


arm Developer Program

A community to build your future on Arm

- Get fresh insights directly from Arm experts
- Connect with like-minded developers
- Build on your expertise and become an Arm Ambassador
- There is something for everyone in our global community

arm.com/developerprogram



Member vs Ambassador

Developer Resources	Member	Arm Ambassador
Community Interaction		
Community Access	Yes	Yes + Special Access
Exclusive Insights	Yes	Personalized Content
Early Access Events Pass (Live or Virtual)	-	Yes
Expert Interaction / Advice		
Arm Personality Office Hours	Limited Access	Yes
Credits for Training, Hardware, Tools & Software	Limited Access	Yes
Expert Talks	Limited Access	Yes
Recognition		
Arm Developer Digital Toolkit	Yes	Yes
Developer Project Spotlight	Limited Access	Yes
Speaking Invites & Co-Marketing	Limited Access	Yes
Arm Welcome SWAG	-	Yes

Arm experts



Jason Andrews

Solutions Director
and Distinguished
Engineer



**Christopher
Seidl**

Director Product
Management
Embedded Tools



Peter Harris

Technical Director
and Distinguished
Engineer



Pareena Verma

Principal Solutions
Architect



**Robert
Williamson**

Sr. Director
Performance and
Solution Engineering



Zach Lasiuk

Staff Solutions
Designer



Mary Bennion

Director Ecosystem



Robert Wolff

Senior Manager
Developer
Evangelism



Thank You

Danke

Gracias

Grazie

谢谢

ありがとう

Asante

Merci

감사합니다

धन्यवाद

Kiitos

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