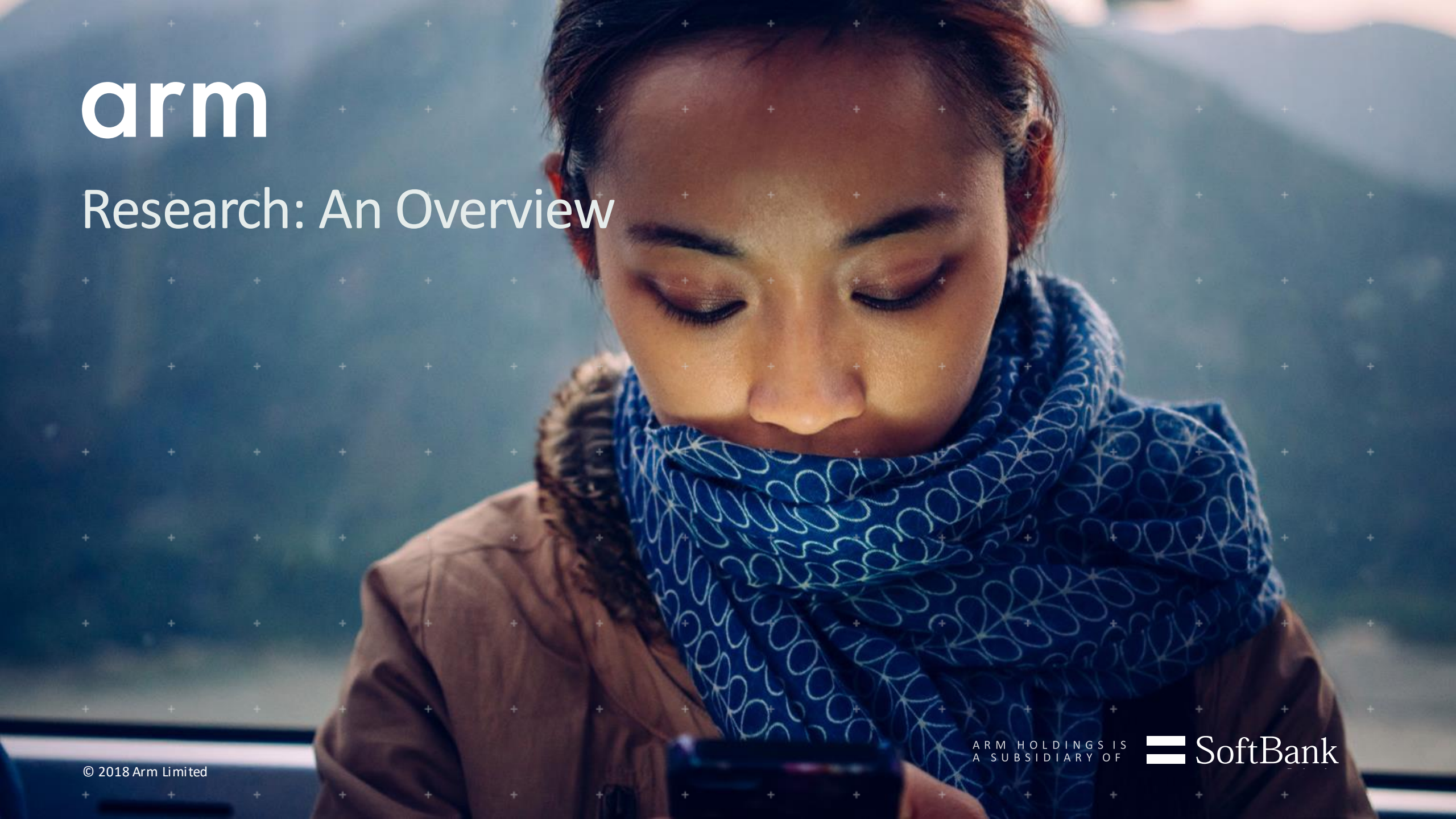


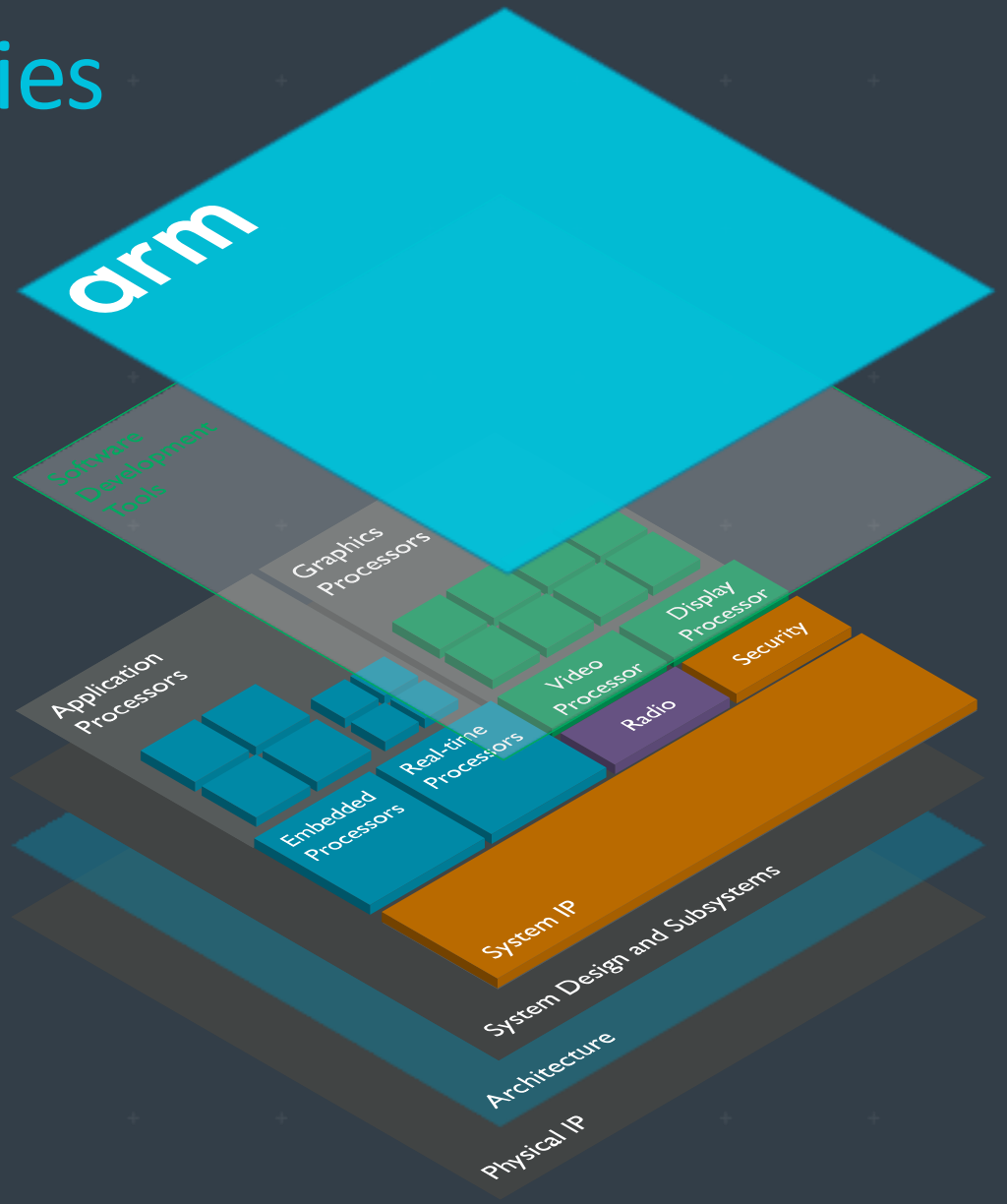
arm

Research: An Overview

ARM HOLDINGS IS A SUBSIDIARY OF SoftBank

Arm technologies

- Architectures
- Processors
- Graphics
- Systems
- Security
- Radios
- Software
- Services



No. 1
shipped GPU in the world

20+bn
Arm-based cellular modems shipped to-date

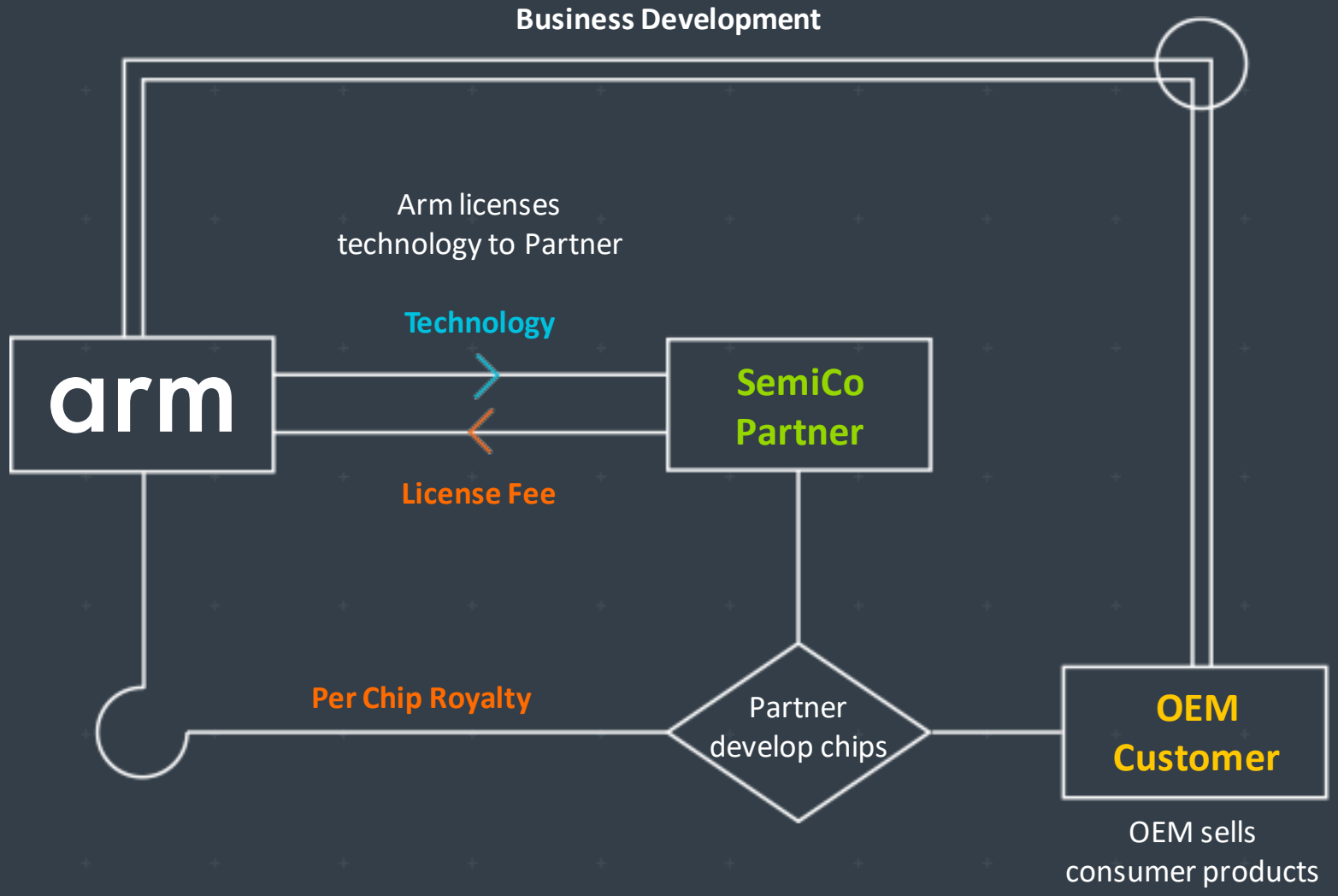
100x
compute increase since 2009

95%
of the world's smartphones are based on Arm

A continuous partnership model

Arm develops technology that is licensed to semiconductor companies.

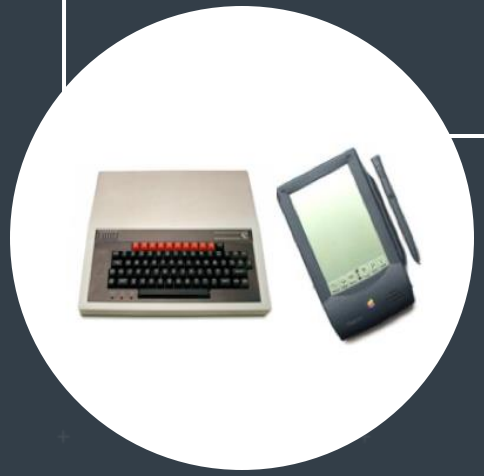
Arm receives an upfront license fee and a royalty on every chip that contains its technology.

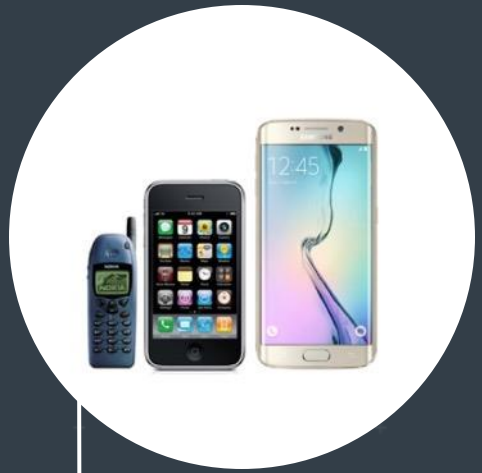


From inception to now

1990

Joint venture between Acorn Computers and Apple.





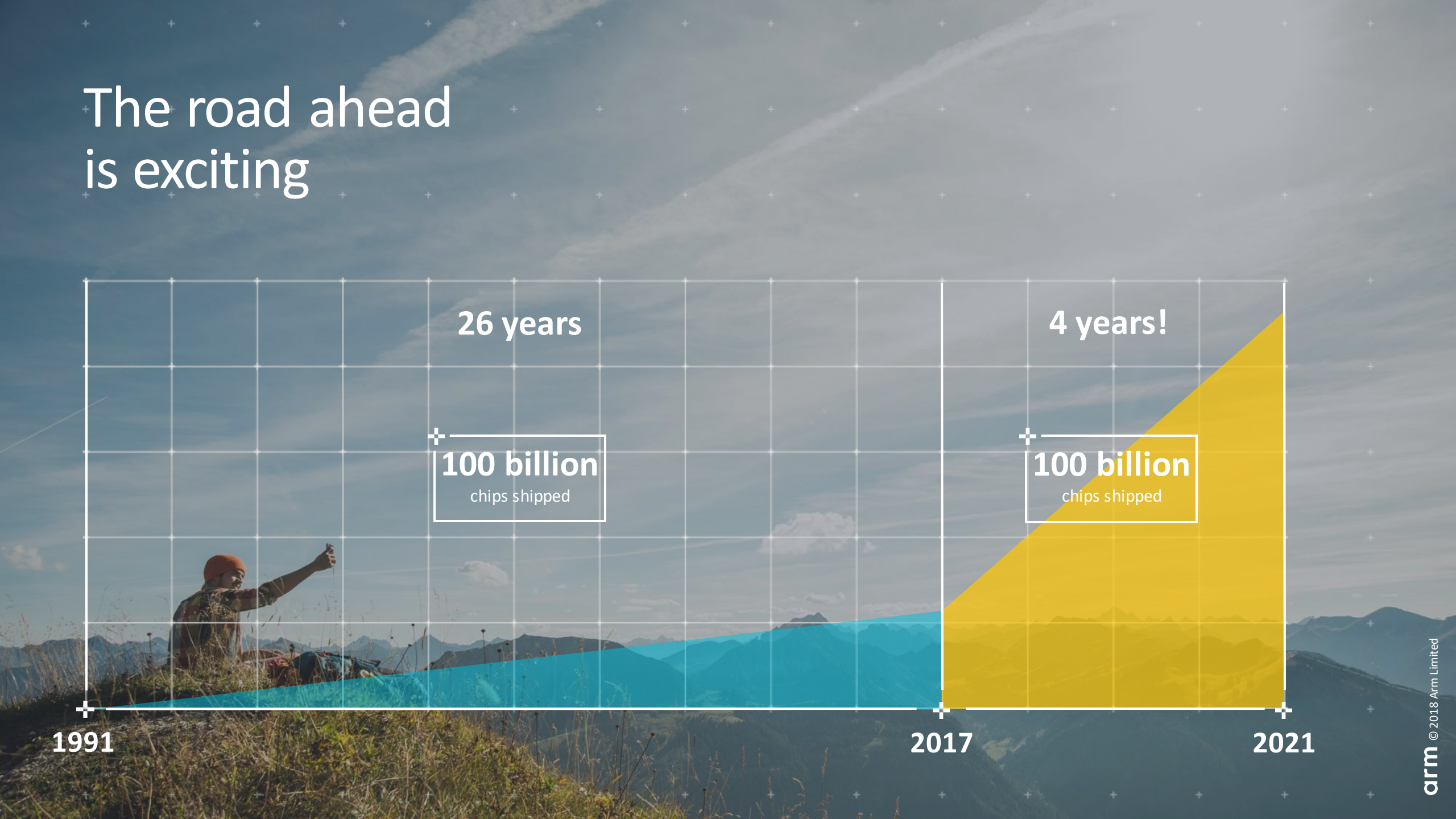
Designed into first mobile phones and then smartphones.

1993 onwards

Today

Now all electronic devices can use intelligent Arm technology.

The road ahead is exciting



Data

Control

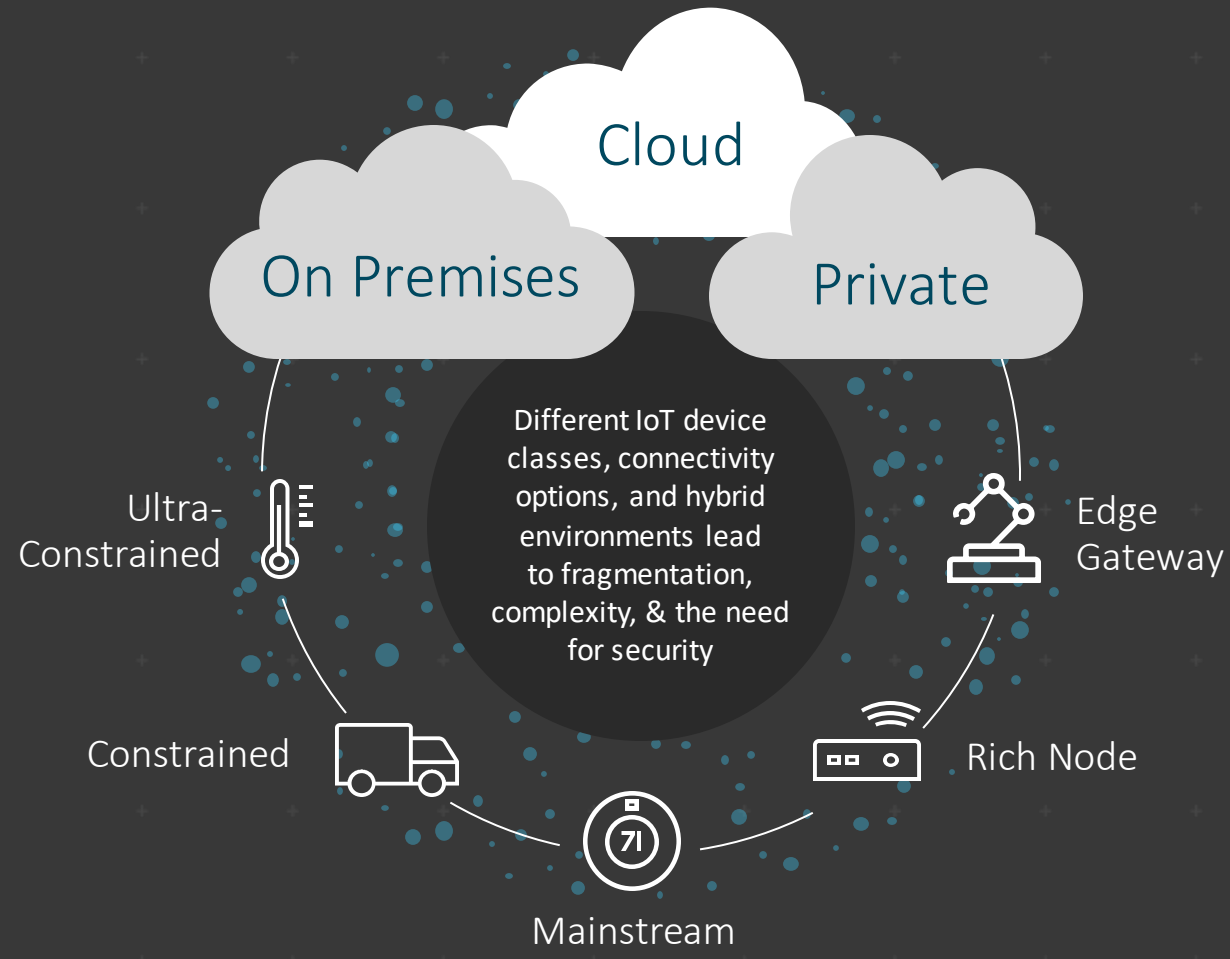
Challenge: Deploying and managing IoT at scale

Harnessing Data

Managing Devices

Connecting Devices

Developing Devices

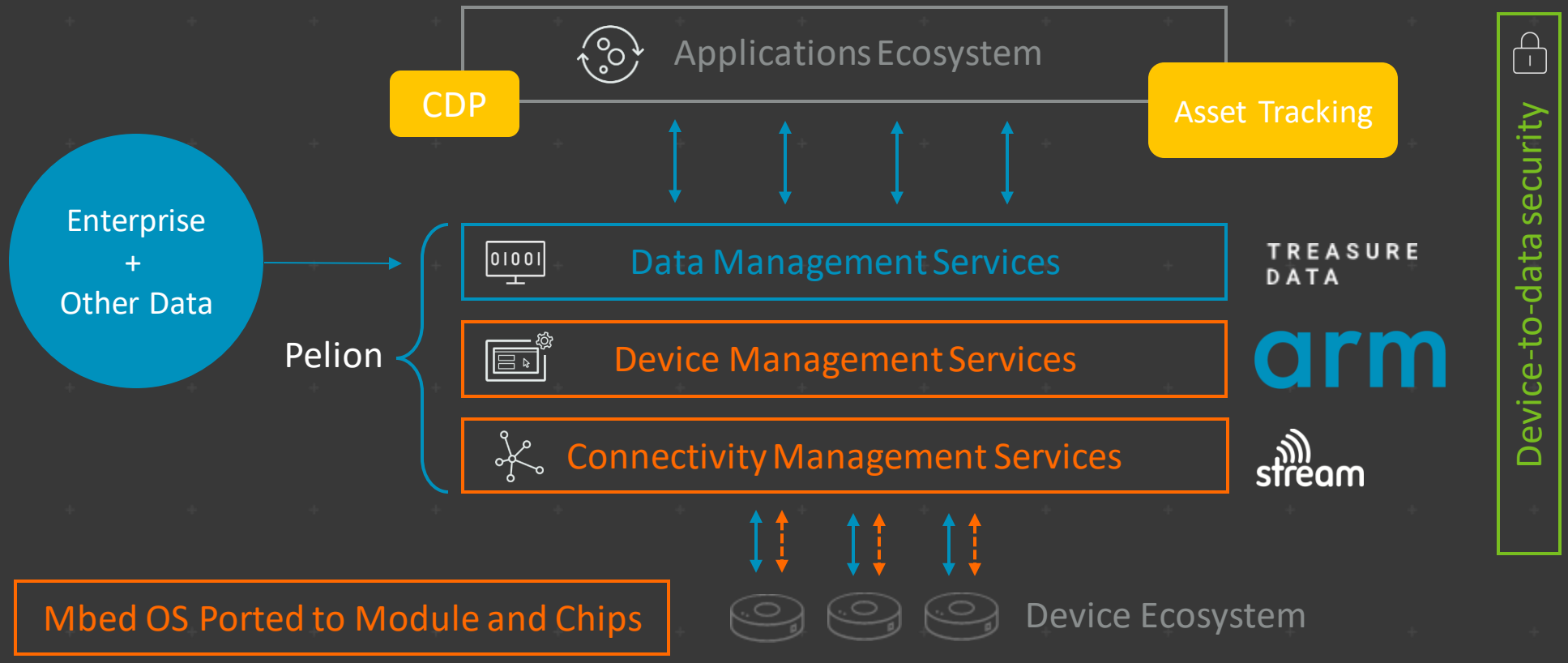


Security

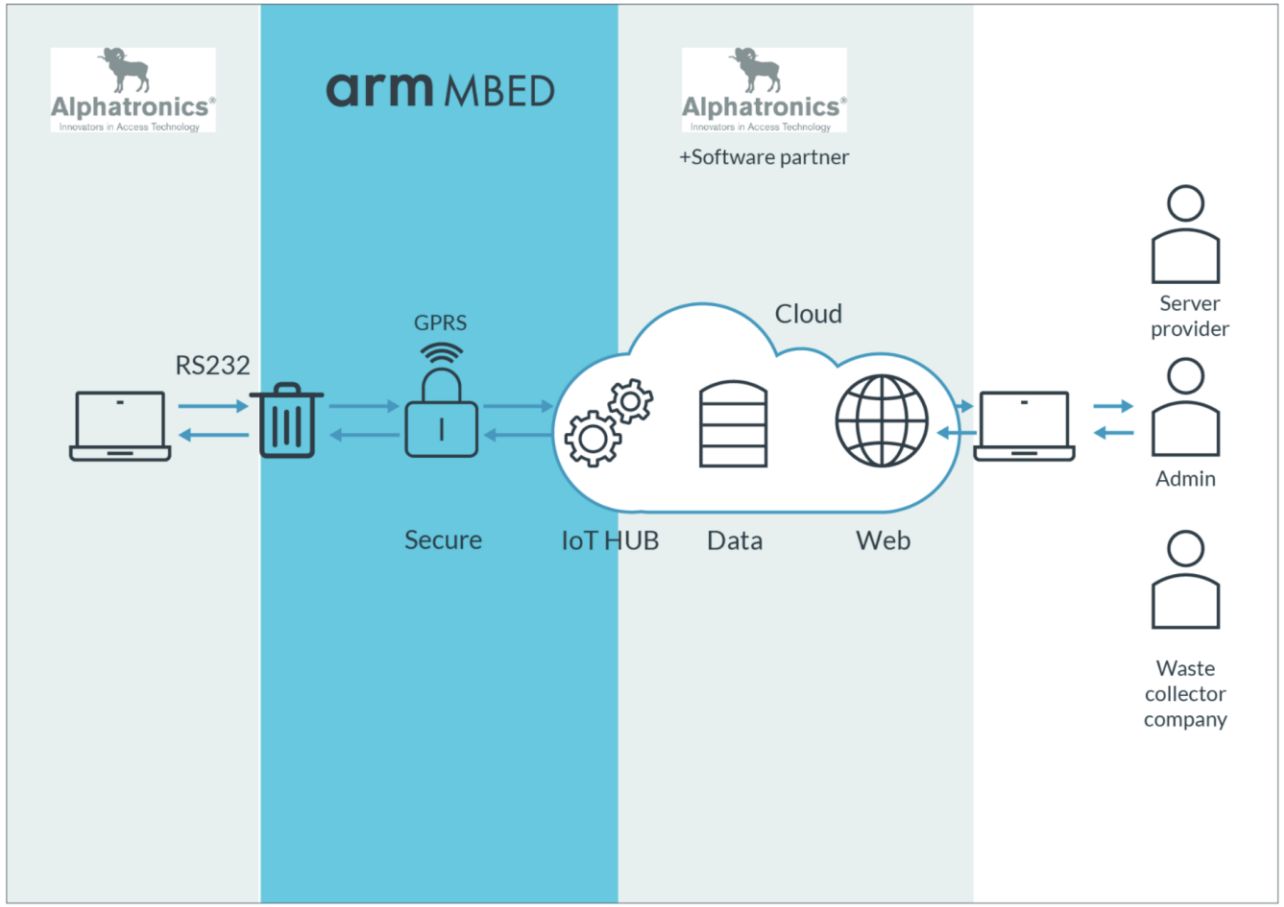
Fragmented Deployments

The Arm Pelion IoT Platform

End-to-end services built on Arm IPG and ISG security framework



Arm + Alphatronics



Waste Management Industry

arm

Introducing Arm Research

Mission

Partner to accelerate innovation and transfer research knowledge across Arm and the Arm Ecosystem

Objectives

Build a pipeline to create and bring future technology into the Arm Ecosystem

Create and maintain the emerging technology landscape

Enable innovative Academic research through collaboration and partnership

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Key Research People

Eric Hennenhoefer
VP Research

Research Programs

Stuart Biles
Dir. Architecture & Fellow

Greg Yeric
Research Fellow

Rob Aitken
Dir. Technology & Fellow

Nigel Paver
VP Engineering & Fellow

Andy Pickard
UK Research Director

Chris Emmons
US Research Director

Matt Horsnell
Architecture

Gary Carpenter
Emerging Technology

James Myers
Devices , Circuits & Systems

Kanak Agarwal
IoT Services

Stephan Diestelhorst
Systems & Memory

Eric Van Hensbergen
SW & Large Scale Systems & Fellow

Hugo Vincent
Security

Matthew Mattina
Machine Learning

Operations

Kim Asal
Senior Director of Operations

Research Collaborations & Enablement

John Goodenough
VP Standards & Collaboration

Arm Education

Khaled Benkrid
Dir. Education & Research

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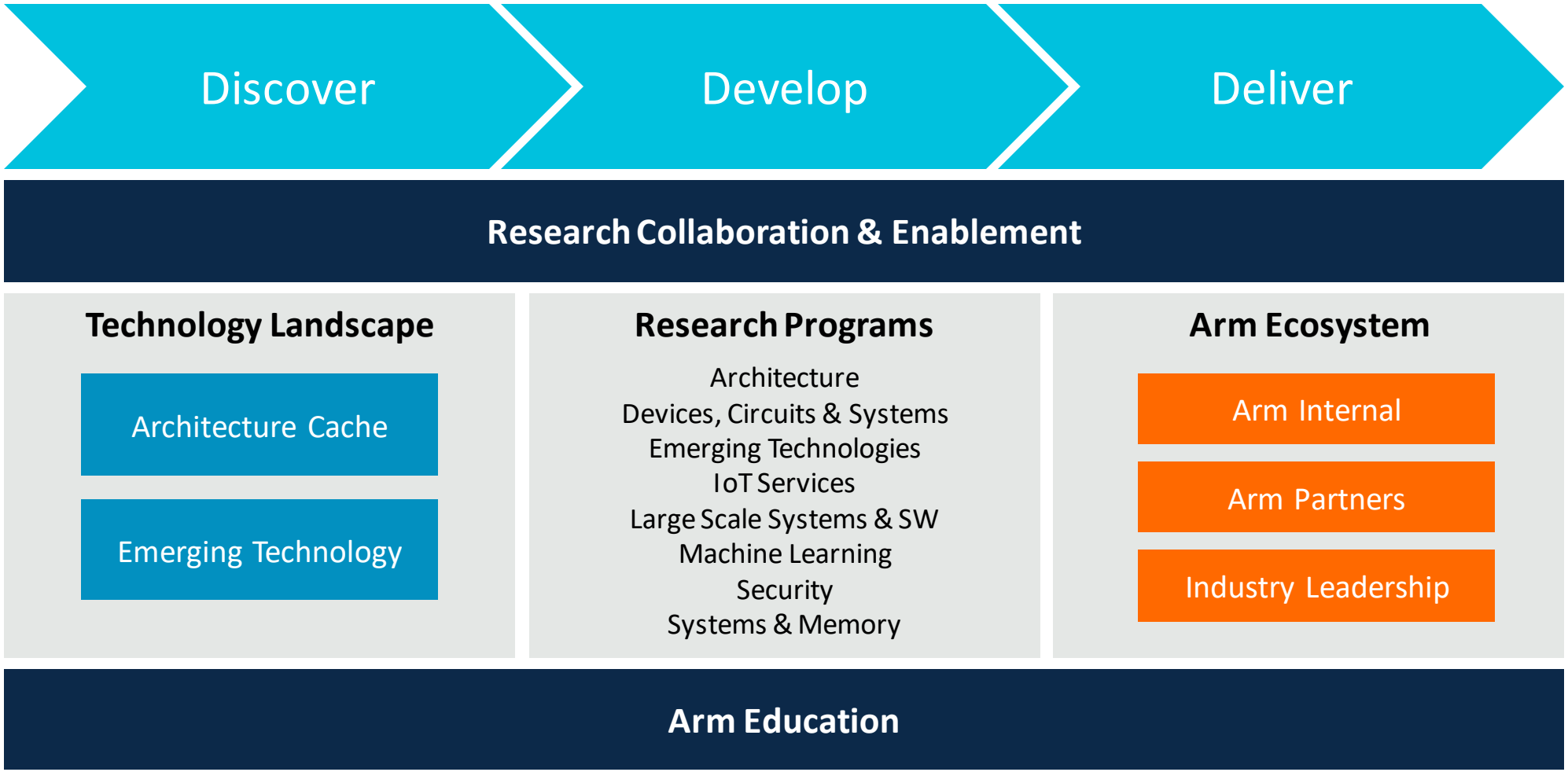
Arm Research Process



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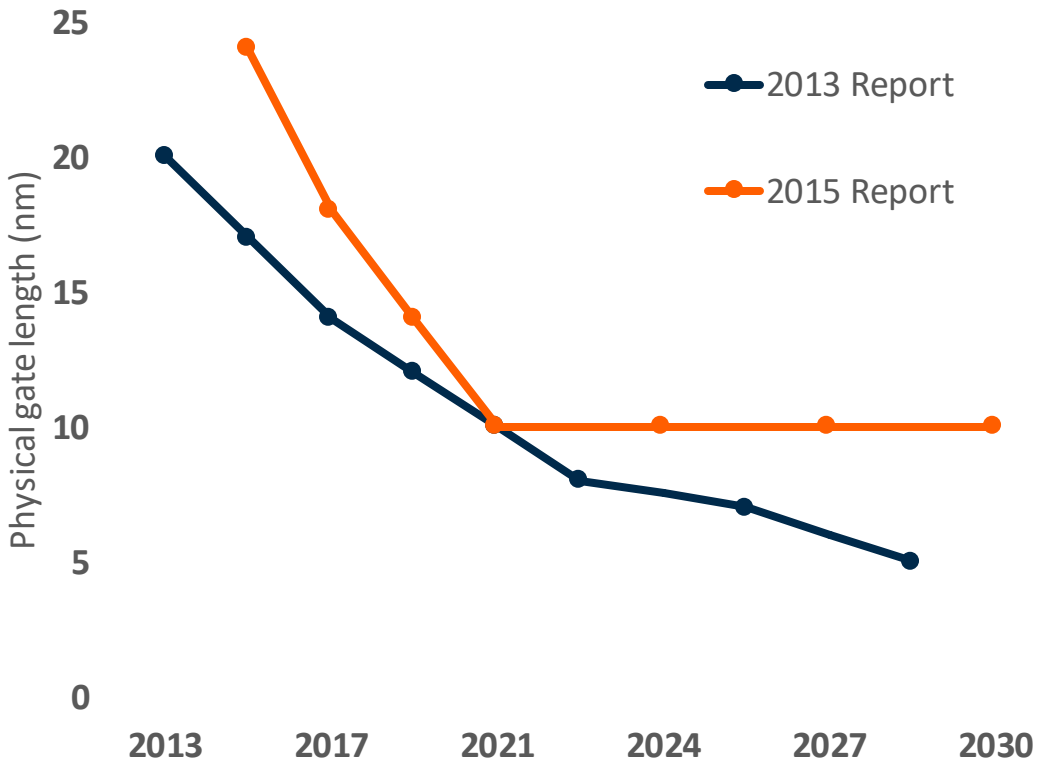
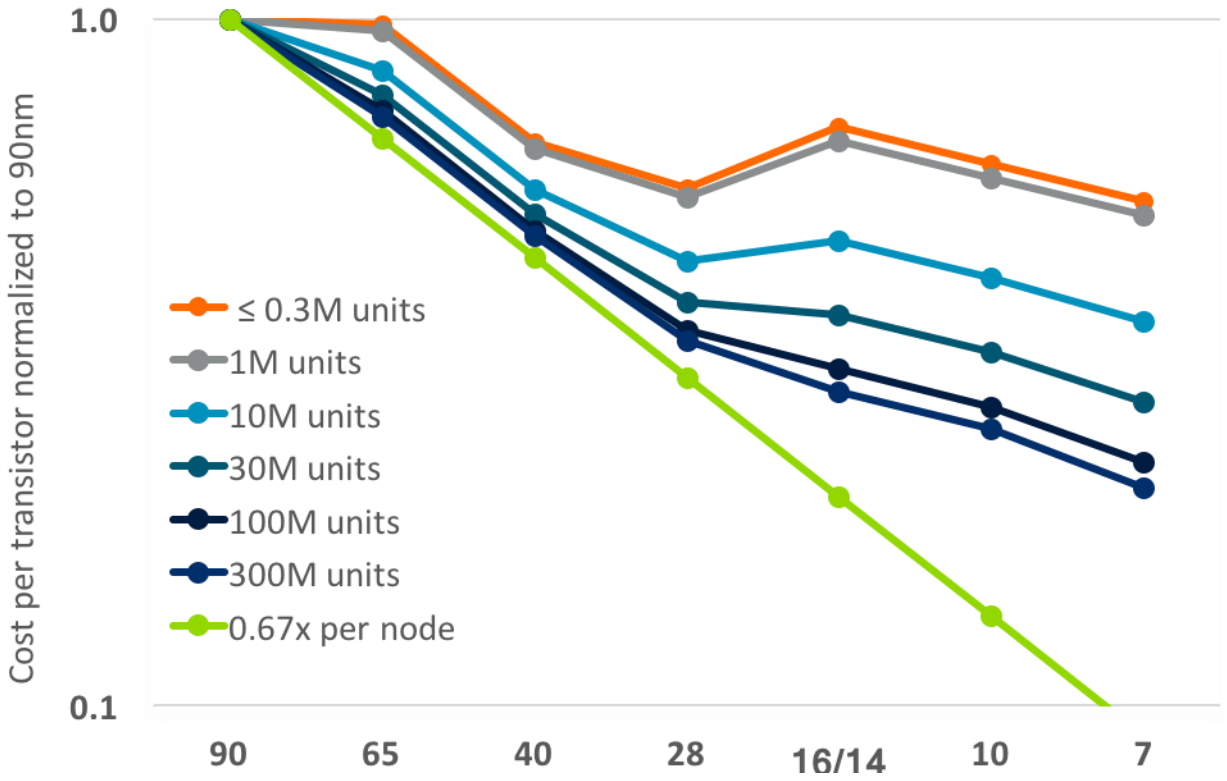
Transistors aren't scaling the way they used to…



ITRS previously predicted shrinkage until at least 2028, but latest report shows feature size going flat. ITRS chair: "Some further scaling may be possible after transistors go vertical".

source: spectrum.ieee.org/semiconductors/devices/transistors-could-stop-shrinking-in-2021



source: G. Yeric, IEDM 2015 Keynote

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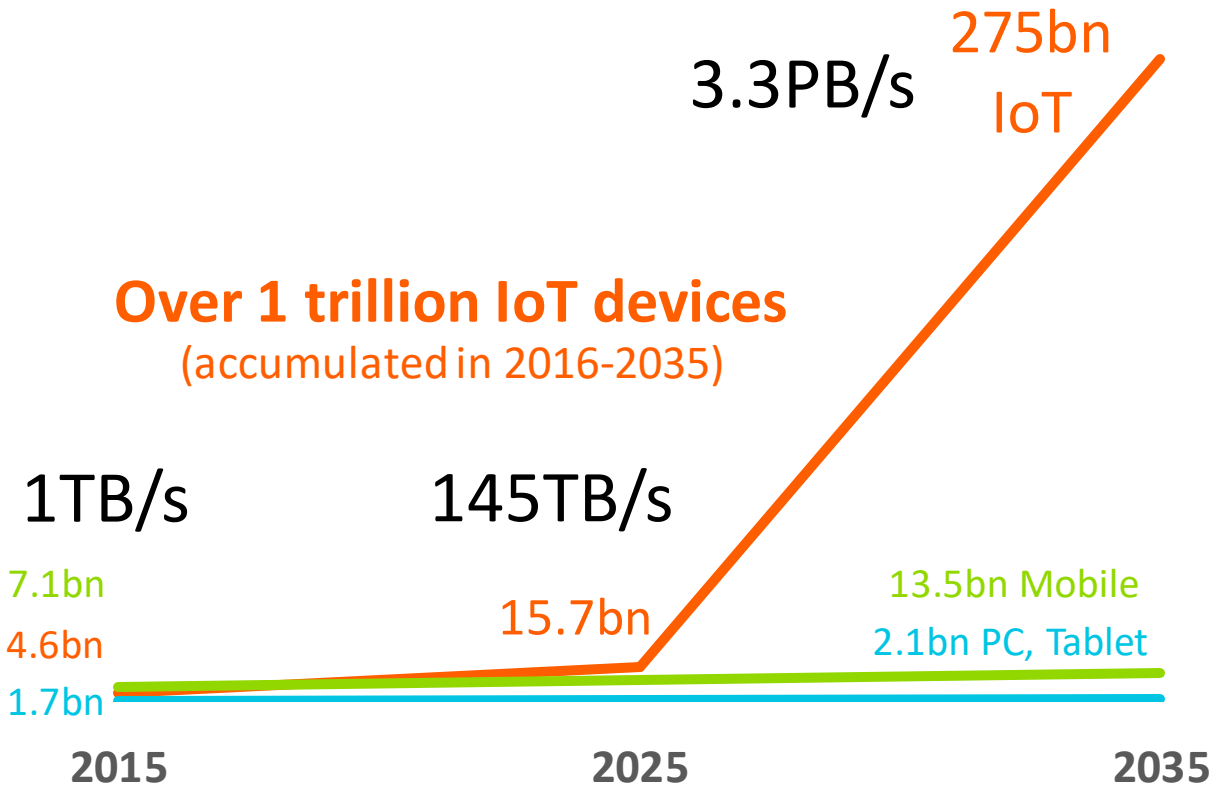
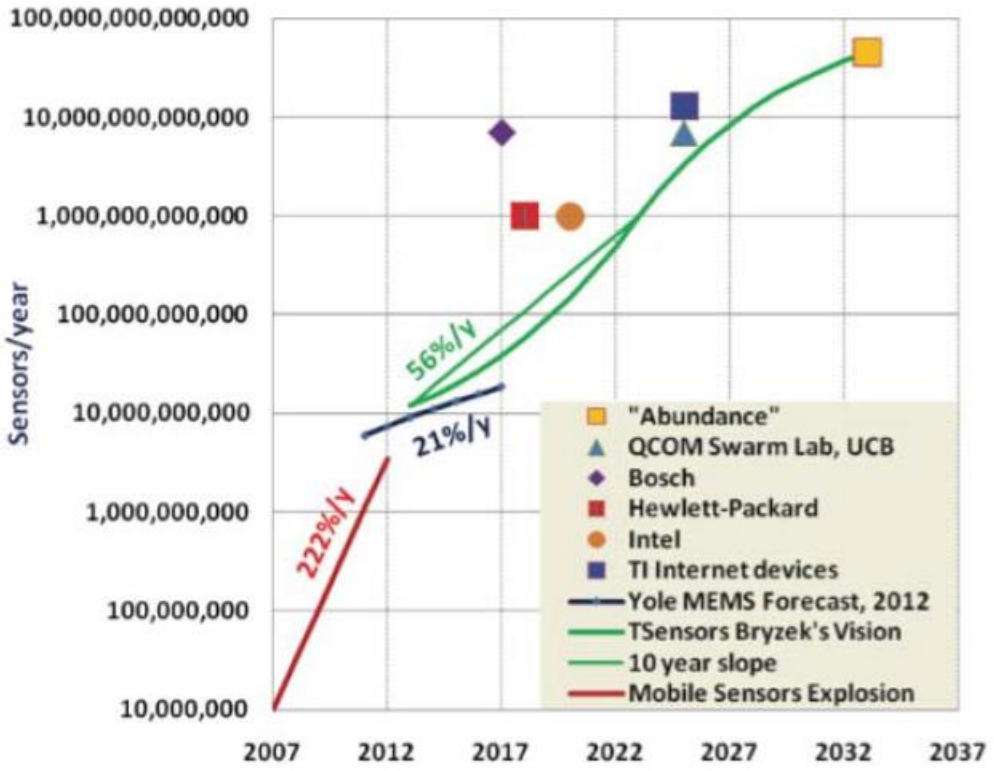
...in a new connected device era

Connected Device Forecast



Source: softbank, based on data by Ericsson
Bandwidth source: cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html

Sensors will populate the world of the IoE



Source: itrs

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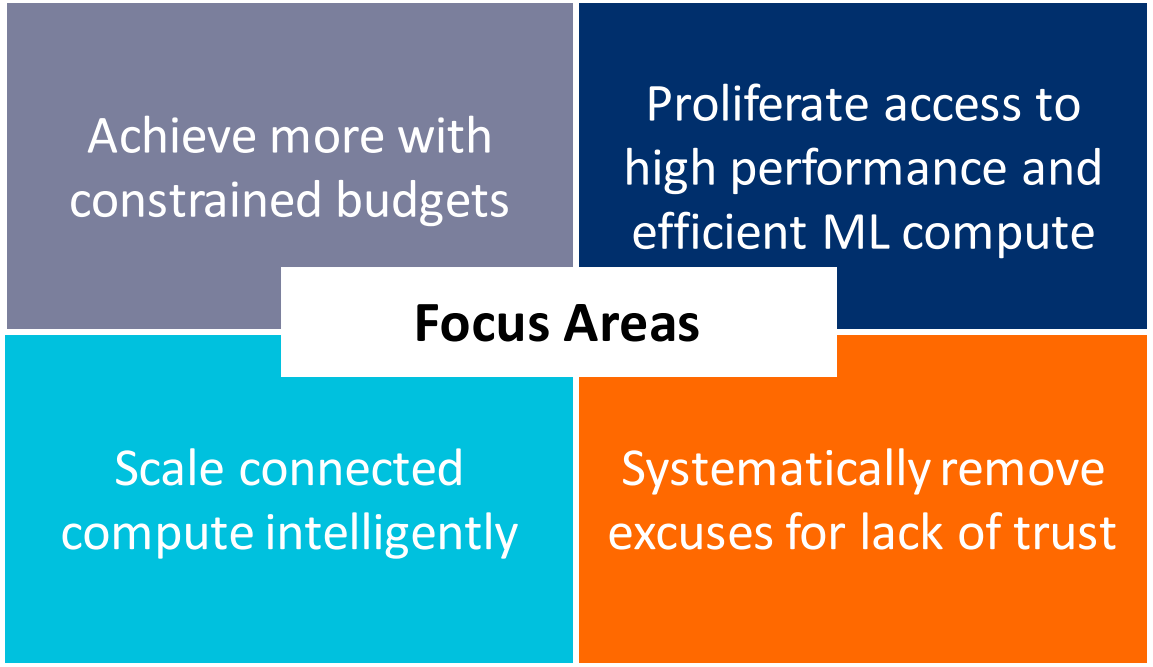
Research Group Charter

Our research focus is defined by these significant challenges

- Demand for increased performance and functionality continue in spite of limited future process scaling
- High growth of connected devices will not be possible without intelligent approaches to scaling connected compute
- Machine learning workloads must migrate to constrained devices at the edge
- Growth of diverse connected systems pose significant security challenges



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Research Programs: Compute wherever it happens

Architecture

Matt Horsnell

- Next Generation Architectures
- Specialization
- Security, Safety and Reliability
- Systems and Platforms
- Efficient Computing

Emerging Technology

Gary Carpenter

- Disruptive Technology Roadmap
- Bio-Technology
- Intelligent Systems
- Novel Materials and Applications

Devices, Circuits & Systems

James Myers

- Adaptive Apps Processors
- Chip-Scale Energy Harvesting
- Ultra Efficient IoT Devices
- Printed Electronics
- Beyond CMOS
- 3D-IC

Machine Learning

Matthew Mattina

- Model Architecture for Edge
- Hardware Acceleration
- Software Optimization
- Emerging Use Cases

Large Scale Systems & Software

Eric Van Hensbergen

- High Performance Computing
- Computational Engineering
- High Performance Data Analytics
- Fog Platform

Systems and Memory

Stephan Diestelhorst

- Caches and Interconnects
- Tracking and driving memory roadmaps
- Compute Near Memory
- Non-Volatile Memories
- Memory Security

IoT Services

Kanak Agarwal

- Fog Computing
- Edge Platform
- Data Services
- Edge Services

Security

Hugo Vincent

- Separation and Isolation Mechanisms
- Trust, Identity and Provenance
- Side Channels
- Specifications and Correctness
- Crypto Performance, Emerging Ciphers

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Machine intelligence ‘wherever computing happens’

Image detection/ recognition

Big data analytics

Natural language processing

Little data analytics

Speech recognition

Gesture/emotion recognition

Decision-making

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Software optimizations for Tensorflow

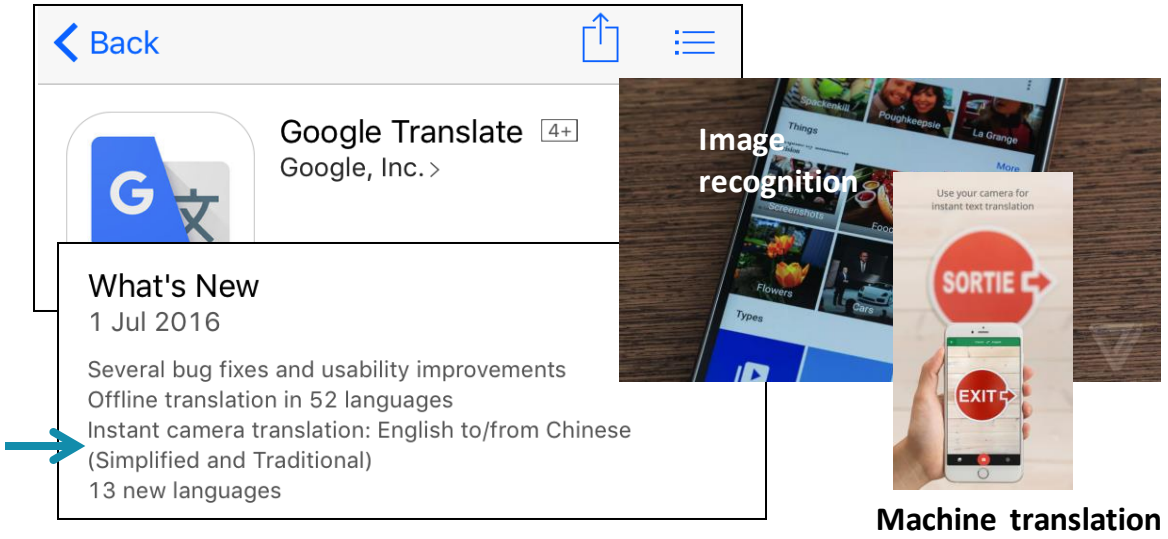
Improve ML on shipping cores

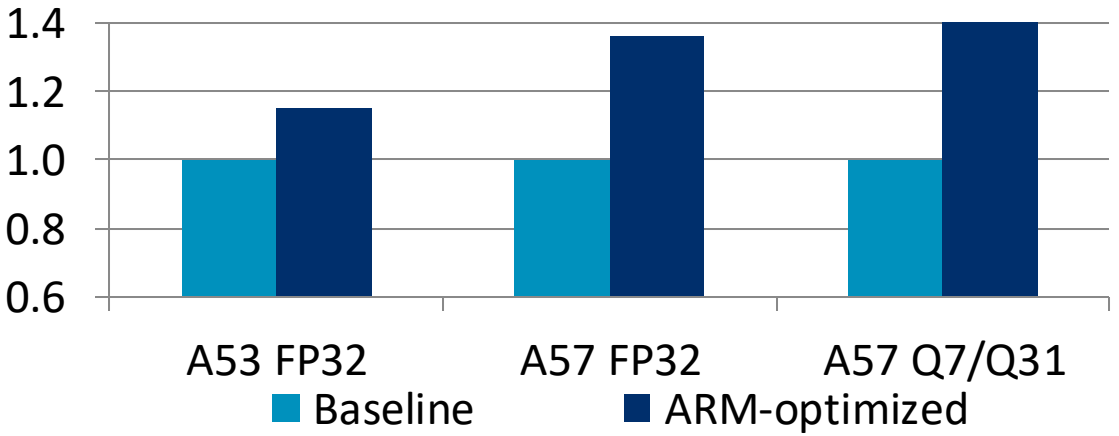
Optimized matrix-multiplication routines

- FP32
- Low-precision arithmetic

Accelerated Google Translate offline performance

Routines now open-sourced to “gemmlowp” project





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Machine Learning: Not just for big cores

Number of smartphone sensors growing

- Microphone, accelerometer, gyroscope, magnetometer, proximity sensor…
- Want to continuously monitor multiple sensors
- BUT: too much data, too expensive to continuously power apps core

Solution: use small core/DSP as a filter (e.g. Cortex-M4)

- Low power, can be always-on
- Wake up big core when we find something interesting

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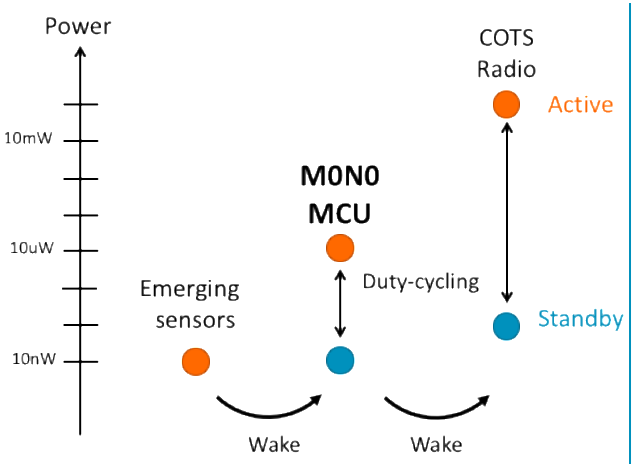
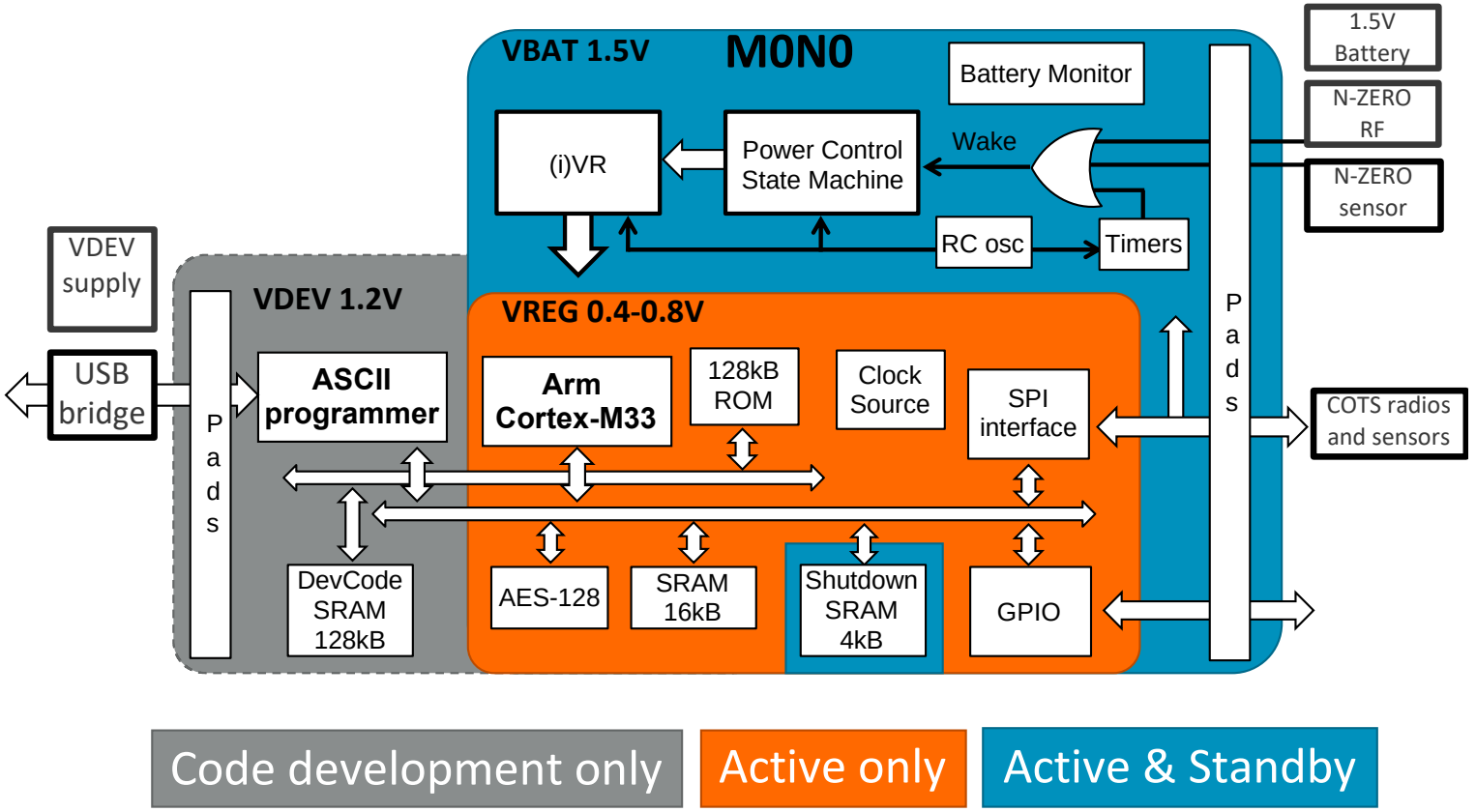
M0N0: a sub-threshold MCU for state of the art nW sensors





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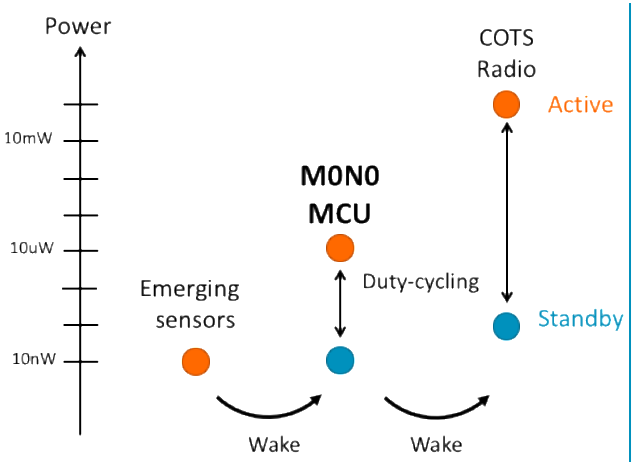

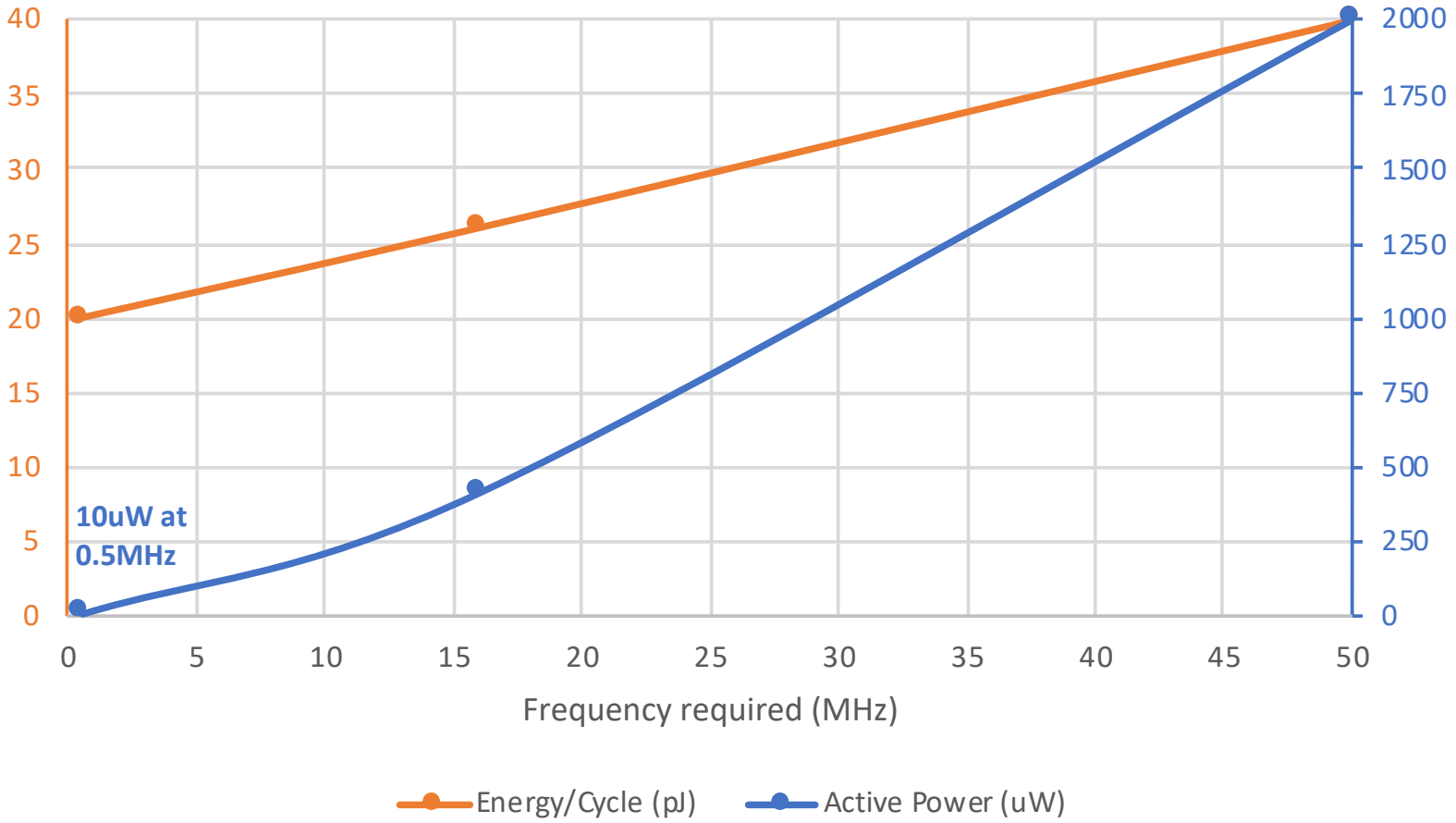

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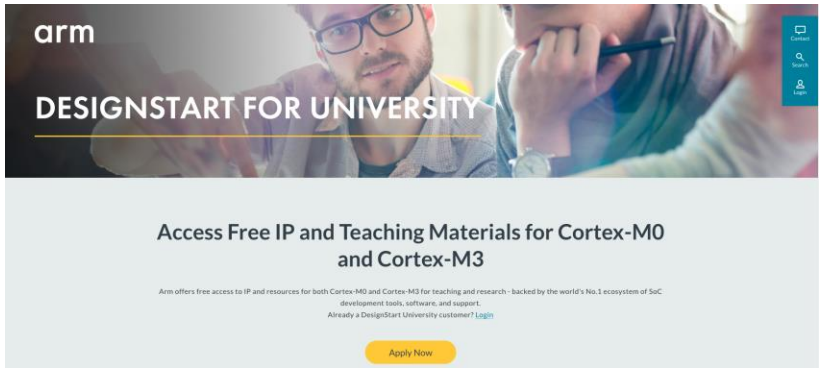
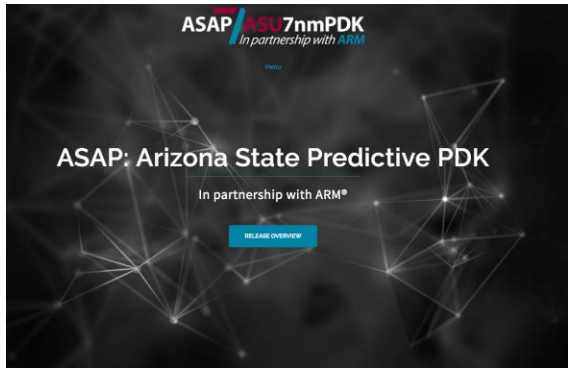
Arm IP and Academic Research: Bridging the Gap

- Arm provides “bleeding edge” logic IPs for academic research via DesignStart University
  - Logic IP offering using ASAP7 process design kit (PDK) – ASAP7 PDK was a partnership between Arm and ASU
  - Further offering of Cortex-M0 based reference design flow





- Publications
  - Embedded tutorials at ICCAD 2017 and Lithography workshop 2018
  - Research blog on ASAP7 standard cell libraries at “arm community”

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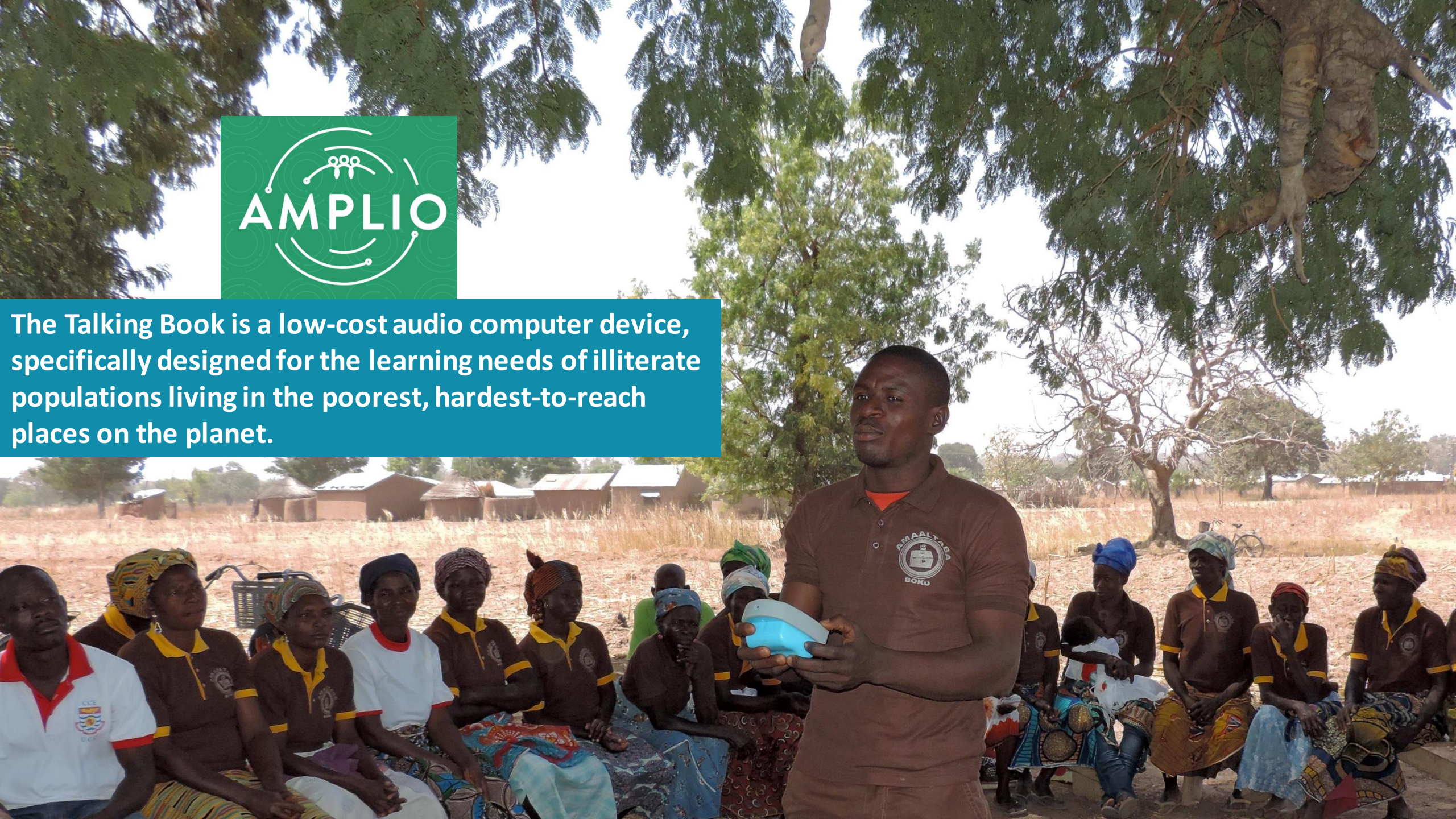
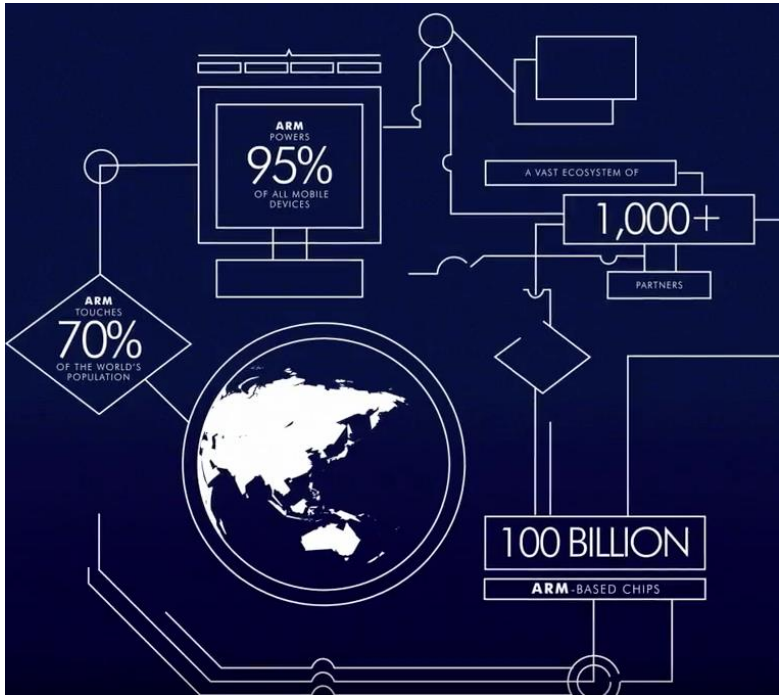

AMPLIO
The Talking Book is a low-cost audio computer device, specifically designed for the learning needs of illiterate populations living in the poorest, hardest-to-reach places on the planet.

Arm Research Collaboration and Enablement Program

For more than 25 years Arm has developed unique expertise, fueled the growth of the semiconductor industry, and has built and nurtured vibrant ecosystems around a wide range of technologies



We now have a dedicated team to bring Arm products, partnerships and expertise to the research community

Led by:
John Goodenough, Ph.D., VP Standards and Collaborations

Research Collaborations:
UK and Europe: Andrea Kells, Ph.D., Director Research Ecosystem

US: Raffaella Montelli, Ph.D., Director Research Ecosystem

Research Enablement:
Ploutarchos Galatsopoulos, Principal Product Manager

Collaboration and Enablement Operations:
Ron Bassett, Senior Manager

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Why Collaborate with Arm?

Proven IP, tools, platforms and expertise to help strengthen the impact of your research

Vibrant partner ecosystem to help you successfully develop and tape out your research products

Talent development opportunities to help your students more easily enter the semiconductor industry

Credible industry support to improve the success of your research proposals

Dedicated team to provide you with what you need to meet your research goals

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Research Collaboration and Enablement

Arm research ecosystem today:

Collaborations

Enablement

How we collaborate:

- Sponsored projects or programs
- Partnering in funding opportunities
- Through our membership in industrial affiliate programs, government sponsored or sector driven consortia
- Through IP and tools delivery and support
- Hosting you or you hosting our researchers
- Internship or sponsorship for your students

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Research Collaboration Examples

A wide range of research partners to fuel innovation and develop future talent

Partner in Funding Opportunities

European Commission

MONT-BLANC

11 H2020 active projects

- 7+ years of continuing funding
- 9 partners: Arm, BSC, ATOS (Bull), Juelich, CEA, LRZ, CNRS, GENCI and CINECA
- World's first Arm-based HPC cluster

Centres of Excellence

(4 active, 3 pending)

MANCHESTER 1824 The University of Manchester

Since 2017

- Numerous alumni at Arm (including the CEO!)
- 3 Arm and 8 UM visiting positions
- 4 iCASE and 2 non-iCASE Arm students
- 4 UK-EPSRC and 3 EU-H2020 active projects
- SpiNNaker, Exascale System prototype, Next Generation die-to-die Interface, Smart Sensors and more

Catalyst of Transatlantic Collaborations

ERI Electronics Resurgence Initiative

DARPA DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

Software Defined Hardware (SDH)

MICHIGAN

THE UNIVERSITY OF EDINBURGH

ASU Arizona State University

Partnerships in Consortia

Global Research Collaboration (since 2015)

SRC Semiconductor Research Corporation

- 190 Research tasks
- 65 US and 15 international universities
- 411 students
- 243 faculty researchers
- 22 Arm liaisons, 6 custom-funded tasks, 10 interns, 5 students hired

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Research Enablement Examples

Wide range of Arm IP available for a range of research projects

Human Brain Project

- EU funded project to develop neuromorphic chips
- 144x Arm M4F included in SpiNNaker-2 prototype chip

Euro Exa

- EU funded project to develop Exa-scale HPC
- Arm A73 based subsystem is the core building block

High Performance Spaceflight Computing

- NASA-funded project
- Bringing cutting edge processor technology to space applications
- Arm A53-based, radiation-hardened SoC

Mont Blanc

- EU funded HPC project
- 3x 3Y projects delivered 2 prototypes
- Powered by Cavium ThunderX2 Armv8 processors

Uniserver

- Universal micro-server ecosystem development
- Powered by Applied Micro Armv8

Advanced Technology Benchmarking

- Co-optimisation of advanced process nodes and state of the art designs
- Based on Arm A53

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Research Collaboration and Enablement Program

Helping you achieve your research goals

Hear more while at the Summit

Tuesday 09:45:

Accessing Arm IP for Education and Research

Tuesday 17:30:

Research Enablement: Connecting Academics to the Arm Ecosystem (Poster)

Wednesday 14:00:

Arm Research Collaboration: Fuelling Innovation

Tuesday-Wednesday One-to-One:

Garden Room (book a time slot at the RCE display table)

Contact us and share your ideas

Website: arm.com/rce

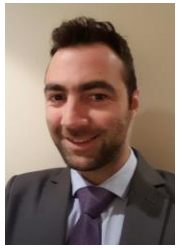
Email: rce-contact@arm.com

Webform: coming soon

Network with us

Andrea
UK/Europe Collaborations

Raffaella
US Collaborations



Plout
Enablement

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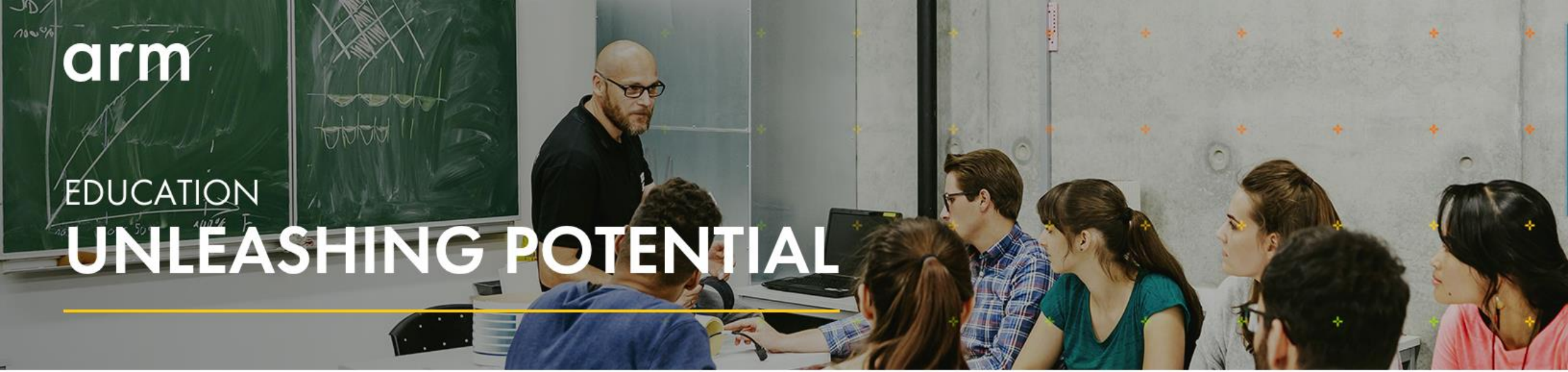

Arm Education, comprising of the Arm University Program and Arm Education Media, works with academic, education and industry partners to support technology innovation and talent development through electrical, electronic, and computer engineering and computer science.

Using the technological expertise and innovation from the Arm ecosystem and leveraging its unmatched partner network, Arm Education empowers accelerated learning through market-leading education materials and technologies that help you learn, design and build with success now and for the future.

Education Kits **Online Resources** **Textbooks**

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Arm University Program: Education Kits

The Education Kit

+ **Teaching materials from Arm**

lecture slides/notes, lab manuals and solutions, code

+ **Professional software**

From Arm and partners

+ **Training**

“train the trainer” workshops and webinars from Arm

Free to educators who adopt the kit in their curricula

Arm Education Media: Online Resources

Lecture videos

Split thematically

Lab videos

Split thematically

Interactive quizzes

Multiple choice questions and problems with answers

Multi-platform with a 4-year upgrade cycle

Always state-of-the-art, wide choice

Subscription-based. Available to all to support classroom learning and independent study.

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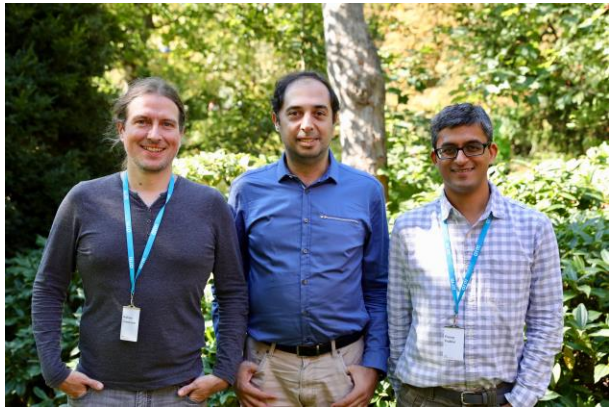
The Arm Summit 2018 PC team



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The Arm Summit 2018 PC team

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