Bringing ‘Intelligence’ to Enterprise Storage Drives

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Arm

Who am I?

- 28 years' experience in embedded
- Lead the storage solutions team
- Work closely with the industry's top storage suppliers
- Previously in wireless at Texas Instruments
- BSc in Computer Science from Portsmouth University (UK)
- I enjoy brewing beer at home!

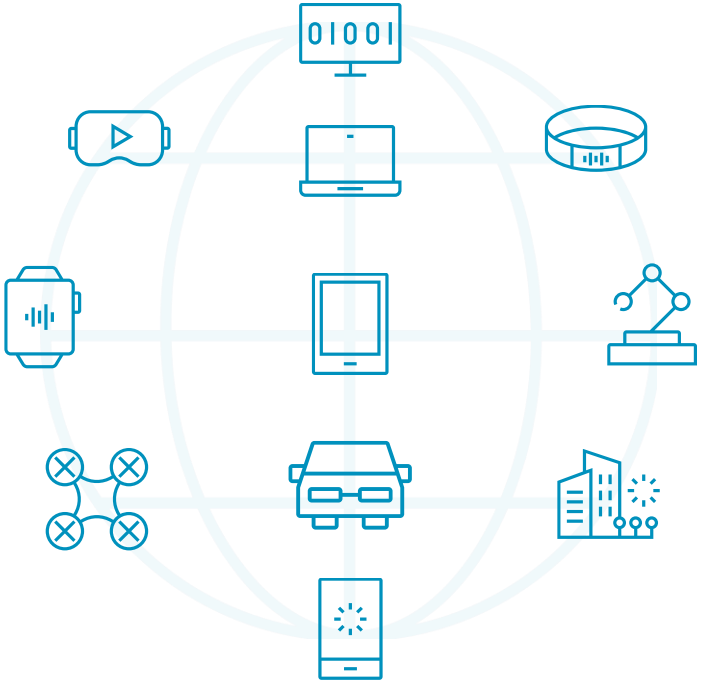
What will we cover today?

- What benefit does in-storage compute bring
- What is needed for in-storage compute
- Ecosystem support available
- Machine Learning in-storage

Arm computing is everywhere

#1
shipping processor in storage devices

21Bn
Arm-based chips shipped in 2017



> 5Bn
people using Arm-based mobile phones

120Bn
Arm-based chips to date

Flash Memory Summit

Why computation is moving to storage

Bandwidth

Power

Cost

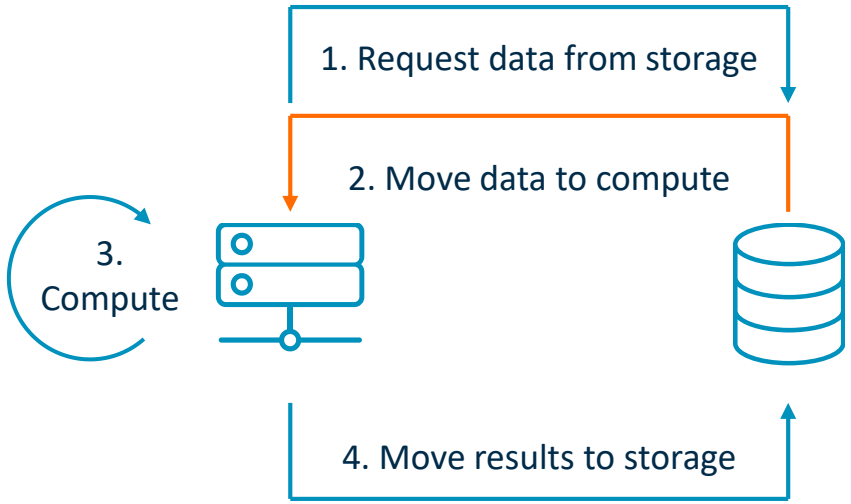
Latency

Reliability

Security

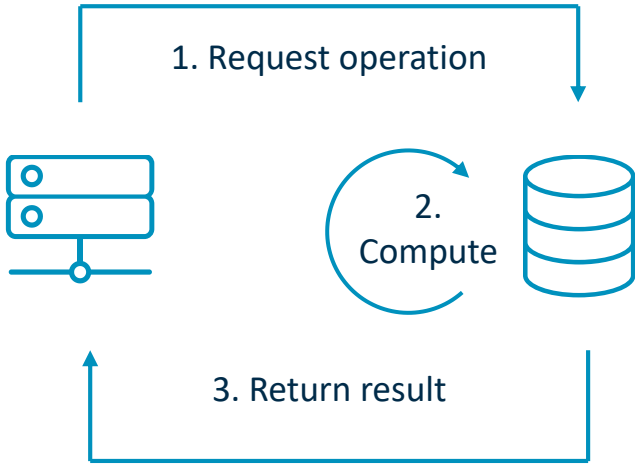
Moving data to compute

1. Compute waits for data
   - Takes time to move data across fabric
2. Adds latency
   - Multiple layers of interface and protocols
   - Data copied many times
   - Bottlenecks often exist
3. Consumes bandwidth and power
   - Moving data is expensive
   - Data copies increase system DRAM



In-storage compute

1. Compute happens on the data
   - Moved from flash to in-drive DRAM and processed
2. Lowest possible latency
   - No additional protocols – just flash to DRAM
3. Minimum bandwidth and power
   - Data remains on the drive – only results delivered
4. Data centric processing
   - Workloads specific to the computation deployed to the drive
5. Security
   - Unencrypted data does not leave the drive



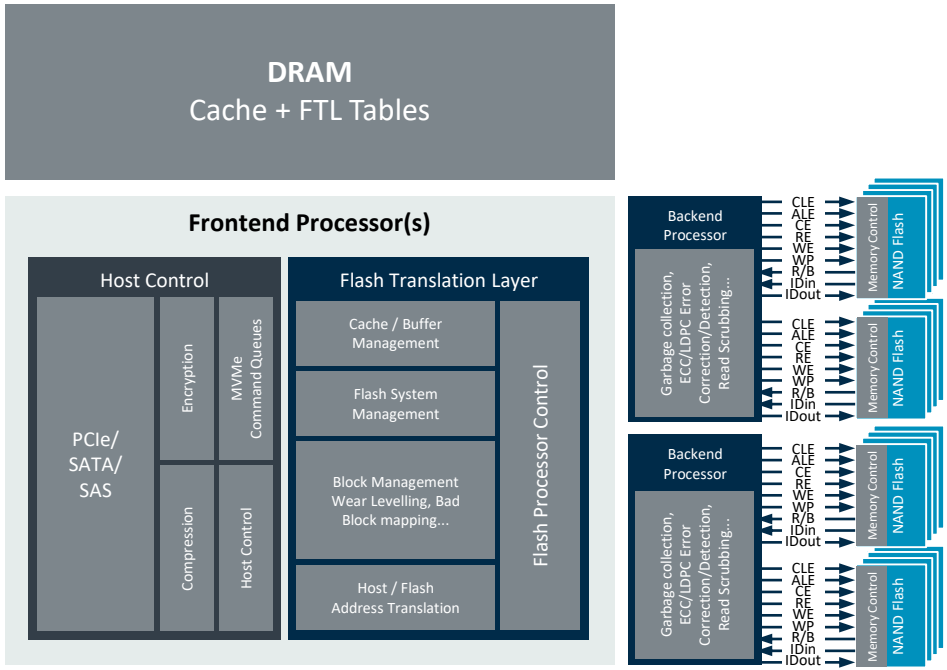
Compute in SSD controllers

Compute:

- Frontend: Host I/F + Flash Translation Layer
  - Cortex-R or Cortex-A series
- Backend: Flash management
  - Cortex-R or Cortex-M series
- Accelerators:
  - Encryption, LDPC,…
  - Arm NEON, ML, FPGA…

Memory: DRAM ~1GB for each 1TB of flash
Storage: 256GB to 64TB… flash storage
Interfaces: PCIe/SATA/SAS…

SSD SoC Functionality:



What is needed for in-storage compute?

Application processor to run a HLOS

- Runs high-level OS through a memory management unit
- Linux for Open Source software stacks
  - All major Linux distribution run on Arm
- Networking protocol stacks: Ethernet, TCP/IP, RDMA…
- Linux workloads:
  - NVMe-oF, databases, file-systems, SDS, custom applications,…
  - Containerization for workload deployment and portability

Linaro

Accelerators for specific workloads or for Machine Learning (ML)

- Potentially combined with additional accelerators: Custom hardware, ML, FPGA, GPU, DSP…

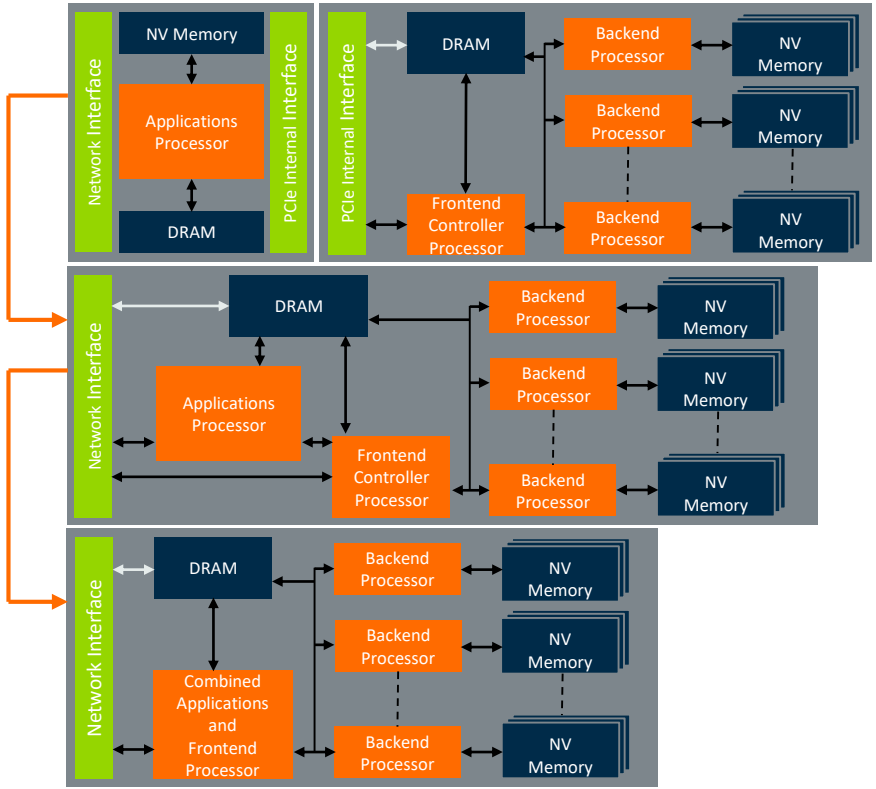
Custom workloads can be run without apps processor, but complex to develop/deploy

In-storage compute evolution

Separate Cortex-A series processor
- Enables any SSD (or HDD) to run Linux
- Wide performance range from Cortex-A5…Cortex-A76

Single SoC for cost/latency reduction
- Lower latency by removing internal (PCIe) interface
- Separation of apps processor and the SSD processing
- Shared DRAM and other SoC resources

Combined into frontend/apps processor
- Hypervisor provides SSD frontend separation from Linux
- Lowest cost and tightest integration
- Lowest possible latency
- Highest internal bandwidth



The benefits of in-storage compute

Scalability of compute

- From a single, low-power core to multiple clusters of high-performance cores

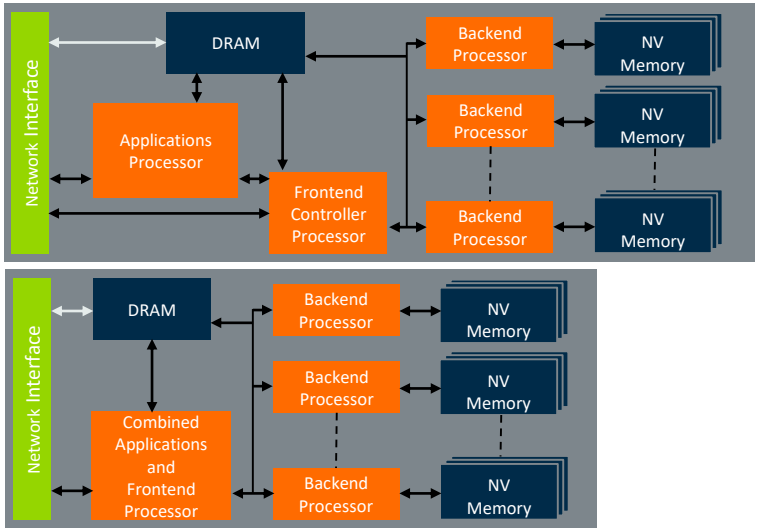
Flexibility

- One SSD SoC that is suitable for:
  - In-storage compute, Edge SSD, NVMe-oF,…

Security

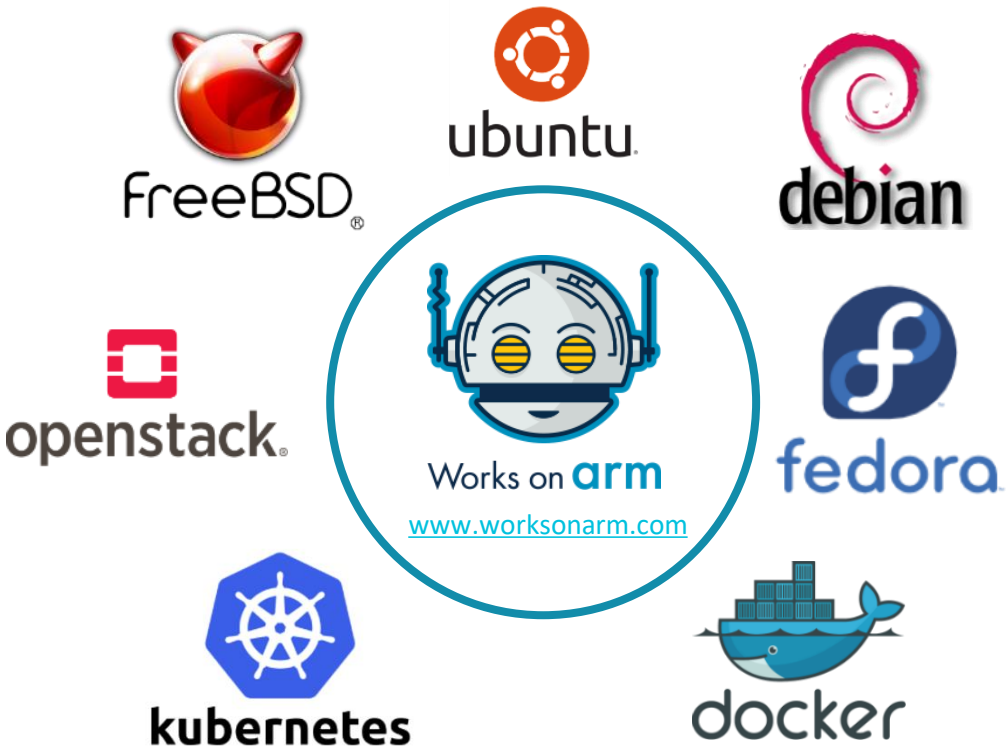
- TrustZone isolates Linux and SSD functionality
- Processing of data is all done on the drive
- Decrypted data remains on the drive

In-storage compute:



Linux ecosystem on Arm

A few ‘Works on Arm’ partners

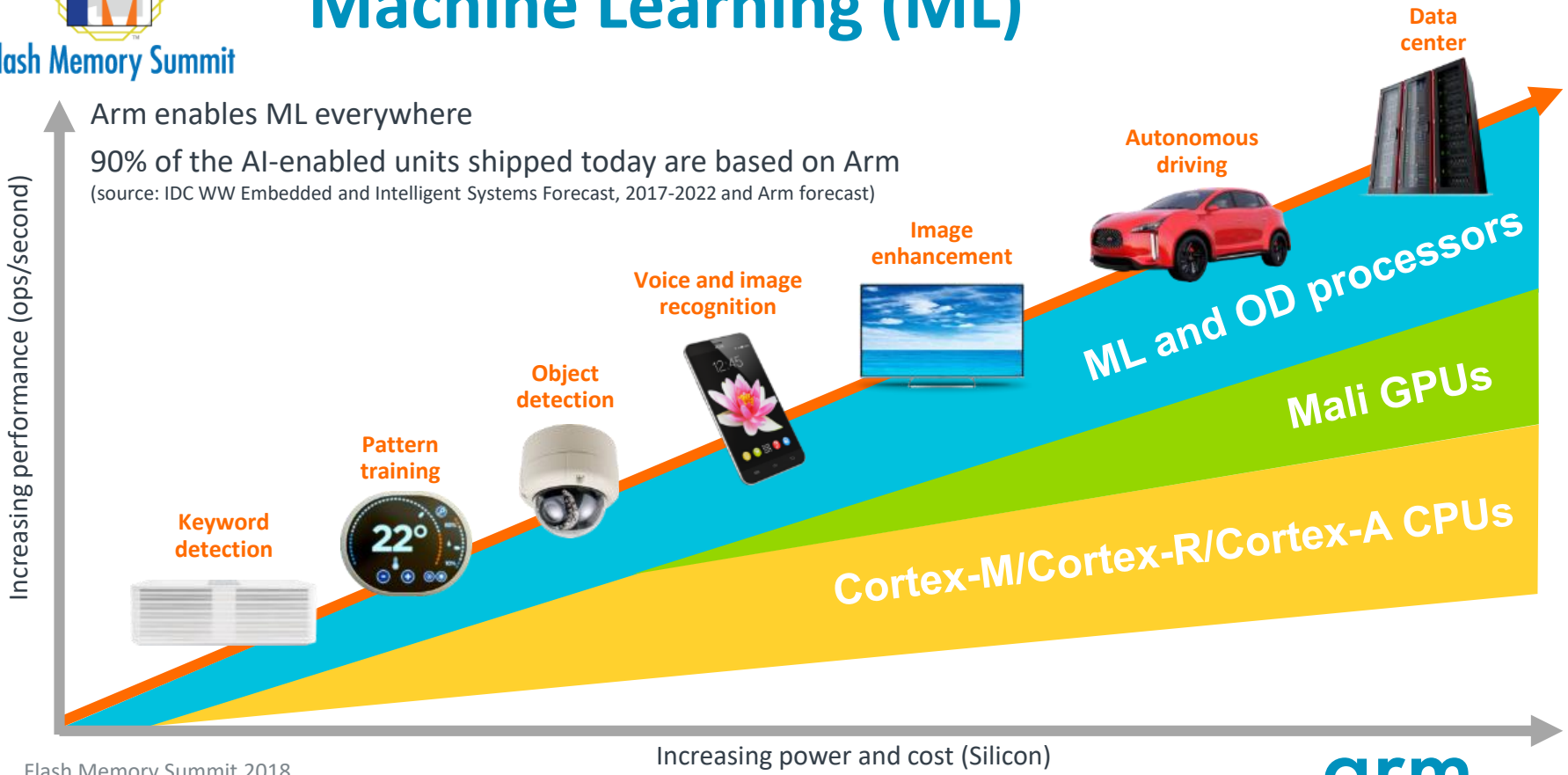


Machine Learning (ML)

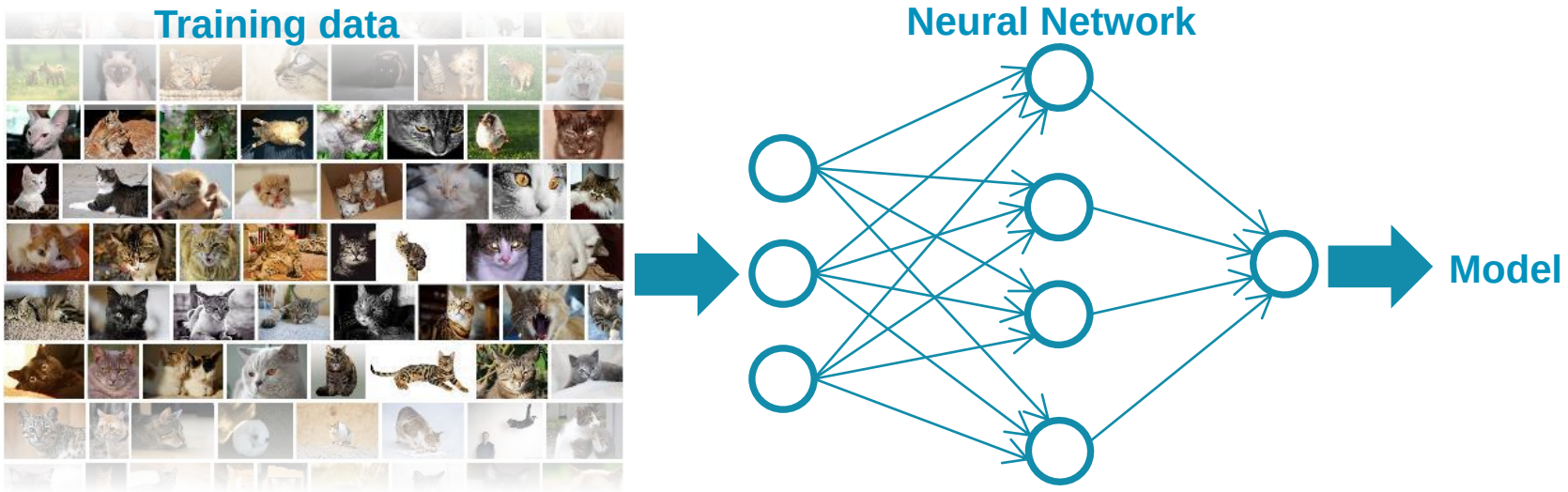
Arm enables ML everywhere

90% of the AI-enabled units shipped today are based on Arm

(source: IDC WW Embedded and Intelligent Systems Forecast, 2017-2022 and Arm forecast)

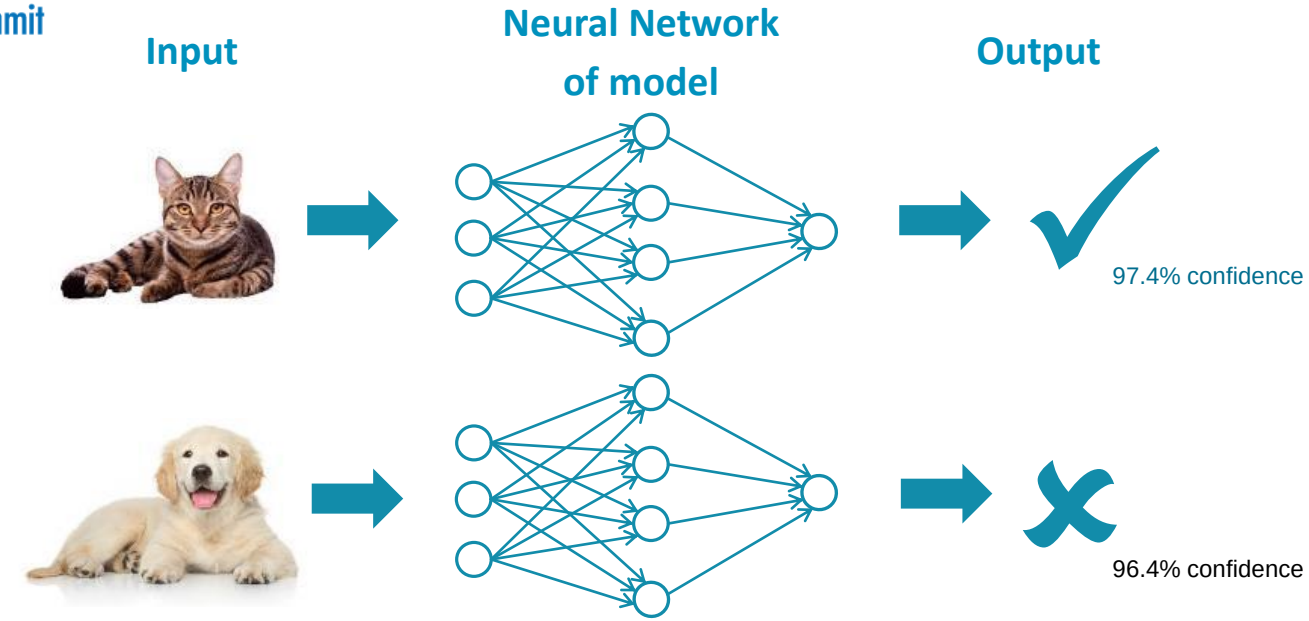


Machine Learning ‘training’



For each piece of data used to train the model, **millions of model parameters are adjusted**
The **process is repeated many times** until the model delivers satisfactory performance
In-storage compute can perform this directly on the data, without movement

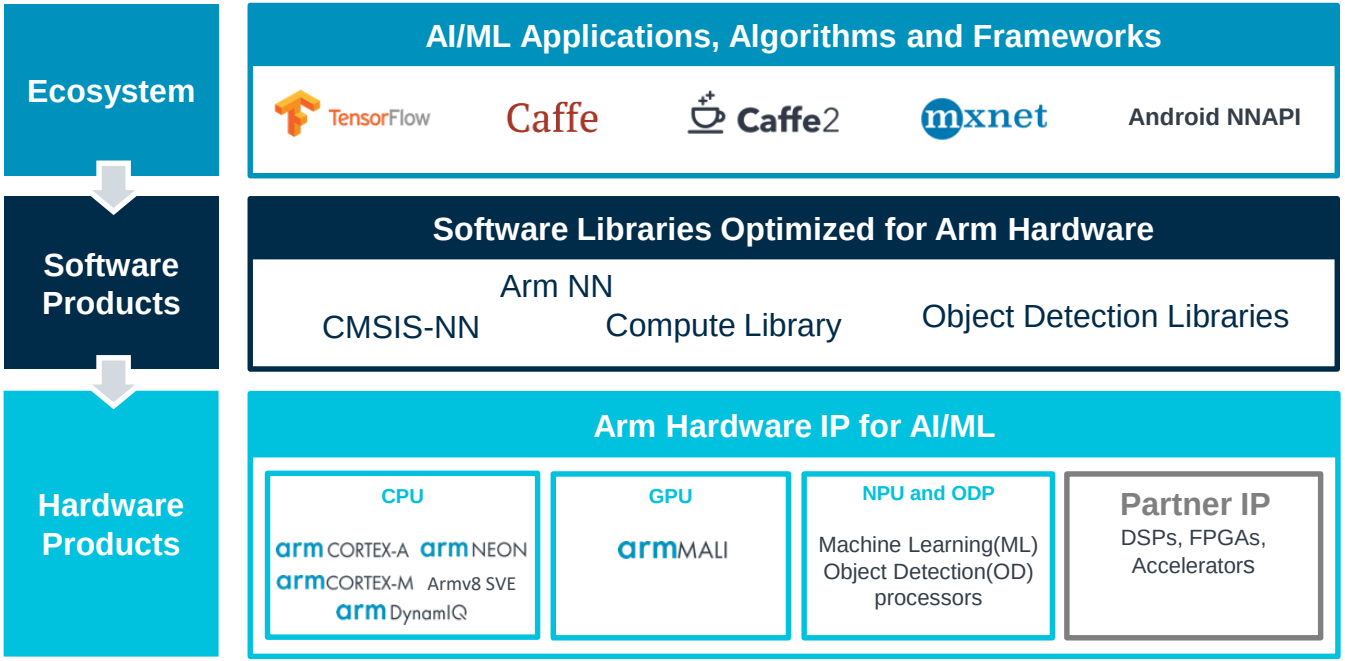
Machine Learning 'inference'



When new data is presented to the trained model, **large numbers of multiply-add operations** are performed using the new data and the model parameters. **Process is performed once In-storage compute can perform this directly on the data, returning results**

Flash Memory Summit

Project Trillium: Arm's ML computing platform



Arm Compute Library

Enable faster deployment of ML

- **Any Arm processor with NEON** and GPU (OpenCL)
- Significant performance uplift compared to OSS alternatives (up to 15x)

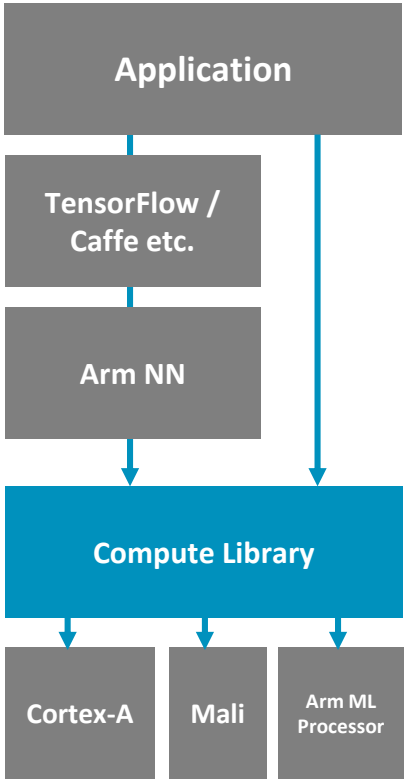
Optimized low-level functions for Arm

- Most popular ML and CV functions
- Supports common ML frameworks
- Over 80 functions in all
- Quarterly releases
- CMSIS-NN separately targets Cortex-M

Publicly available now (no fee, MIT license)

developer.arm.com/technologies/compute-library

Key Function Categories
Neural network
Convolutions
Colour manipulation
Feature detection
Basic arithmetic
GEMM
Pyramids
Filters
Image reshaping
Mathematical functions



Bringing Intelligence to SDD

Enterprise SSD already has considerable compute performance

- Cortex-A series already adopted by some Arm partners

In-storage compute delivers with low-cost, low-power and lowest-latency

Machine Learning use cases growing rapidly

In-storage compute and Edge SSD opens up many possibilities

- Please download this presentation
- COMP-301-1: “Bringing Intelligence to Enterprise Storage Drives”
- If you missed my first talk on Tuesday please download the presentation
- ARCH-102-1: “Transforming an SSD into a Cost-Effective Edge Server”

To learn more…

I'll be here all week!

For more information, visit **storage.arm.com.**

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Thank You!
Danke!
Merci!
谢谢!
ありがとう!
Gracias!
Kiitos!
감사합니다
धन्यवाद

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