PULP PLATFORM
Open Source Hardware, the way it should be!

Bitcraze Workshop: GAP8 Architecture Overview

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Greenwaves Technologies

Company Foundation Grenoble France

Start Developing Gap8

Launch First Product Gap8

Started Shipping Gap8 HDKs

November 2014

May 2016

February 2018
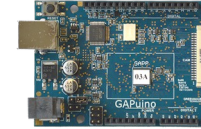
May 2018

April 2021

June 2020

December 2019

November 2019

June 2019

Open Office in Bologna

51 Employees and Growing...

Gap8 on AI Deck

Gap9 Launch

Open Office in Shanghai

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GAP8: a RISC-V IoT Application Processor
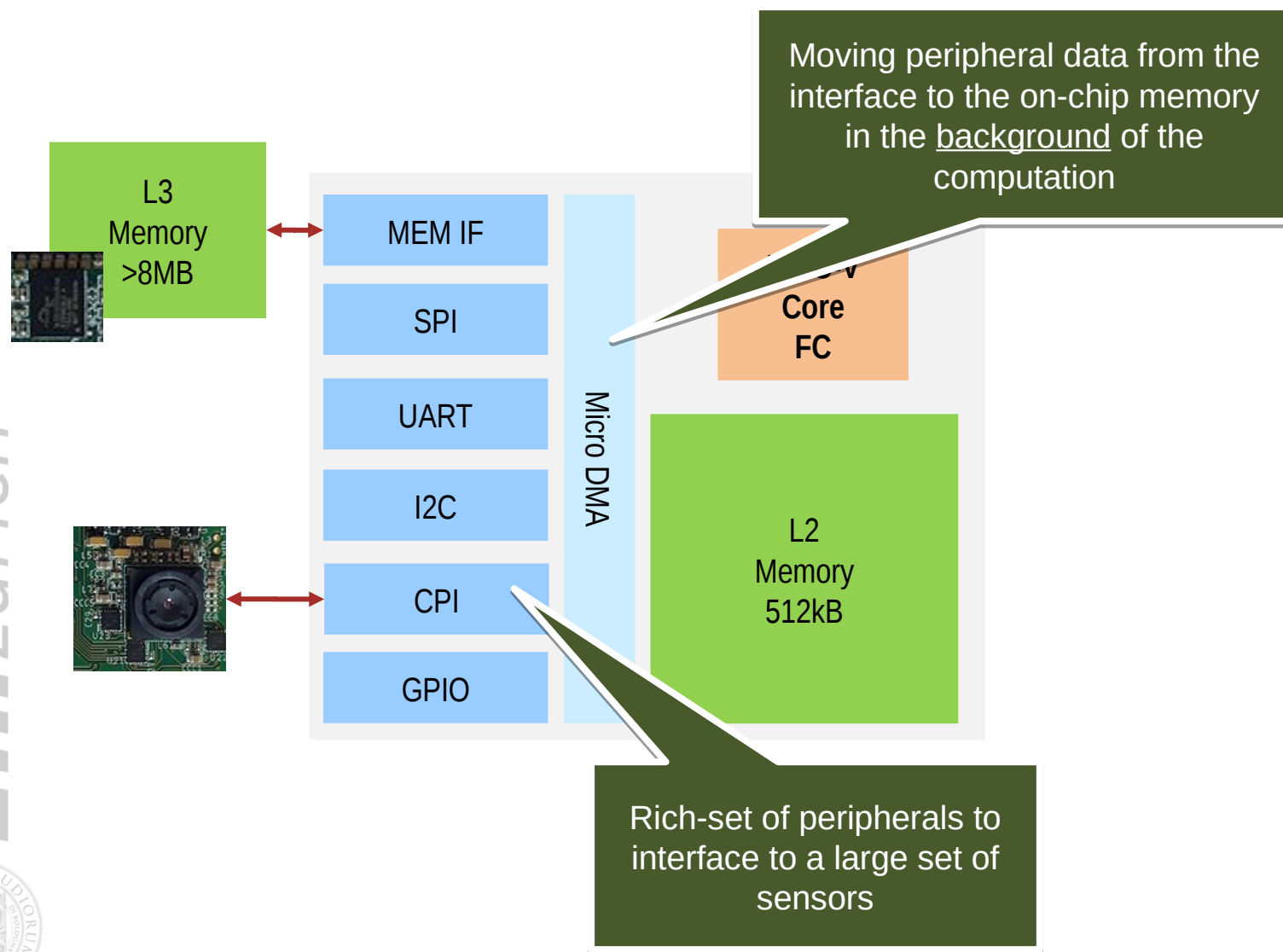
MEM IF

SPI

UART

I2C

CPI

GPIO

Micro DMA

RISC-V Core FC

L2 Memory 512kB
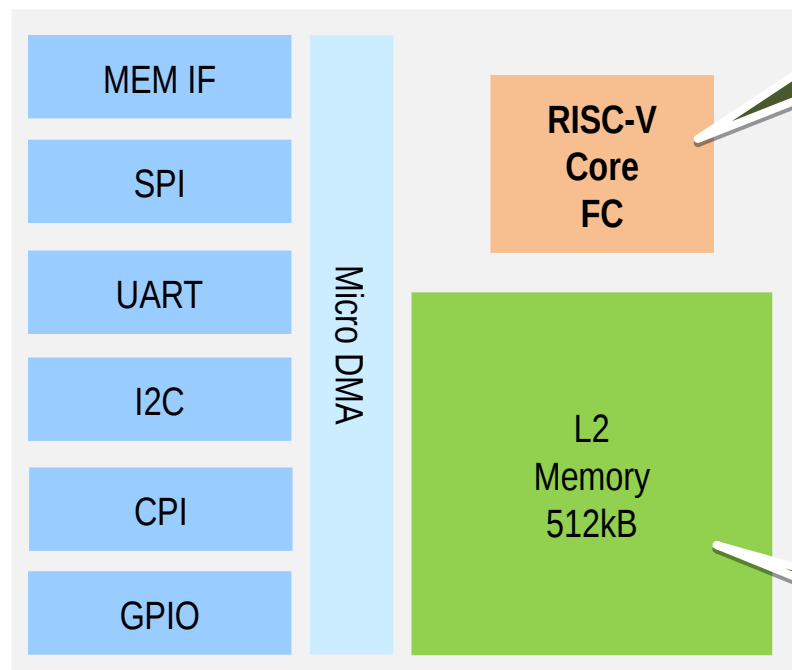
RISC-V Instruction Set optimized for **Digital Signal Processing** computation

On-Chip Memory for data storage

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GAP8: a RISC-V IoT Application Processor

Moving peripheral data from the interface to the on-chip memory in the background of the computation

L3 Memory >8MB

MEM IF

SPI

UART

I2C

CPI

GPIO

Micro DMA

Core FC

L2 Memory 512kB

Rich-set of peripherals to interface to a large set of sensors

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GAP8: a RISC-V IoT Application Processor

Efficiently copying data from L2 memory to L1 memory

Octa Core Cluster

L3 Memory >8MB

MEM IF

SPI

UART

I2C

CPI

GPIO

Micro DMA

RISC-V Core FC

L2 Memory 512kB

DMA

L1 Cluster TCDM Memory (64kB)

Core 0

Core 1

Core 2

Core 5

Core 6

Core 7

Parallel Processing for compute-intensive tasks on sensor data

Tightly-coupled On-chip memory with low-latency access

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Enabling AI on the Edge

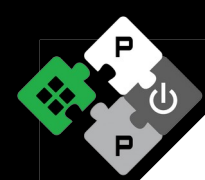- **Parallel Processing**
  - ○ **Up to 9x faster than traditional single-core MCUs**
  - ○ **Targeting highly-parallelizable AI workloads**

- **Flexibility**
  - ○ **General Purpose RISC-V Cores programmable via SW**

- **Energy-efficiency**
  - ○ **Optimized for low-power: ~100mW at 200MHz clock frequency**

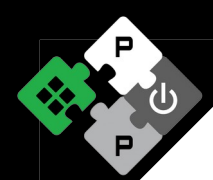# Data Analytics at the edge with GAP8

Sensor Input
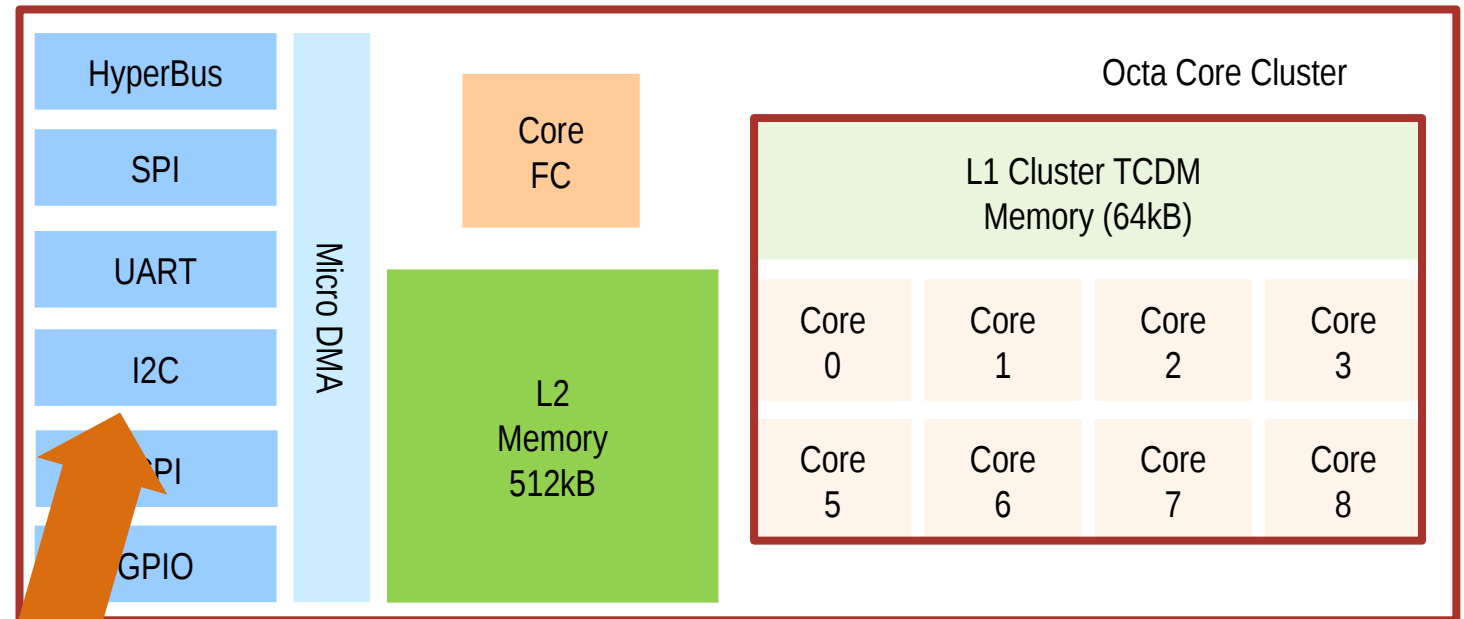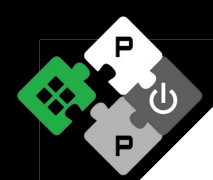

Digital Signal Processing

$$f(x)$$

Output

CAT

How to deploy it on a GAP8-based system?

A Low-Power Intelligent System

1) Get your GAP8-based system (e.g. AIdeck)

| HyperBus |
| SPI |
| UART |
| I2C |
| SPI |
| GPIO |

Micro DMA

Core FC

L2 Memory 512kB

Octa Core Cluster

L1 Cluster TCDM Memory (64kB)

| Core 0 | Core 1 | Core 2 | Core 3 |
| Core 5 | Core 6 | Core 7 | Core 8 |

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A Low-Power Intelligent System

1) Get your GAP8-based system (e.g. AIdeck)

2) Data Acquisition

HyperBus

SPI

UART

I2C

SPI

GPIO

Micro DMA

Core FC

L2

Octa Core Cluster

L1 Cluster TCDM Memory (64kB)

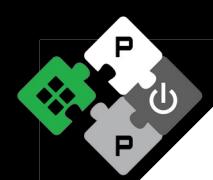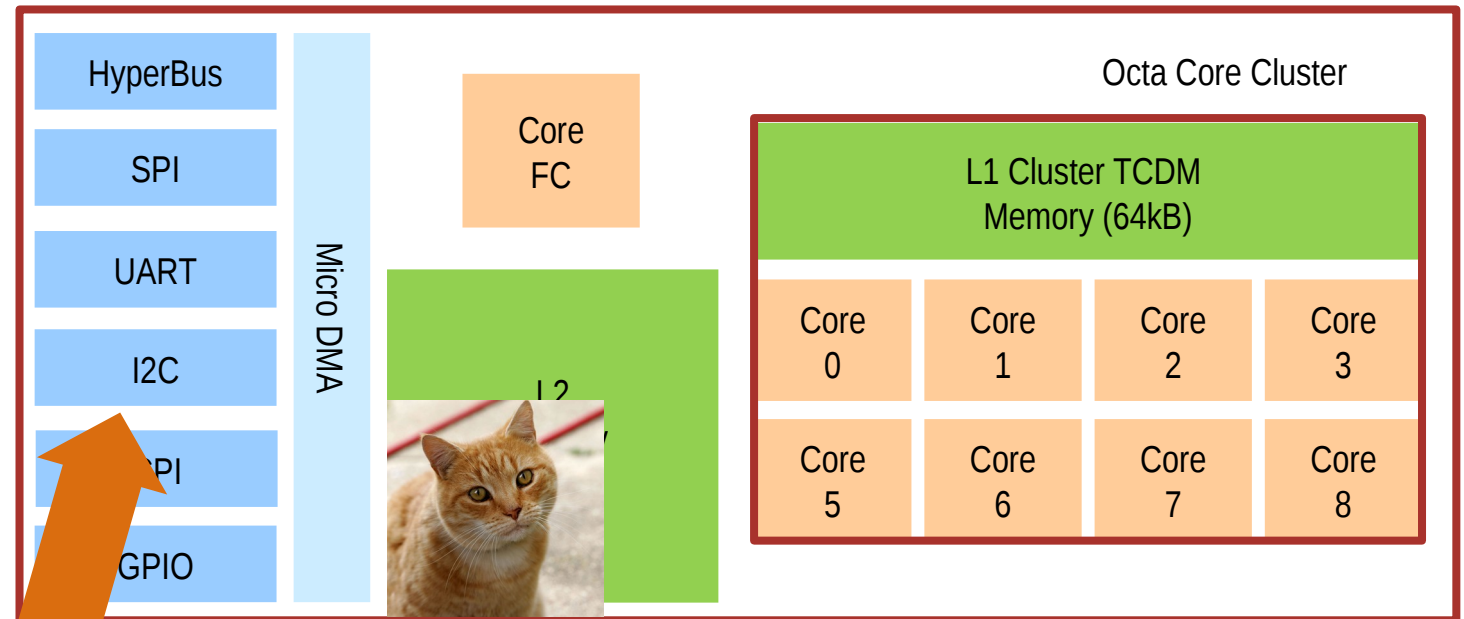| Core 0	Core 1	Core 2	Core 3
Core 5	Core 6	Core 7	Core 8

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A Low-Power Intelligent System

1) Get your GAP8-based system (e.g. AIdeck)
2) Data Acquisition
3) Turn the cluster ON

HyperBus

SPI

UART

I2C

SPI

GPIO

Micro DMA

Core FC

L2

Octa Core Cluster

L1 Cluster TCDM Memory (64kB)

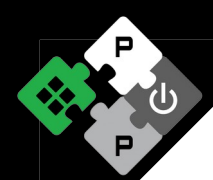| Core 0	Core 1	Core 2	Core 3
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A Low-Power Intelligent System

1) Get your GAP8-based system (e.g. AIdeck)
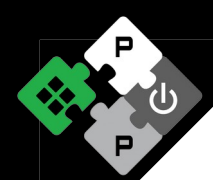
2) Data Acquisition

3) Turn the cluster ON

4) Run Digital Processing on Sensor Data

Octa Core Cluster

HyperBus		Core FC		L1 Cluster TCDM Memory (64kB)	
SPI	Micro DMA			Core 2	Core 3
UART					
I2C		L2 Memory 512kB	Core 5	Core 6	Core 7	Core 8
SPI					
GPIO					

11
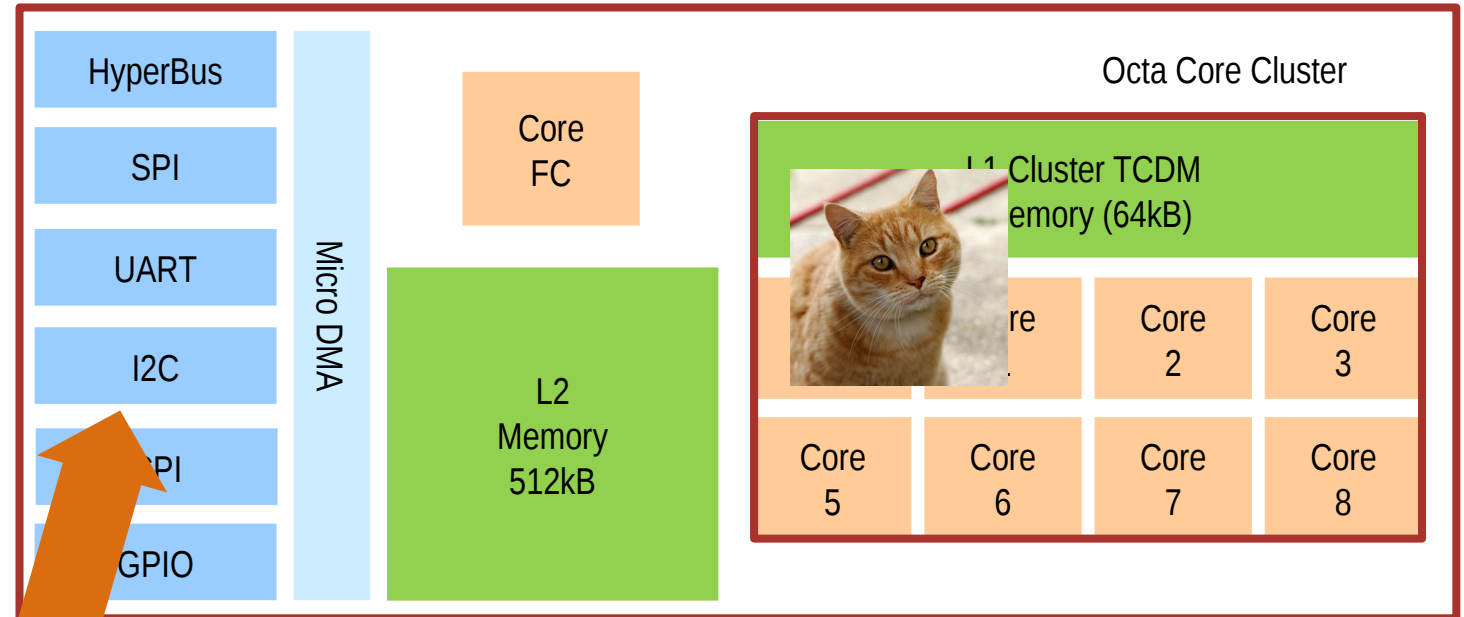
GAP8 – A complete solution for embedded machine learning at the very edge

GreenWaves-Technologies / gap_sdk

CORE-V™

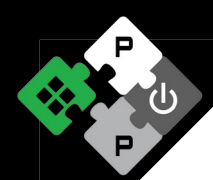| PMSIS API |
| RTOS FreeRTOS, PULPOS, Zephyr |
| SOC Simulator |
| RISC-V GCC |

| GAP AutoTiler |
| NNTool |

- RISC-V 8 + 1 core MCU
- ISA Extensions
- Fine grained parallelism
- Application Boards

- GCC Based toolchain
- PC SoC Simulator
- Variety of different RTOS's
- PMSIS API unifies API across RTOS's

- GAP*flow* toolchain for embedded ML development

ETH zürich

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GAP NN Menu

GreenWaves-Technologies / **nn_menu**

The **Neural Network Menu** is a collection of software that implements Neural Networks on Greenwaves Application Processors (GAP). This repository contains common mobile and edge NN architecture examples, NN sample applications and full flagged reference designs.

ingredients

❑ Image Classification Networks (several versions of Mobilenet V1, V2, V3 minimalistic, full V3 to come)

❑ kws (Google Keyword Spotting)

❑ Mobilenet V1 from Pytorch Model

starters

❑ Body Detection (SSD w/ custom CNN backbone)

❑ Face Detection (SSD w/ custom CNN backbone)

❑ People Spotting (NN from MIT Visual Wakeup Words)

❑ Vehicle Spotting (Customization and embedding of a deep learning pipeline for visual object spotting)

main courses

Full flagged applications (aka reference designs) running on GAPoC series boards.

❑ ReID (on GAPoC A)

❑ Occupancy Management (on GAPoC B)
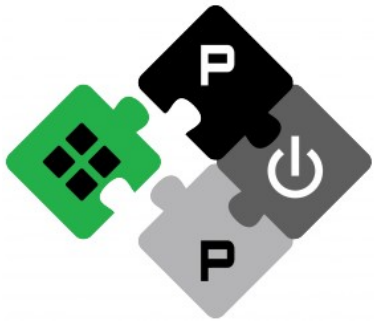
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Thanks for listening

More about **GreenWaves Technolgies**:
https://greenwaves-technologies.com/
https://github.com/GreenWaves-Technologies/