GAP8 IoT Application Processor

Intelligence at the very edge of the network

GAP8 is an IoT application processor that enables massive deployment of low-cost, battery operated intelligent devices that capture, analyse, classify and act on fusion of rich data sources such images, sounds, radar signatures and vibrations.

GAP8 is uniquely optimized to execute a large spectrum of image and audio algorithms including convolution neural network inference and signal processing with extreme energy efficiency.

GAP8 allows industrial and consumer product manufacturers to integrate signal processing, artificial intelligence and advanced classification into new classes of battery operated wireless edge devices for IoT applications including image recognition, counting people and objects, machine health monitoring, home security, speech recognition, audio enhancements, consumer robotics and smart toys.

By enabling autonomous operation GAP8 dramatically reduces deployment and operating costs of a wide range of intelligent edge devices.

Highlights

- **Enable artificial intelligence and signal processing at the very edge of the network**

- **Analyse images, sounds and vibrations inside battery operated sensors**

- **Dramatically reduce sensor installation and operating costs**

- **Eliminate data privacy concerns through local analysis**

- **Highly integrated design brings low total system cost**

- **Fully programmable, multi-core architecture keeps pace with fast changing DNN models**

Hierarchical Processor Architecture

GAP8's hierarchical, demand-driven architecture enables ultra-low-power operation by combining:

- A series of highly autonomous smart I/O peripherals for connection to cameras, microphones and other capture and control devices
- A fabric controller (FC) core for control, communications and security functions
- A compute cluster of 8 cores
- A Convolutional Neural Network accelerator (HWCE)
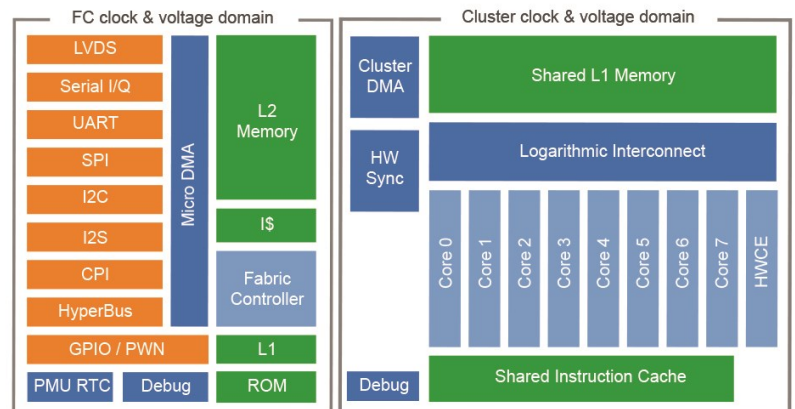
GAP8 Block Diagram

All cores and peripherals are power switchable and voltage and frequency adjustable on demand. DC/DC regulators and clock generators with ultra fast reconfiguration times are integrated. This allows GAP8 to adapt extremely quickly to the processing/energy requirements of a running application. All elements share access to a L2 memory area. The cluster cores and HWCE share access to a L1 memory area and instruction cache. Multiple DMA units allow autonomous, fast, low power transfers between memory areas in parallel with computation. A memory protection unit is included to allow secured execution of applications on the fabric controller.

All 9 cores support the same rich extension of the RISC-V Instruction Set Architecture (ISA). GreenWaves is a key contributor to the RISC-V based PULP (Parallel Ultra-Low-Power Processing Platform) open-source platform, which provides the foundation for GAP8. This gives GAP8 a solid heritage based on several generations of test chips, a vibrant community and a full tool chain to support software development for devices, which enables fast time to market for integrators.

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Applications

GAP8 has been designed to run fusion applications analysing high bandwidth data from image, audio and motion sensors and communicating over low data rate networks.

GAP8 can analyse rich data sources at the sensor with ultra-low power consumption reducing upstream data throughput requirements. This enables autonomous operation over low bandwidth networks, removing the need for expensive installation of cabling and allowing new levels of deployment of rich-data sensors. GAP8 can be used in a variety of different applications such as:

People counting	Autonomous microdrone
Road monitoring	Electricity meter reading
Consumer robotics	
Gesture recognition	Key words spotting
Pedestrian detection	Sound monitoring
Vital sign monitoring	Surveillance camera
Geophysics sensing	Machine health monitoring
Inattention detection	Smart Homes
Face detection	Audio/Voice enhancement and beamforming
Laptop activity detection	

Example Application Performance

Tiny Darknet: 0.8fps, 85mW

QVGA Face Detection: 0.4mW avg per fps (3 levels Viola Jones)

QVGA Pedestrian Detection: 3.4mW avg per fps, up to 15 fps (6 levels HOG)

Autonomous Drone Navigation: QVGA 15fps, 84mW (DroNet, derived from ResNet)

10 keyword spotting CNN: 1mW per analysis per second, no accuracy compromise (open source implementation by Google. Can support up to 7 mics with beamforming, echo cancellation and noise reduction.)

# GAP8 Features

Performance

- Up to 250 MHz (FC) 175 MHz (Cluster) internal clock
- ~8 GOPS at a few tens of mWs
- 5x5 convolution 16 bit-fixed point in one cycle
- FC delivers 200 MOPS at
  - 10mW @1.2V/250MHz
  - 4mW @1.0/150MHz
- 2µA deep sleep current
- 8 µA to retain each of the four 128kB banks of L2 memory
- 1.2 V down to 1V core VDD supply
- 1.8 V to 3.3 V for I/Os
- 0.5 ms cold boot time
- 200µs to start 10µs to stop cluster

Architecture Efficiency

- 9 identical high performance, RISC-V extended ISA based cores.
- Dynamic Voltage & Frequency Scaling
- Fabric controller (FC) core for control and communication
- Cluster of 8 cores for compute intensive tasks:
- Software controlled data streaming across memory hierarchy
- Logarithmic interconnect
- Hardware event synchronization
- Shared instruction cache
- Hardware Convolution Engine (HWCE) for Convolution Neural Network

Hardware Features

- Fabric controller core: 16 kB data and 1 kB instruction cache
- Cluster: 64 kB shared data and 4 kB shared instruction cache
- All cores support the same extended RISC-V ISA. Extended instructions include SIMD vector, DSP, bit manipulation, etc.
- Multi channel 1D/2D DMA
- Specialized multi-channel micro DMA for autonomous peripheral support
- Programmable Voltage Regulator
- Real Time Clock
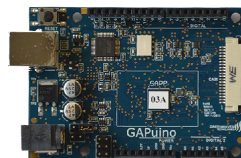
- 2 programmable clocks
- Secured execution support with Memory Protection Unit
- 512 kB State Retentive L2 Memory
- Optional external high speed low power SDRAM up to 8 MB & 64MB flash via HyperBus
- 32 kHz external quartz
- aQFN 88 package

I/O Interfaces

- Serial I/Q
- UART - Quad SPI Master + additional SPI Master
- SPI Slave
- I2S(2)
- I2C(2)
- Camera parallel interface (CPI)
- HyperBus (External Flash and RAM)
- GPIOs (up to 32)
- PWM (up to 16)
- JTAG

Tools

- C / C++ / OpenMP programmable
- Runtime and API set
- Based on GNU toolset (GCC & GDB)
- PlatformIO based cross platform IDE and debugger
- Arm® Mbed™ OS, FreeRTOS™, NuttX and CMSIS API support
- Debug support including on chip debug
- GAP8 AutoTiler code generator for optimal parallel processing
- Translation of Machine Learning networks generated for example by TensorFlow

Libraries

Parallelized, vectorized and highly optimized software components:

- Data Analysis (FFT, MFCC, etc.)
- Deep Learning (CNN/DNN based)
- Image Processing (HOG, DOG, Viola-Jones, etc.)

GAPUINO Development Board

GAPUINO is an evaluation board for the GAP8 in an ARDUINO™ UNO form factor.
It is available for purchase from our web site.

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For further information visit our web site or scan the QR code

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