WHITE PAPER

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The Embedded Systems Authority

Intel® Apollo Lake Atom™ SOC

An Examination of the Graphics Engine and Display Controller Capabilities in the Apollo Lake Family of Low-Power SOCs

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SCOPE

This document will detail the graphics and image processing capabilities present in the Apollo Lake family of low power SOCs.

OVERVIEW

Intel's Apollo Lake Atom system-on-chip (SOC) integrates the next generation of the Intel processor Core, Graphics, Memory Controller, and I/O interfaces. The graphics and image processing components of the Apollo Lake SOC are comprised of a 9th generation Intel graphics processor and display controller. The Gen9 LP graphics engine contains three groups (subslices) of eight execution units (EUs) each. The EUs are connected to the CPU cores and the System Agent using a ring topology that supports a 32 bit bi-directional data bus, with separate lines for request, snoop, and acknowledge. The ring attached System Agent provides access to the SOC's DRAM memory management unit, the display controller, and other off-chip IO controllers such as PCIe.

DISPLAY CONTROLLER

The Apollo Lake's display controller includes 3 display pipes, and supports simultaneous displays using either the MIPI DSI, HDMI, or eDP interfaces. It is capable of resolution up to and including 3840x2160 @ 60HZ, with a 24bpp color palette. It supports multiple scaling options using any of the display interfaces.

Features of Display Controller

- Support 3 Display pipes, simultaneous multi-streaming on all three display pipes (1x Internal and 2x External Displays)
- Support 2 MIPI-DSI 1.1 ports
- Support 3 DDI ports to enable eDP 1.3, DP 1.2, or HDMI 1.4b
  - Supports 1x Internal Display (eDP 1.3). DDI2 port is dedicated to eDP
  - Supports 2x External Display (DP 1.2, HDMI 1.4b). DDI0 and DDI1 can be used for external displays
- Supports HD audio on DP and HDMI
- Supports Multi Plane Overlay (MPO)
- Supports Intel® Display Power Saving Technology (DPST) 6.3, Panel Self Refresh (PSR) and Display Refresh Rate Switching Technology (DRRS)

Power Savings

The display controller supports advanced power saving technologies, including Graphics Render C-state (RC6), dynamic display frequency scaling, dynamic backlight brightness, panel self-refresh, and the ability to dynamically adjust the core display clock and the display's framerate.

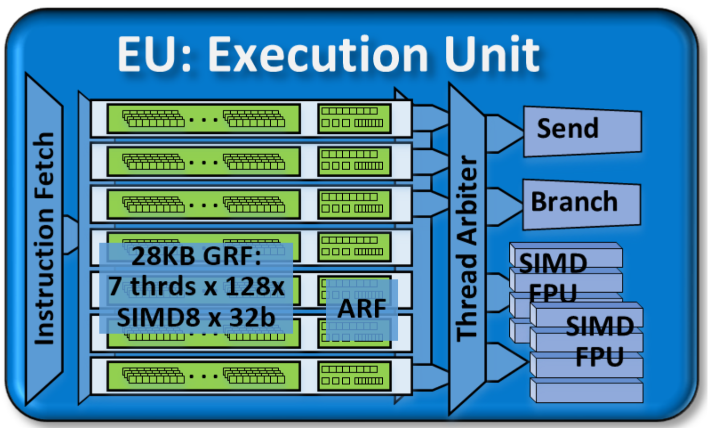
The Apollo Lake's graphics Dynamic Frequency and Power Sharing implementation provides efficient conservation of energy by varying burst frequency depending on the type of instructions being executed. It is capable of boosting power level to achieve performance gains for high intensity "dynamic" workloads using intelligent power averaging algorithms to manage power and thermal headroom.

GRAPHICS AND MEDIA ENGINE

The Apollo Lake Gen9 LP has built-in hardware decoders for many video compression standards including H.264, MPEG2, VC-1, WMV9, HEVC, VP8, VP9 and JPEG/MJPEG. Built-in hardware encoders are included for H.264, HEVC, VP8, and JPEG/MJPEG video compression standards.

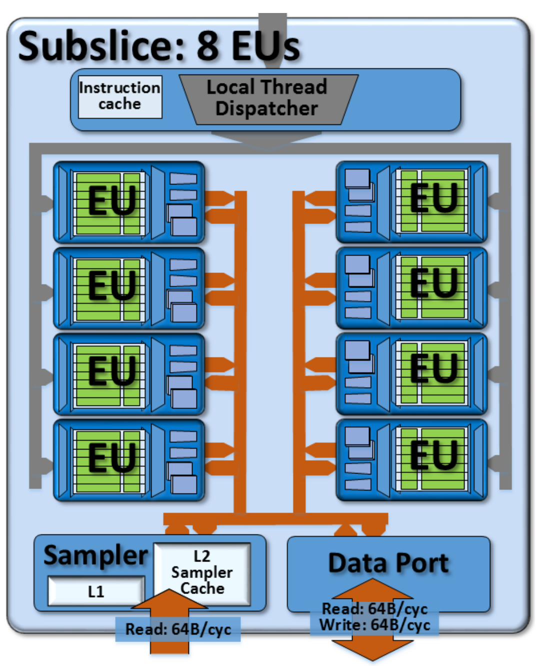
GRAPHICS ENGINE ARCHITECTURE

The foundational building block of the Gen9 LP compute architecture is the execution unit (EU). The architecture of an EU is a combination of simultaneous multi-threading (SMT) and fine-grained interleaved multi-threading (IMT). The EUs are compute processors that drive multiple issue, single instruction, multiple data arithmetic logic units (SIMD ALUs) pipelined across multiple threads for high throughput floating-point and integer compute. The fine grained nature of the EUs insures continuous streams of ready to execute instructions, while also enabling latency hiding of longer operations.



Graphic from Intel document: "The Compute Architecture of Intel® Processor Graphics Gen9."*

The grouping of EUs into subslices, with each subslice containing a locale thread dispatch unit and its own local instruction cache, allows each subslice to support 56 simultaneous threads.



Graphic from Intel document: "The Compute Architecture of Intel® Processor Graphics Gen9." Graphic does not accurately reflect the actual Apollo Lake's EU topology.*

IMAGING

The Apollo Lake's MIPI CSI2 controller and Image Signal Processor are capable of capturing concurrent streams from four (4) operating sensors (cameras). The imaging block can save streams to memory for offline processing, or can pipeline them through the Gen9 graphics engine.

Features of Graphics Engine

- Intel 9th generation (Gen 9) LP graphics and media encode/decode engine
- Three slices of 6 EUs each (3x6); each slice supports 6 threads resulting in a total of 108 available threads
- Supports 3-D rendering, media compositing, and video encoding.
- Graphics Burst enabled through energy counters.
- 4x anti-aliasing
- Supports Content protection using PAVP 2.0 and HDCP 1.4/2.0.

SOFTWARE SUPPORT

The Apollo Lake's Gen9 LP graphics engine supports the industry standard DirectX 12 and OpenGL 4.2 graphics APIs for 2D and 3D rendering of vector graphics.

In addition to the dedicated graphics APIs, the Apollo Lake SOC also supports the use of the OpenCL framework to support parallel computing using task and data-based parallelism, harnessing the power of the Apollo Lake's multicore and vector processing capabilities.

The OpenCV (computer vision) API has been ported by Intel to the Apollo Lake's Gen9 LP graphics engine. OpenCV is useful in designing applications requiring support for computer/machine vision. The OpenCV API enables the Apollo Lake SOC to be used in designs for medical imaging, digital surveillance, biometric identification, autonomous driving, and optical correction.

OpenVX is another computer vision API that can be used to accelerate Apollo Lake computer vision applications. OpenVX is targeted at real-time mobile and embedded platforms that are constrained by low power requirements – unlike OpenCV which provides a very wide scope of functions and camera APIs/interfaces, OpenVX has a tight focus on core hardware accelerated functions for mobile vision. OpenVX has lower precision requirements than OpenCL, which permits its use in low cost and low power system designs.

Support for Intel's RealSense technology allows the implementation of perceptual computing algorithms, useful in such fields as medical imaging, computer vision, digital surveillance and factory machine vision. The RealSense SDKs from Intel contain libraries and example programs that, when used with a supported RealSense camera, demonstrate facial expression recognition, hand gesture recognition, depth perception, and 3D rendering of objects.

Intel has also created the Integrated Performance Primitives (IPP) package which is a function library and collection of tools that provide low level building blocks for image processing, signal processing, and data processing (compression/decompression/cryptography). IPP functions are highly optimized for performance using Intel's Streaming SIMD Extensions (Intel SSE) and Intel's Advanced Vector Extensions (Intel AVX/AVX2). The IPP enhances OpenCV by providing functionality optimized to Intel's wide range of x86 architectures.

Applications

The Apollo Lake's graphics and image processing capabilities are useful in many industrial application areas.

Numerical Applications

The OpenCL framework allows numerically intensive applications the ability to offload complex mathematic operations onto the graphics engine and its EUs. The parallelism available in OpenCL improves the efficiency of multi-threaded applications by allowing the software designer the ability to distribute tasks across a collection of heterogeneous compute units. The collection of compute units and how they are used within the application is left up to the software developer which permits the application to customize computing resources to the specific tasks performed by the application.

Image Capture/Processing Applications

The Apollo Lake's on-die integrated processor graphics architecture offers outstanding real time 3D rendering and media performance. These image processing capabilities allow the system designer to implement complex image capture and image processing applications.

The OpenCL API allows the use of the Gen9 LP to efficiently analyze images to maximize clarity and minimize visual noise and halos. An example using OpenCL of the before and after Smart Sharpen feature in Adobe Photoshop is shown below.

Example using OpenCL of before and after Smart Sharpen filter application.

Images from Intel.

Before After

Photoshop's "Intelligent upsampling" feature can be also be accelerated using OpenCL and Intel's processor graphics to accelerate the upsampling operations while preserving details and sharpness without the introduction of visual noise.

Perceptual Computing Applications

Intel's perceptual computing mission statement is "Add human like sensing and intelligence to devices and machines". To this end, Intel has developed a suite of components that may be used to provide a device or machine the ability to better understand and interact with its environment. RealSense cameras provide 3D depth sensing capabilities, and RealSense tracking modules allows devices to comprehend position and orientation, providing the ability to navigate the world. RealSense middleware enables devices to locate, sense, identify and interact in both real and virtual worlds.

The Intel Simultaneous Localization and Mapping (SLAM) middleware library provides devices with the ability to understand position and orientation. The SLAM library has functions for 6-degrees-of-freedom tracking with real world scale, fast initialization, and no prior knowledge of the environment. Re-localization provides machines with the ability to learn an area, save/load a tracking state, and recover localization with saved data. 3D dense reconstruction uses depth data to create live 3D models and maps for use in virtual/mixed reality landscapes, and 2D dense reconstruction uses depth data to allow creation of 3D occupancy maps as inputs to robots.

The Person middleware library permits sensing, recognition and understanding of body posture, body tracking, and body gestures. Additional functionality supports person detection (locating persons within a scene) and tracking body parts movements (with understanding of pre-defined body movements such as pointing and waving). Tracking of face movements and facial expression detection (emotion detection: smile=happy, frown=sad) are additional Person library features. Body direction (front/back/side) and body posture (sitting/lying/standing) comprehension is also supported.

An Object library allows software applications to identify and locate objects within image streams. This includes a library of components that can be utilized in market-specific applications. Deep learning cloud services allow for accuracy improvement of existing objects and for collecting data to increase the number of supported objects. Using room and object localization, machines will understand what objects and rooms are and where they are within image streams. With a moving camera, object tracking allows a machine to not lose the understanding of objects of interest.

The Hands library can detect hand movement and interact with objects in virtual environments. Possible applications include user interface control and navigation. Interaction with objects in virtual reality is enabled through the 3D mesh of hands and collider-based interaction with virtual objects.

All of these perceptual computing abilities enable system designs for use in the virtual reality, robotics, and autonomous vehicle markets. Additional markets include shipping/logistics, PC peripherals, home/retail surveillance, and mobile 3D scanning.

CONCLUSION

The Apollo Lake SOC couples its multi-core CPU with the sophisticated graphics signal and image processing of the Gen9 graphics engine and a robust display controller. These features allow the Apollo Lake SOC to be designed into industrial products that are useable in a wide variety of modern applications. Rich software support is available through the implementation of open standards.

This white paper has been made available through WinSystems, Inc. and is offered as an educational resource. Please feel free to contact us if you have questions about what you have read or would like to speak with the author/s or one of our application engineers.

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