Mali-G78AE:
The Power of Arm's First Safety-Capable GPU

INTRODUCTION

As electronics and software become more a part of everyday life, the reliability and predictability of these systems also increases in importance. Arm Ltd., the developer of the Arm processor, has licensed over 160 billion processor devices for phones, tablets, TVs, and even systems in airplanes and automobiles. This paper discusses Arm and their role in meeting the challenges related to safety certification within the graphics processing market. Safety certification challenges unique to GPU architectures will be addressed along with solution "eco-systems" related to solving the certification challenges for GPUs.

ARM AND GRAPHICS PROCESSORS

Arm has enabled a plethora of companies to create low-power/low-cost solutions with a range of performance for a variety of markets for three decades now – all at the expense of traditional silicon powerhouses like Intel®, AMD, and NXP® (Power Architecture™). This "incursion" into the natural order of things continues to grow. Beyond the consumer space where product life cycles tend to be quite short, the licensing of Arm processing cores has significantly extended these life cycles and is driving strong adoption by system product developers in embedded markets, especially automotive, aerospace, and industrial automation. Many of these applications are considered safety-critical and Arm complements many of its products with supporting safety packages to accelerate designs. Arm's CPU cores are showing up in SoCs that are being designed into new avionics and automotive systems, like NXP's i.MX 8QM and LX2160A, both of which have data kits to support safety certification. For avionics, this is accomplished through the Multi-Core-For-Avionics (MCFA) working group, which works with NXP to define the data needed by the industry to support certification. The next step, and a first for the Mali GPU architecture, is the provision of GPU technology with support for certification.

Arm introduced its first IP-licensable GPU core, the Mali-55/110, in 2005. Since that time, Arm has released more capable and powerful versions of the Mali GPU family, often beating the performance-per-watt metrics of other market leaders. The Mali-G77—released in 2019 and based upon the Valhall architecture—is scalable from 7 to 16 cores and includes support for a variety of Application Programmer Interfaces (APIs).

For the automotive market, the Arm GPU approach targets implementations that are scalable across a wide variety of automotive applications and use cases, which has reduced both development costs and software certification costs. Arm's Mali-G78AE GPU Valhall architecture was specifically developed to enable General Purpose GPU (GPGPU) processing that can be used with safety-critical APIs like Vulkan® SC, which supports efficient use of the shader cores (up to 24). On-chip support of Machine Learning (ML) algorithms with a Fused Multiply-Add (FMA) unit are particularly beneficial to today's autonomous platform applications.

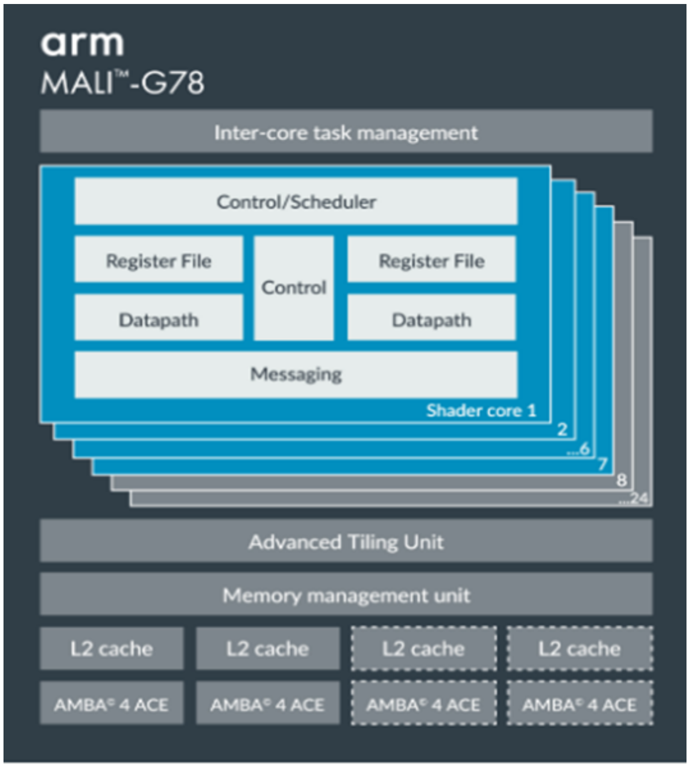

Figure 1: Arm Mali-G78AE

Arm Mali is the industry's number one shipping graphics intellectual property (IP), with a total of one billion units shipped in 2019. Arm's continued success with GPUs, in a marketplace dominated by big players like AMD and Intel, will be determined by Arm's unique combination of licensable IP, efficient/low-cost operations, and consideration of the need for safety certification in various industries.

SAFETY CERTIFICATION

While it is rare to find silicon developed with safety certification in mind (that is, beyond the custom silicon such as FPGA-based implementations and ASICs developed to DO-254 guidelines), the growing trend toward functional safety is causing change. Arm is an active participant in this change, with CPUs developed with functional safety from the outset, to the industry's first GPU developed for functional safety, the Mali-G78AE is developed to ISO 26262 ASIL B/D. This does not limit the CPU and GPU usage to automotive. Rather, this level of design assurance and support from Arm bridges into other functional safety areas such as IEC 61508, EN 50128, as well as avionics A(M)C 20-152A (which calls up DO-254 with guidance). Arm's partner, Core Avionics & Industrial (CoreAVI), provides support such as Failure Mode and Effects Analysis (FMEA) and failure detection solutions, to silicon integrators and system integrators who are targeting certification. See CoreAVI's white paper on Meeting Diagnostic Coverage Requirements with the Mali-G78AE GPU, which also covers a method to detect failures that may lead to hazardously misleading information on the display.

Certification is more than process; the architecture must support the system level and safety requirements to be useful. The Mali-G78AE includes flexible partitioning capability to safely enable mixed-criticality applications to use the GPU resources. See CoreAVI's white paper on Innovative Mixed-Criticality with Mali-G78AE for further details.

GPUs are executing mission-critical software that must meet rigorous safety criticality standards to provide safe graphics, artificial intelligence, image processing, etc. GPUs have challenges that are typically not applicable to CPUs when it comes to certifying the software that run on them. This is described in some detail in the CoreAVI white paper Safety Certification of Compiler Generated Object Code. While this software is compiled offline, it is loaded and run through a driver that also must be certified along with the application.

Arm partner Core Avionics & Industrials Inc. (CoreAVI – Tampa, FL) produces safety-critical software libraries and drivers conformant to the highest Design Assurance Levels (Level A for DO-178C) and Automotive Safety Integrity Level (ASIL D for ISO 26262). In its products, CoreAVI supports the open standards created by the Khronos Group, which strengthens both near term portability and extended life cycle support. CoreAVI products are tailored to the Arm Mali GPU architecture, and when combined with safety-critical Vulkan, results in products having reduced driver overhead, and a GPU API that supports both graphics shaders (vertex, fragment) and compute shaders. The coupling of CoreAVI products with the Arm Mali GPU and partner Human Machine Interface (HMI) tool vendors avoids certification pitfalls, accelerates development, and enables application portability.

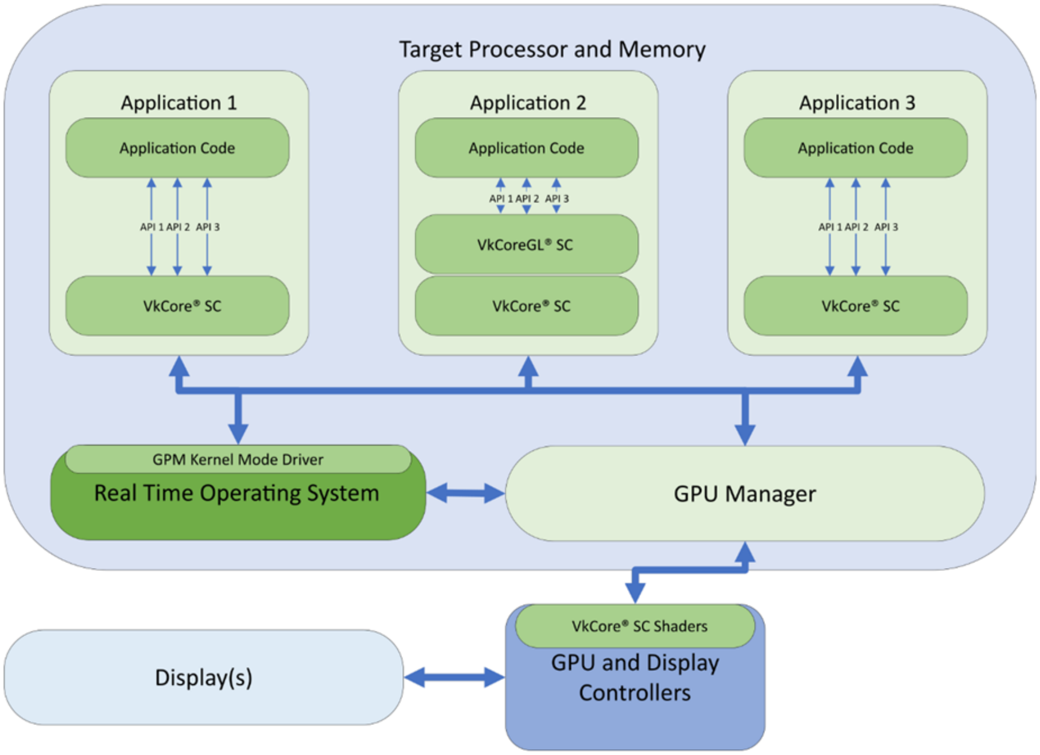

Figure 2: Example Vulkan Use Case

CoreAVI's most recent product line complies with the proposed Vulkan SC standard (based on Vulkan 1.1) with support for the legacy embedded OpenGL® standards (OpenGL SC 1.0.1 and OpenGL SC 2.0). These products address synchronization and blocking, concurrent CPU/GPU computation methods, cross-task memory isolation and protection, etc. CoreAVI also offers a GPU health monitoring system called TrueCore™ that monitors the health and integrity of a GPU, which aids in the prevention of rendering hazardous or misleading information. Compute libraries are also supported for Basic Linear Algebra Subprograms (BLAS), Fast Fourier Transforms (FFT), vision processing, Neural Nets (Artificial Intelligence), and more. Further information can be found in CoreAVI's VkCore® Functional Safety Suite for Arm Mali-G78AE GPU product brief.

SUMMARY

The use of Arm SoCs in safety-critical applications presents both opportunity and risk. The incorporation of AI and ML algorithms onto low-power/low-cost Arm-based SoCs is an attractive solution, but the risks of creating a product that can also meet the stringent requirements of the safety community and government regulatory groups is also a huge challenge. Combining a safety-critical Arm CPU with a safety-critical Mali-G78AE GPU, along with libraries and drivers from a company like CoreAVI can most assuredly meet both performance and safety certification requirements across multiple markets and application areas. For more information on Arm Mali-G78AE, please click here.

For more information on CoreAVI's VkCore Functional Safety Suite, please contact sales@coreavi.com.

AUTHOR

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Mike's role as Director Strategic Accounts & Solutions Architect at CoreAVI allows him to bring together the rapidly evolving world of "open" software infrastructures with the safety-critical requirements of both manned, pilot assisted, and autonomous platforms. Mike has over 40 years of experience in Defense and Aerospace markets. Previously, as an engineering fellow with Honeywell, Mike developed cockpit architectures and systems for a variety of airborne defense platforms like the F-15, F-16, F/A-18, C-130, OH-58D, CH-47, and the V-22. Mike's focus on all of these platforms was in using open system architectures for high reliability/mission critical roles in rugged military environments.

Mike is based in Albuquerque, New Mexico, has a BSEE from Brigham Young University, and holds two patents in the area of sensor processing