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Artificial Intelligence Application, Edge And eFPGA

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Artificial Intelligence (AI) applications differ significantly from regular applications in computational, operational, and memory requirements. This change necessitates specialized Systems on Chip (SoCs) designed to meet the unique AI application requirements.

While traditional applications might rely on general-purpose processing units for a wide range of tasks, on the other side, AI applications - such as machine learning, deep learning, and neural network processing - need intensive computational power for jobs like pattern recognition, data analysis, predictive modeling, text-to-data generation, and many more. These tasks involve complex mathematical computations, including matrix multiplications and tensor operations, which are resource-intensive and time-sensitive.

It is where specialized AI SoCs are needed to handle AI-specific operations. Examples of such SoC architectures are Graphics Processing Units (GPUs), Tensor Processing Units (TPUs), and other custom cores that significantly speed up AI computations.

However, as development has moved forward, the semiconductor industry is realizing that the processing of AI applications will not only occur at the AI Centers (data centers designed with AI SoCs) but also at the edge - AI Edge. It means that users requesting processing capabilities from the AI applications will run tasks on the devices they are using or, at the maximum, will offload the job to the nearest mini AI centers. To cater to the use case, AI SoCs will not be applicable. The main reason is the power consumption, which is very high for high-performance processing cores that AI SoCs have. On top of that, these AI SoCs are not modular and become obsolete as the requirements of the AI applications change, which is happening at a breathtaking speed.

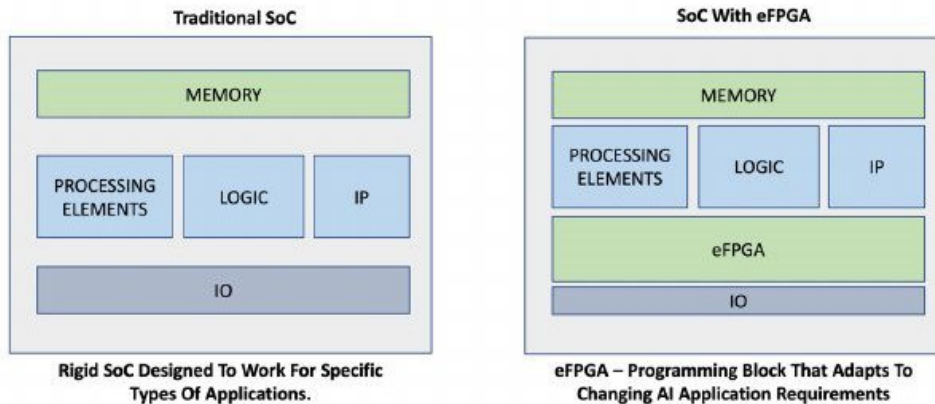
To balance this and to cater to the AI applications at the edge. The semiconductor industry is advancing the development of SoCs equipped with FPGA cores. This new genre of SoCs will be called AI SoC FPGA. Where eFPGA stands for embeddable field-programmable gate array.

What Is eFPGA And How It Integrates With AI SoC

An embedded Field Programmable Gate Array (FPGA) is a semiconductor device that can be programmed and reprogrammed post-fabrication to perform specific functions. Unlike traditional FPGAs, which are standalone devices, eFPGAs must get integrated into larger semiconductor devices like application-specific integrated circuits (ASICs) or system-on-chips (SoCs).

They consist of programmable logic blocks, also known as Configurable Logic Blocks (CLBs), which are easily configurable to create unique digital circuits. This reconfigurability is crucial, allowing for dynamic adaptation to specific application requirements and making eFPGAs highly efficient, flexible, and adaptable for various modern computing applications - mainly AI application processing.

Integrating eFPGAs into SoCs, particularly in the context of AI Edge computing, offers significant advantages. System architects can define custom block functions to get included in the eFPGA, which increases the capability of the eFPGA by adding functions optimized to decrease area and improve the performance of targeted applications.



Benefits, Hurdles, And Current Status Of eFPGA:

Benefits:

1. **Flexibility And Reconfigurability:** eFPGAs can be reprogrammed after manufacturing to update the device's functionality or add new features. This allows for in-field updates and the ability to adapt to changing standards or requirements without redesigning the hardware.
2. **Speed To Market:** By incorporating eFPGA technology, developers can iterate their designs more rapidly and adapt to changes without requiring extensive hardware modifications. It can significantly reduce development time and cost. It is also something the AI market needs as the AI application requirements change every month, not every year.
3. **Customization For Specific Applications:** eFPGAs provide the ability to customize operations for specific applications or workloads, enhancing performance and efficiency for particular tasks compared to general-purpose processors. Thus, it is suitable for AI edge-focused applications.
4. **Long-Term Viability:** With the ability to update and reconfigure the logic, eFPGAs help ensure that a product can remain relevant and compliant with new protocols or standards, extending its market life.

Hurdles

1. **Area And Power Overhead:** Integrating an eFPGA into an ASIC or AI SoC can increase the overall size of the chip and its power consumption. The programmable nature of eFPGAs means they generally have less area and are more power-efficient than fixed-function logic.
2. **Complexity In Design And Verification:** Designing with eFPGAs adds complexity to the chip design process, including the need for specialized tools and expertise for programming and verification, which can increase development costs.
3. **Performance Trade-Offs:** While eFPGAs offer flexibility, they may not match custom-designed ASICs' performance or power efficiency for specific functions due to the overhead associated with programmable logic.
4. **Limited Resource Availability:** Depending on the size of the eFPGA, there might be limitations on the amount of logic implemented, which could restrict the complexity of the functions.

Current Status:

There's a growing trend of integrating eFPGAs with AI SoCs to accelerate machine learning tasks directly on the device. Companies like QuickLogic, FlexLogic, Achronix, and Intel, to name a few, already have promising

eFPGA-based SoCs.

As AI and machine learning continue to evolve, the role of eFPGAs in enabling adaptable, efficient, and powerful computing solutions is expected to grow significantly.

Take Away

While the initial development and integration of eFPGA technology into SoCs may require substantial investment, the long-term benefits can be significant. The adaptability and reconfigurability of eFPGAs can lead to cost savings in the long run by extending the useful life of the chips and avoiding the need for frequent hardware upgrades - a much-needed feature for ever-changing AI applications and workload types.

In conclusion, eFPGA-based AI SoC represents a significant advancement in semiconductor technology, offering unmatched flexibility and adaptability for various applications, especially in AI Edge. The potential for cost savings and enhanced performance makes them attractive despite the initial complexity and investment required.

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