FPGA Based IOT Systems

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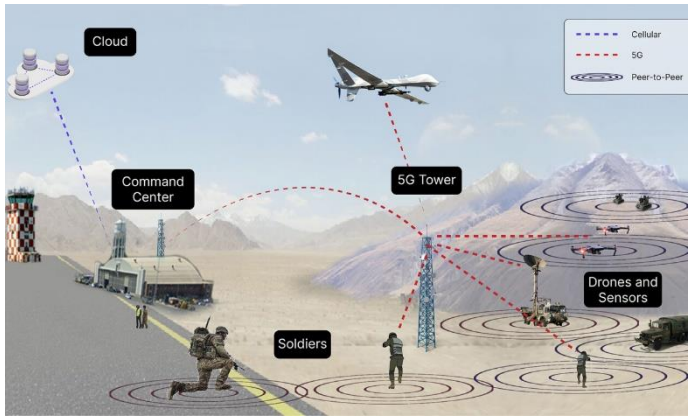
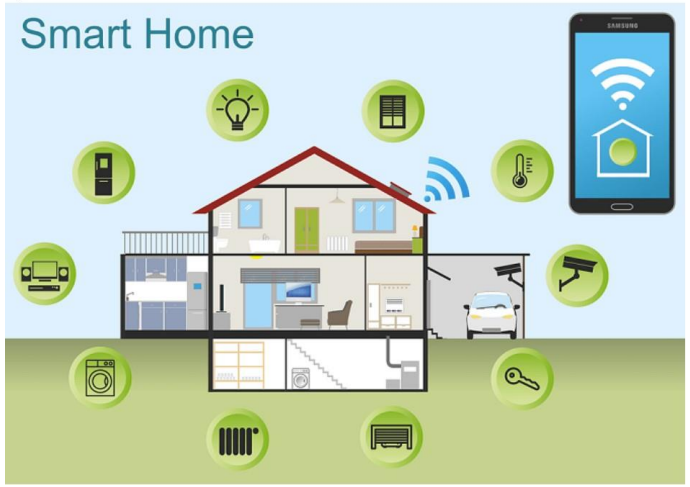
Introduction to IOT

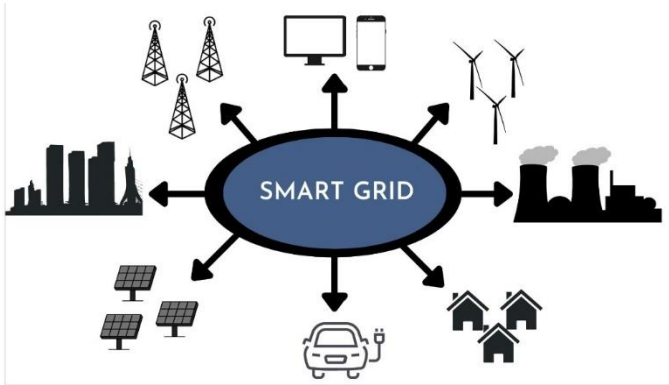
- Internet of Things (IoT) has emerged as a transformational concept, significantly woven into our daily lives.
- It enhances connectivity by merging everyday 'things' and integrating them into the digital realm.
- The name IoT is derived from the words 'Internet' and 'Things’.

IOT APPLICATIONS

- Military: Smart uniforms and helmet sensors enhance situational awareness, response times, and safety.
- Home Automation: Internet-connected appliances improve convenience and energy efficiency.
- Smart Grid: Efficient power management with IoT-enabled smart grids.
- Surveillance: Enhanced safety and security through continuous monitoring.
- Healthcare: Remote monitoring, ingestible sensors, and smart hospitals improve healthcare delivery.
- Agriculture: IoT sensors on equipment and in the field can give useful data for precision farming in agriculture.
  Monitoring soil conditions, crop health, and irrigation optimisation are all part of this.







FPGAs In IOT

FPGAs, or Field Programmable Gate Arrays, are semi-conductor devices built on a matrix of configurable logic blocks connected by programmed interconnects.

FPGAs play an important role in IoT systems for a variety of reasons, including their ability to provide significant computational power.

However, the main reason FPGAs are an excellent answer for IOT-based systems is their flexibility and re-configurability.

The use of FPGA as a supporting edge device, FPGA-enabled network layer filter for edge devices.

FPGA hardware is used solely for image processing operations and is interfaced with an IoT-based device such as Raspberry Pi

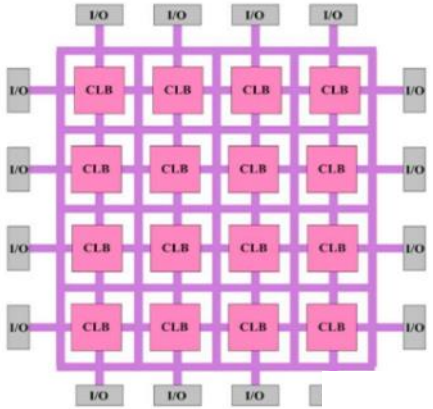
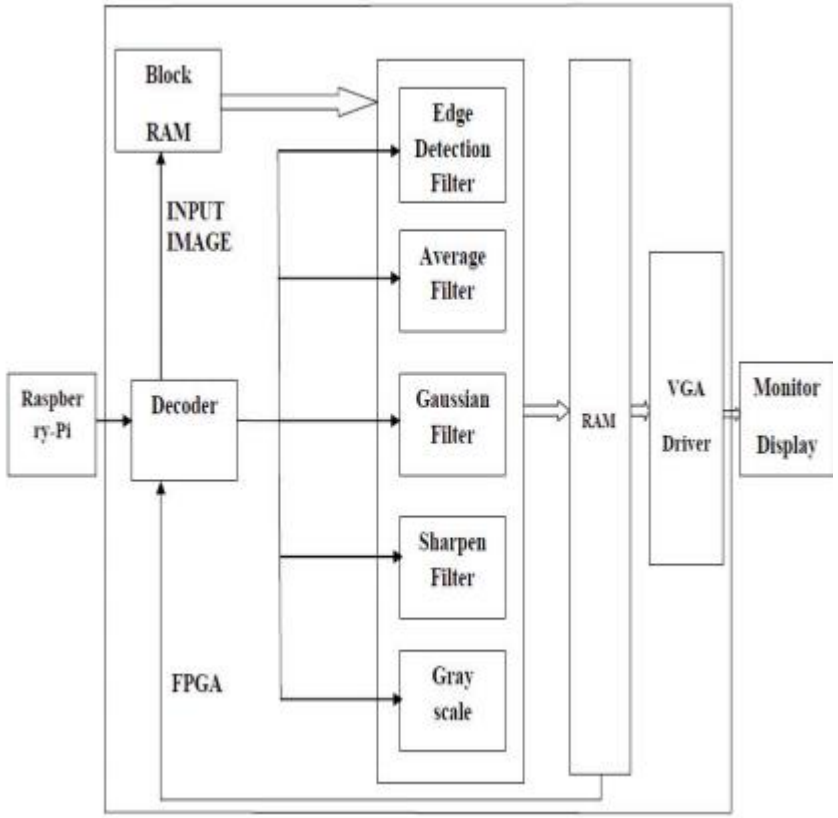


Figure 1: An FPGA Architecture Overv



System block diagram of R-Pi interface with FPGA in IoT application

Advantages of FPGA in IOT

Reconfigurability: FPGAs can be reprogrammed for specific needs, offering flexibility.

Security and Parallel Computing: Enhanced security and efficient parallel processing capabilities.

Low Latency and Powerful Processing: Ideal for real-time processing and decision-making in IoT.

Custom Hardware Design: Optimizing throughput, security, and minimizing latency:

FPGA VS Microcontroller FOR IOT

FPGA Strengths: Flexibility, parallel processing capabilities, high-speed performance.

FPGA Challenges: Higher cost and complexity.

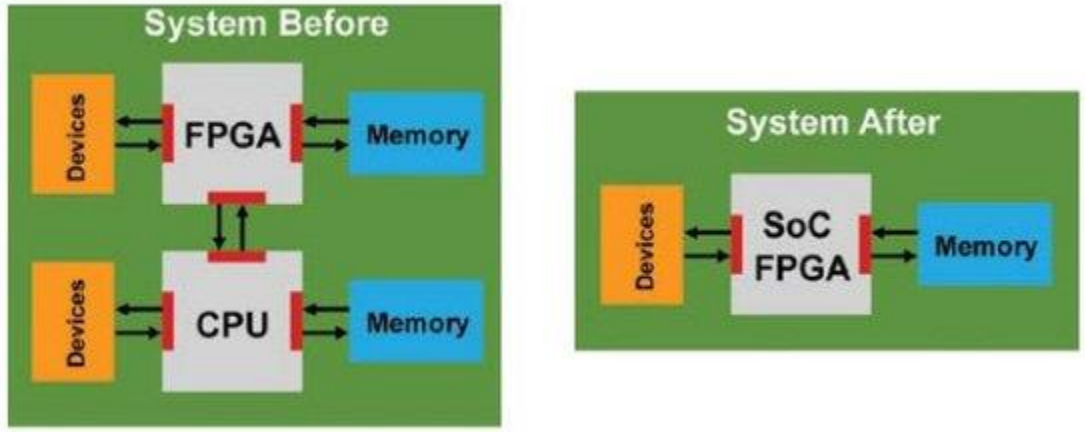
Microcontroller Strengths: Cost-effectiveness, ease of use, low power consumption.

Microcontroller Challenges: Limited processing power and lack of flexibility.

IoT-Enabled SoC FPGA

There are three reputable providers of SoC FPGAs in the market, namely Altera, Xilinx and Microsemi.

- Reduces production cost and saves space on the circuit board
- This substantially reduces power consumption, lowers communication latency and consequently increases bandwidth.
- IoT devices function very efficiently when implemented with reprogrammable technology like SoC FPGA devices

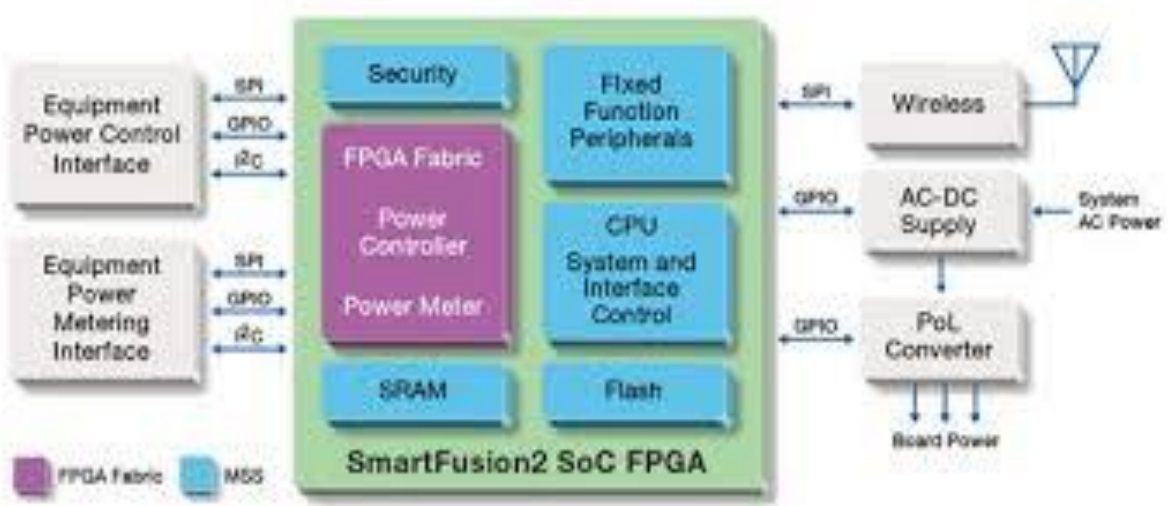


An SoC FPGA device in their proposed application model

Application of SoC FPGAs based IoT

Microsemi smartfusion2: Used in the smart grid energy management and distribution system.

One of the popular vendors of SoC FPGAs, proposed a design using SmartFusion2 SoC FPGA.



Proposed design of smart energy meter system

Advantages of SoC FPGA In IoT system

An SoC FPGA device, provides the processing capability that is required to essentially transmit data to other devices over an IoT-based platform.

Using the FPGA fabrics can reduce the execution time of the communication operations involved greatly within the IoT communication protocol stack.

This application makes the edge devices responsible for combining data processing as well as data transmission while connected to other devices on an IoT platform.

Major Manufacturers of FPGA

Xilinx:

Xilinx is the leading global provider of FPGAs with over 50% market share. The company was founded in 1984 and has its headquarters in San Jose, California. Some key facts about Xilinx:

- Offers industry's broadest FPGA portfolio including UltraScale+, UltraScale, 7-series, Spartan-7, and older families.
- Majority of revenue comes from Communications, Data Center, Industrial, Aerospace & Defense markets.
- Ships over 20 million FPGAs per year.
- Wide range of software, IP cores, development boards and tools for FPGA design.
- Extensive worldwide technical support and training options.

Intel:

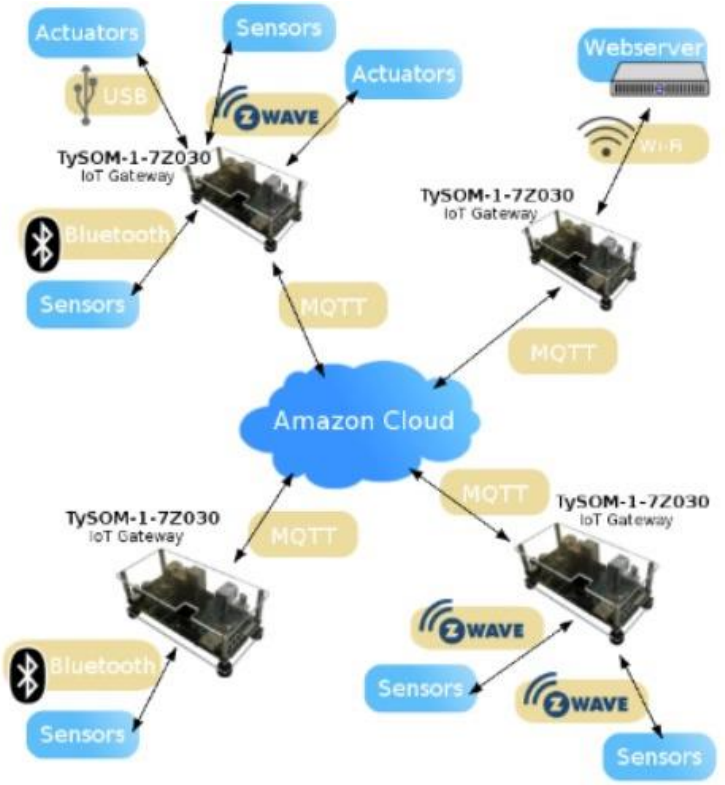
- Intel acquired Altera in 2015 and now offers FPGAs under the Intel brand. Some facts about Intel's FPGA business:
- Intel Stratix 10 FPGAs offer leading-edge performance, density and bandwidth ideal for high-end applications like AI acceleration and network infrastructure.

Microsemi

- Microsemi is a major provider of defense and aerospace FPGAs.
- Microsemi's space-grade FPGAs undergo specialized manufacturing and screening to provide the highest quality and reliability for satellite payloads and launch vehicles.

Available FPGA Solution

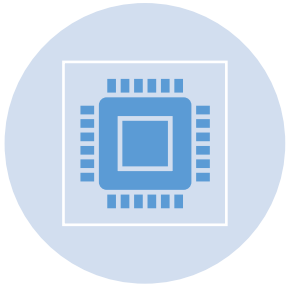
- Aldec specializes in comprehensive IoT solutions powered by FPGA technology, enhancing the gateway and services layers of IoT infrastructure.
- The IoT Gateway built on the TySOM - Xilinx Zynq based hardware platform.
- Versatility: Zynq devices integrate ARM processors with programmable logic, making them suitable for embedded applications. Virtex and Artix FPGAs are often used in high-performance computing and communication
- **FPGA technology in Aldec's solution offers High-Performance Computing (HPC).**
- **Aldec's FPGA technology is energy-efficient.**
- **Ease of Integration.**



Aldec's TySOM IoT Gateway Integration - Demonstrating connectivity with sensors, actuators, and cloud services, essential for efficient IoT network management.

Challenges of FPGA Implementation

Performance and Timing Issues: Delays can affect system efficiency.



Efficient EI Implementation: Challenges in computational processing and scalability.

Security and Privacy: Risks in unsecured environments and need for tailored security measures.

Complex Learning Curve: Programming complexity and resource intensity.

Conclusion

- FPGAs, with their adaptability, high performance, and energy efficiency, are critical in developing complex data-driven urban environments. Their ability to meet evolving standards and robust security and processing capabilities position them as a cornerstone technology for smart cities. This integration marks a significant milestone in urban planning, driving towards smarter, more efficient, and sustainable cities.