Custom ASICs enabling the Internet of Things

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Introduction

This whitepaper will discuss how the Industrial Internet of Things (IIoT) is a disruptive trend in the electronics sector. As the number of sensors grow and the demand for proactive rather than reactive systems take hold, the need for computing at the sensor edge is dominating. Enabling edge computing using the same traditional ways is not always possible or indeed not always the best solution. This paper will discuss how custom ASICs are enabling the move to edge computing through highly optimized solutions that are specific to your system requirements and offer area and costs savings regardless of volume.

Industry Changes

In a world that is continuously changing, technology and innovation are key to how industry is transformed, and the Internet of Things has become central to that transformation. What was originally part of the German strategic initiative, has spread across the world, disrupting manufacturing and factory automation in all territories. The Industrial Internet of Things has enabled the vision and execution of smart factories where cyber physical systems monitor physical processes, create a virtual copy of the physical world and make decentralized decisions. With the Internet of Things, communication between cyber physical systems and humans takes place in real time and with cooperation via the Internet of Services. Disruptive technologies bring many benefits to early adopters. More and more, people need to be flexible in relation to their engineering, and responsive to their customers. Standard products are not always the answer as different variants are needed depending on the product requirements. Custom silicon is the solution.

Market Changes

Today, manufacturing is on the threshold of a revolution. With the power of steam in the 18th century, the development of engines enabled the mass mechanism of Industry 1.0. The creation of electricity and assembly lines brought Industry 2.0, and then Industry 3.0 signalled the information revolution and a new era of automation and robotics. The Industrial Internet of Things and Industry 4.0 is bringing connected intelligence into Industry. With the predicted market growth and levels of automation in factories increasing as processing becomes more automated, technology must keep up. The World Economic Forum & McKinsey1 recently published results of a poll which showed that 71% of respondents were just about to pilot IoT solutions or had not yet piloted them. The options for companies en route to the IoT and the paths they take are varied. What is definite is that one size does not fit all when it comes to the Industrial Internet of Things (IIoT).

One Size does not fit all

IIoT is enabling manufacturing to influence the capacity of objects to communicate with and sense the world around them. Industry 4.0 enables factories to unlock efficiencies, optimize product and increase employee safety. While IIoT offers a lot of opportunities, there are also many challenges. As the level of monitoring increases, with the global sensor2 market estimated to increase to $11.23B in 2021 from $3.77B today, there needs to be a seamless flow of information in and information out. When the concept of cloud computing first became known over 12 years ago, the thought that over 2.5quintillion bytes of data is being created each day was unbelievable. And this number is being accelerated with the growth of IoT. Cloud computing and big data are an excellent combination. But is moving all the data to the cloud always a good idea? What happens if there is latency in communications and you cannot access the data that you want at the time that you want it? What is the cost associated with gathering this data, and do we really need to store all this data to achieve our business goals? More and more, when it comes to the IIoT, we see that one size does not fit all and engineers need to examine different solutions to realize the full benefits of the Internet of Things

Edge Computing

Being able to offload all the processing to a central data center in the cloud has always been the attraction of the Internet of Things. However, to do this, we need to be able to install the requisite sensors to measure all the data required. The placement of these sensors is not always in easy to access locations and not always connected to a main power source. Common with remote locations is also the issue of having communication constraints. So, while the ideal is to measure and process large amounts of data to make intelligent decisions, the reality is that it's not always possible. In real-time control, system processing can be performed at the source so that system responsiveness, communication overhead and even security can be optimized. This is what has become known as processing at the edge or edge computing. Bringing the processing right to the sensor edge, where the physical world interacts with the analytics world offers many advantages. The response time is shortened, and at-source filtering of unrequired data can be achieved which leads to unburdening of the network. However, performing signal conditioning at the edge is not without its difficulties. Space can be constrained; power budgets are low as the sensors are being driven by batteries, and connectivity to the cloud is not always continuously available. Edge processing also needs to be considered in the selection of components in the analog signal chain. Selecting the wrong component can result in the performance of the system being limited, or achieving the performance required but paying a premium for the components selected. Additionally, it is common for edge nodes to be space constrained and therefore a situation could arise with having to trade off on performance in order to be able to fit the solution at the edge. Performance trade-offs may also be necessary to meet the overall power budget. Therefore, while there is a strong desire to implement processing at the edge, the reality is not as clear

Custom Solutions

In the past custom chips or ASICs were considered the luxury of companies shipping very high volumes. However, this is no longer the case. Custom ASICs are now possible for many original equipment manufacturers (OEMs) who previously would have found such designs outside of their budgets. Designers of consumer electronics are pushing the development of foundry nodes smaller and smaller, to allow the development of the smallest, thinnest and fastest products on the market. As they move to these bleeding-edge processes, opportunities open for everyone else to use these vacated mature technologies. Designers may see these fully depreciated are lower in cost than the latest generation process node. Industry3 reports have shown that by 2025 the demand for process nodes greater than 20nm will still be in excess of 50%. With the technology requirements for IIoT requiring a mix of analog and digital technology, these mature mixed-signal process nodes are the perfect solution to develop solutions for edge computing.

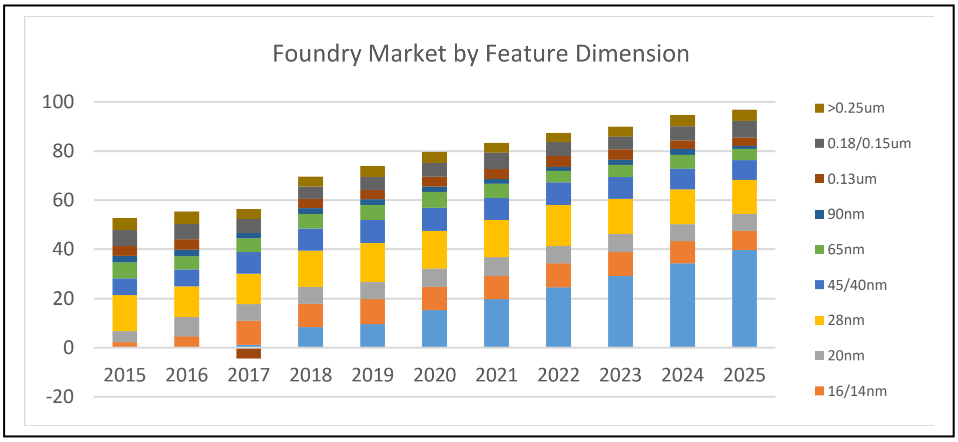

Fig. 1 Foundry Market by Feature Dimension

A typical edge node will be monitoring large numbers of sensors. Added to this are the many components needed to process this data; analog components, microprocessors, memory and communications protocols. The scale of deployments in IIoT is a lot larger than what is normal for typical industrial applications. As a result, there are cost sensitivities also. Even boards that appear to be moderately simple can contain hundreds of components. When you add to this the overhead of specifying, purchasing, integrating and testing all these components, the challenge and time involved is considerable. And this is before you consider risks like discrete off the shelf product obsolescence and future re-certification for new components. Custom silicon is looking much more attractive.

SmartEdge Platform

The ASIC & IP Division have brought to fore their Smartedge platform. SmartEdge offers designers the option of incorporating all the functionality required for their edge computing requirements into one single piece of silicon, while delivering up to 75% savings in PCB area and power and up to 80% reduction in bill of material (BOM) costs.

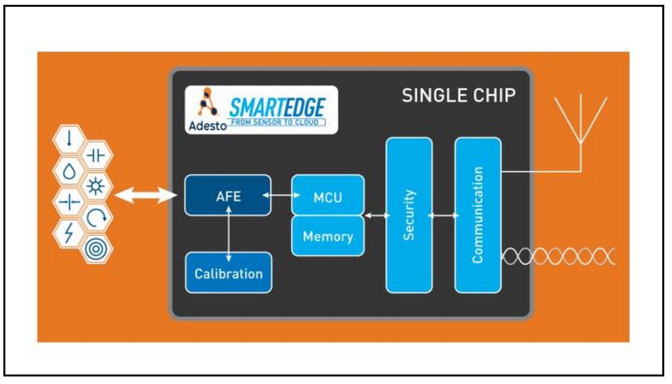

Fig. 2. SmartEdge platform

Integration

The SmartEdge platform contains the key integrated functions of:

• Sensor Analog Front End. Connecting to the physical stimuli (temperature, humidity, pressure, flow) via sensors. These low-level signals are amplified and processed into digital data that can then be monitored to drive better decision making in your smart factory.

• Calibration. Sensors are inherently non-ideal and therefore calibration is needed to be able to overcome these non-linearities. With custom integration, calibration and compensation algorithms can be integrated onto the - ences.

• Control. Having processed the information from the sensors, we now want to be able to act on the data received. This could be driving an actuator, turning on a fan or whatever the physical response is to the inputs received.

• Securely Communicate. To complete the connection from sensor to cloud, its necessary to integrate the communications protocol that best suits your requirements. With custom silicon you have as many protocols as you like, whether wired or wireless, all integrated onto the same chip. Being able to integrate a security first hardware-based strategy during the specification stage increases the overall security of your system.

• Embedded Software. When all the hardware considerations are in place, it’s important to also consider the software requirements. Renesas will support our customer with their embedded software development.

PCB Area Reduction

With the SmartEdge platform and integrating all the functionality on a single piece of silicon significant PCB area reduction can be achieved. An example is show in Table 1.0. Using for comparison some standard components that would be utilized in the analog front end to process the signals from the sensors, by choosing a custom silicon solution you can save almost 100x the area than by taking a typical discrete route. Integrated vs Discrete Size comparison

Product	Integrated Size	Discrete Size
12-bit DAC	0.09 mm^2	10.0 mm^2
14-bit ADC	0.24 mm^2	14.7 mm^2
1.8V LDO	0.06 mm^2	8.26 mm^2
4:1 Analog MUX	0.21 mm^2	9.0 mm^2
Power Switch	0.01 mm^2	4.2 mm^2
RTC	0.07 mm^2	15.2 mm^2
Total	0.68 mm^2	61.36 mm^2

Table 1: Integrated vs. Discrete Size Comparison

Bill of Material Cost Reduction

Adding to the area savings that custom ASICs offer, they also provide a great deal of component consolidation which results in a reduction of the electronic bill of material costs. In Industrial systems, that have much longer lifetimes than consumer products, the full return on investment should be analyzed over the lifetime of the product. our ASIC & IP division have developed an online calculator which can help you determine what exactly the savings could be. It considers not just the components that you are using in your design, but also the volumes you are shipping and the life-time of the product. In a typical Industrial example, the results are graphically shown in Figure 3 where there are 50k units shipped a year over a 6-year lifetime. The design uses four data converters and twenty other non-RF analog components. It has a mid-level performance processor on board with 64kB of RAM and 128kB of flash memory. It also has RF connectivity on board. The results show that in just over a year, the program has broken even and over the lifetime of the product there are savings of over $15M to be gained by going the custom ASIC route. These savings are just considering the component reduction costs. There are additional savings to be had in the program through reduced assembly costs and improved reliability because of the large reduction in the number of components being used.

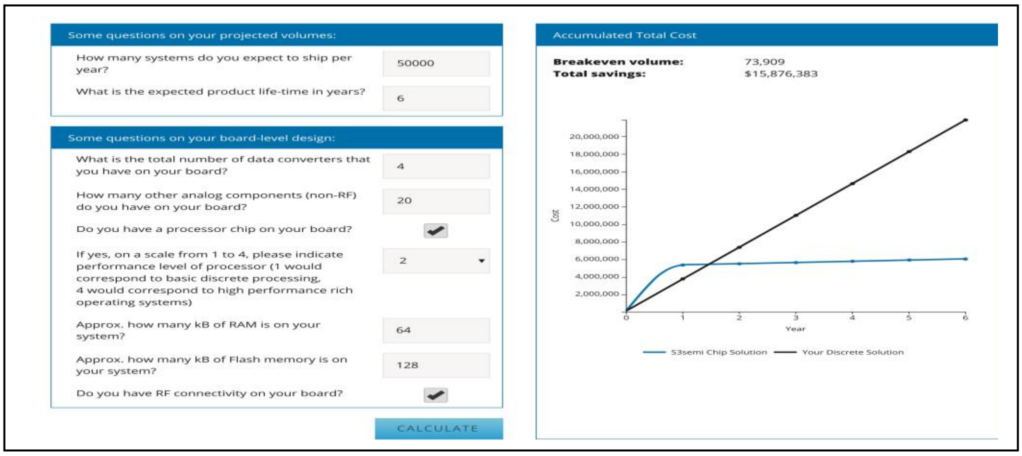

Fig. 2 Calculator input and output

Conclusion

While the Industrial Internet of Things is offering many opportunities in the creation of smart factories, there are also many challenges. As the growth in the number of sensors being monitored increases and the demand for seamless processing and flow of information in and out to create predictive rather than reactive situations, the tried and tested systems of old are no longer optimum. With custom ASICs like the SmartEdge platform from Adesto, a single chip can incorporate all the functionality you need while reducing space, power and BOM costs enabling you to bring your design right to the edge of the sensor node.

References

[1] H. Leurent, E. deBoer, “The Next Economic Growth Engine Scaling Fourth Industrial Revolution Technologies in Production,” World Economic Forum, pp. 6-7, January 2018

[2] Frost & Sullivan, Analusis of Sensors in the Global Internet of Industrial Things Market, 2015.

[3] Dr. Handel Jones, Semiconductor Industry from 2015 to 2025, International Business Strategies (IBS)

Revision History

Revision	Date	Description
1.0	Mar 01, 2018	Initial release
1.1	Dec 22, 2021	Re-brand