A modular approach for Industrial Internet-of-Things

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This article highlights standard device platforms for gateways, edge servers, industrial firewalls and AI systems that help to implement Industry 4.0 system concepts quickly and cost-efficiently. The modular layout always facilitates easy customer-specific modifications to the standard platforms.

■ In the future, data and information will play an even more important role in optimizing processes, reducing costs and automating process flows. Concepts like smart manufacturing and Industry 4.0 stand for digitalization, sensible and secure connectivity and the profitable use of information in the industrial field. The focus needs to be on the benefits and added value generated by these industrial IoT applications. They include such aspects as cost optimization, faster throughput times and minimized downtime. For many, however, the primary focus is on such issues as customized manufacturing and the provision of auxiliary services. Skillful approaches are needed to solve the associated challenges. It is important to think big, to start small and to scale cleverly. Individual solutions open degrees of freedom that enable the combination of established standards and application-specific system solutions. A modular approach based on a universal concept can form a solid foundation for success.

The use of embedded modules and building blocks makes it easy to implement customized IoT hardware solutions. These include such solutions as gateways, industrial firewalls and edge servers. But also, solutions for automatic determination of information supported by artificial intelligence (AI) are gaining in importance. Uniform platform approaches can result in universal product families which enable scaling and flexibility in terms of performance, range of functional features and interfaces.

In many cases, a worthwhile first step is to consider solution approaches for existing systems and concepts. Gateways make it possible to access data, put it in a uniform data format and make it available to the superordinate system via standardized interfaces. This also makes it possible to implement and maintain security aspects – decoupled from the existing system. Local data storage and preprocessing in the gateway are needed when the interfaces to the higher-level system and the cloud only offer limited communication bandwidth, or if a distribution should be made between decentralized (local) intelligence and central intelligence (in the cloud for higher-level analysis). Local preprocessing and provision of data also minimize latency. Different performance classes may be needed for processors, memory and data throughput, depending on the application. This leads to a wide variety of requirement profiles for the gateway which are, however, very easy to implement based on modular solution strategies.

Performance may be scaled using different embedded CPU modules such as those based on COM Express Mini or the newer SMARC 2.0 standard. In the case of SMARC, both x86 and ARM processors are supported. In combination with a carrier board that has been adapted to the specific application, this is a way to implement individual solutions cost-effectively. For example, finished building blocks such as the 100mmx100mm standard MB-M10-1 carrier board from TQ could serve as a basis, enabling shorter evaluation and implementation times. Uniform dimensions and layouts of the interfaces are important prerequisites when different versions are planned as a platform concept.

Wireless interfaces such as 2G/3G/LTE, WiFi, Bluetooth, LoRa WAN and ZigBee can be added very easily as plug-in modules, and this also makes it possible to consider country-specific differences in standards and regulatory approvals. Module standards such as Mini PCIe and M.2 cover an extremely broad range of applications here. USB dongles are also commonly used, but they must be suitable for industrial use and must also be able to be mechanically fixed accordingly.

There are many systems which utilize IP-based communications, but so far, they have only been integrated into closed system environments. This applies, for example, to many capital goods such as machines and systems in the industrial environment. Over the course

Figure 1. TQ industrial IoT platform concept addresses individual gateway, industrial firewall, edge server and AI solutions.

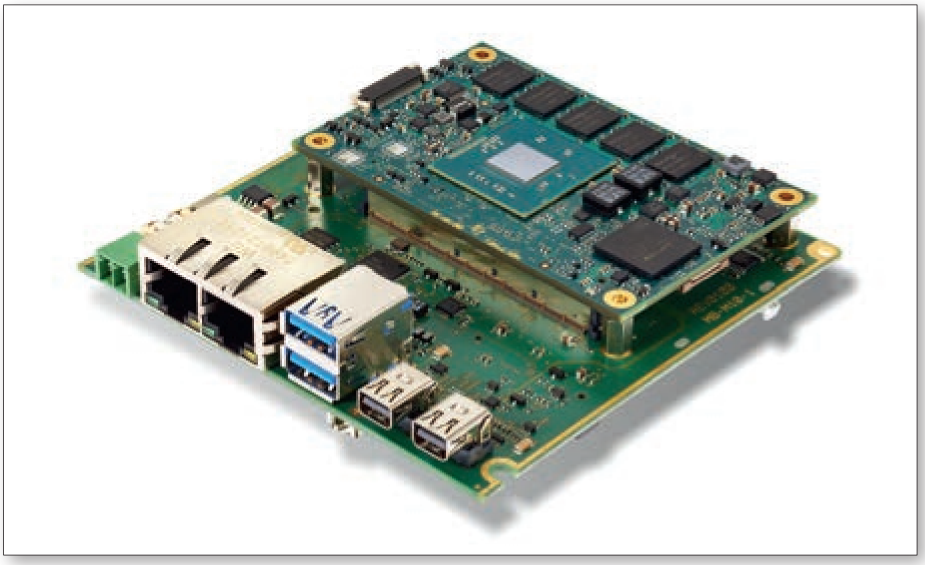

Figure 2. A modular approach enables scalability and flexibility. The TQ standard carrier board MB-M10-1 in combination with COM Express Mini modules like Intel Atom based TQMxE38M builds the heart of very compact, robust and powerful IoT applications.

of digitalizing systems and incorporating them into smart manufacturing concepts and Industry 4.0, Internet access often needs to be enabled as well. This lets the system manufacturer offer profitable auxiliary services such as predictive maintenance and service support. This is an important component for tapping additional business potential. Locally installed firewalls are used to cover the necessary security aspects. Often, standard IT firewalls are unsuitable for this purpose, because they have not been designed for the special needs in the industrial environment. This not only relates to their physical and electrical characteristics such as the housing, power supply, temperature resistance and robustness. Important functions and configuration options needed in the industrial IoT environment are frequently missing as well. Industrial firewalls can be matched very precisely to system requirements. They are usually installed directly at the machine or system and enable secure yet transparent communications over the Internet via specified IP addresses and ports. In this so-called Stealth Mode, the firewall itself remains invisible, so that potential system hackers cannot scan it. This closes potential security gaps. Depending on the system type and infrastructure, however, alternative configuration options are also important,

Figure 3. The MBox-ADV is equipped with four independent Gigabit Ethernet ports and is therefore suited for industrial firewall applications. The compact size and the robust housing addresses use cases within the harsh factory floor environment.

Figure 4. The carrier board MB-COME6-3 is designed for COM Express Type 6 modules and offers PCIe x4 and PCIe x16 high bandwidth connectivity to add-on cards which are used in high-performance AI solutions, for example.

so that the firewall deliberately works as a proxy, for example. Here, the firewall is not inserted invisibly into the communication path, rather it passes information as a proxy for the internal or external communications partner. Other important components of an industrial firewall include auxiliary functions such as automatic encryption/decryption of protocols such as ftp/sftp. This enables continued full use of older machines and systems over the course of Industry 4.0.

Generally, the physical interfaces of industrial firewalls are very similar, because communications are via Ethernet. Different processors may be used depending on the range of functions, the required data bandwidth and diverse encryption options. Simple scaling can be implemented by using a customized carrier board in combination with various COM Express modules. Over the course of years, this also makes it possible to continually update the product family with the latest processor generation. This allows product developers, and therefore users as well, to benefit from the latest innovations in processor and memory technology without great expense. This not only applies to computing performance and data throughput, but also innovations in the security area. With a modular solution approach, this results in a universal device concept that is viable over the long term.

In industrial IoT applications, it is not essential to transfer all data to the cloud unfiltered. Performed in the cloud are higher-level data and information analysis and data sharing for global services. Local data storage and data processing enable faster and autonomous local access, making shorter reaction times possible. Edge servers are used for this purpose. The performance requirements differ widely here. However, the common basic requirements are reliable data storage – often even in a RAID configuration – and reliable continuous operation under industrial environment conditions. For extremely reliable solutions, additional technologies may be necessary, such as ECC memory, in which automatic error correction is performed on individual bit errors. The features and performance capabilities of the edge server that is used are therefore application-dependent, and it is difficult to cover all needs with one all-round solution. Here too, it is advantageous to implement a modular layout which can be optimally configured for a specific purpose of use with different CPU modules, variable memory expansion and optional auxiliary features. The COMBox-V embedded PC from TQ is a good example to demonstrate the full flexibility based on the usage of COM Express CPU modules. This edge server implementation can not only be scaled from Intel Core i3 up to Intel Core i7, it can also be equipped with Intel Xeon based COM Express modules which support up to 32 GB DDR4 with ECC.

The topic of artificial intelligence (AI) figures prominently in the context of Industry 4.0. Focal points in this area are automation of intelligent behavior and machine learning. To extract meaningful information from the flood of data and intelligently derive the right results and actions, it is important to use suitable algorithms and execute them efficiently. In many cases, the program code is executed in the processor or in the graphic controller. In systems with a modular layout, these two scaling factors can be adjusted very easily using different embedded CPU modules. If the modular system layout also provides expansion slots for additional cards, the system can be supplemented with coprocessors which have been optimized for AI applications. They can significantly boost efficiency when executing the algorithms mentioned. In many cases, this further reduces costs, because a less expensive processor can be used.

Scaling options can be illustrated by the example of the compact Box PC family MBox from TQ. It not only permits scaling via different COM Express modules. There is also a Mini PCIe slot that is available for expansion with the coprocessors mentioned already. In the MBox with AI Extension solution, for instance, the Intel Movidius Myriad 2 VPU is used as a coprocessor, and within AI applications this provides a substantial performance boost – especially in the area of vision processing. In the Industry 4.0 environment, there is often interest in high-end AI systems as well. The COMBox-V– mentioned as an edge server solution already – offers expansion options via PCIe x4 and PCIe x16 to also support high-performance FPGA expansion cards for AI.

Regardless of whether it is a gateway, firewall, edge server or AI system, in most cases, a specific range of functions is already defined at the beginning of product development, and the required computing performance and memory requirements are adapted to these functions. The goal is to obtain the best system in terms of functionality, performance and price. But what can be done if, over the course of a product life cycle, the desired functionality expands so much that the original estimate has been rendered obsolete? A modular approach to a solution can readily overcome these hurdles.

For example, a new premium variant might be defined, which could easily cover the added functions with a more powerful processor module and, if necessary, other expansion cards. Over the course of device development, this approach often goes so far as to result in a wide variety of versions and potential uses which were not envisioned at all in the concept phase. Even the combination of several solutions in one device (known as workload consolidation) can easily be covered by the upgrade to high-performance embedded modules. Looking to the TQ portfolio of embedded CPU modules for example, the COM Express form factor covers the widest range of scalability – from Intel Atom up to server-class Intel Xeon processors. The use of modularly designed systems is a way to tap into new application fields and related new business opportunities with minimal effort.

Flexible housing concepts, such as those used in the IoT device platform from TQ, enable uniform yet customized implementation of different performance properties and equipment variants in a universal series of devices. It is easy to adapt their dimensions and heatsinks to specific requirements. In the process, a uniform look-and-feel leads to a universal and flexibly expandable product lineup. When the housing concept and the modular hardware layout are well matched, a platform concept results in which the boundaries between gateway, firewall, edge server and AI system are flowing, and all systems can be built upon one another.

TQ is a technology partner which not only provides support during the conceptual design phase for vendor-independent industrial IoT applications but also offers a vast wealth of experience when it comes to development and production. An extensive portfolio of embedded modules and building blocks based on x86, ARM and Power Architecture create the foundation for customer-specific solutions. ■