Defining IoT and Industry 4.0 with embedded systems

By Konrad Zöpf, TQ-Systems

Embedded systems play a vital role in both characterizing and developing the Internet of Things as well as in creating new processes in automation. They address several requirements of IoT solutions and thus enable highly project-specific solutions.

(Source: istockphoto/a-image)

■ Today, the age of the steam engine can be considered Industry 1.0 because this invention ushered in the first industrial revolution. That was pretty much the breakthrough on the road toward automation. This was followed by the introduction of conveyor belt production, considered another milestone for the rational and effective production of goods and thus Industry 2.0. In Industry 3.0, programmable logic controllers - called PLCs - made their arrival in this new age. The fixed wired control processes that were usually used via a relay system up to that time became a thing of the past.

The age of hardware and software began, thereby laying the foundation for embedded systems. The effort required for wiring was reduced and this new kind of control system had more and more flexibility. Initially, embedded systems were based on 8 or 16-bit microcontrollers. In this automation phase, so-called field busses were used for the first time along with the connection of sensors such as optical barriers, limit switches, temperature and level sensors. Smaller, decentralized controllers were connected with PLCs via field busses and proprietary networks. The demands made on networking and data supply grew continuously. Thus, the requirements for bus systems and networks also increased in order to display data on completion statuses, inventories, production capacities etc. This is achieved by linking the machines to a company administration computer (vertical integration). This is referred to as a networked factory.

A new age of automation also began when networking became commonplace: Today we speak about Industry 4.0 and IoT. Both are neither a product nor a concept. Rather, it is a vision of the total networking of intelligent digital systems. In the future, machines should be able to control each other through new information and communication techniques. Production processes such as production itself, planning and service should be automatically optimized. The entire process should occur in real time as much as possible in order to achieve a self-organizing production system or added value chain.

In order to implement this project in reality, all the data required for this purpose must be available. If this could be considered on a global level, there would not be enough energy as well as memory capacity to save all data in a cloud. Thus, logical system concepts are the prerequisite for the implementation of this vision. Important requirements for this are the localization and networking of all systems as well as the use of energy-efficient systems and the transfer of required information instead of complex and large data volumes. Another important point is a sufficient security concept when networking machines, systems and devices and transferring and networking safety-critical information. No one wants critical information and data to be made available to the public or even competitors through global hackers, security gaps or inadequate protection.

Companies face numerous tasks which require a solution according to the project-specific requirements. Possible approaches to a resolution are embedded modules and system solutions. The manufacturers of ARM-based CPUs often offer sound system and security concepts. In addition to the hardware-based security functions integrated in the CPU, there are already many software solutions to implement secure and reliable systems.

Particularly ARM-based embedded systems are an ideal platform to implement projects in terms of the requirements of IoT and Industry 4.0 regarding energy efficiency. ARM has the highest performance per chip surface and is a leader in chip technology when compared to the other architectures. ARM-based CPUs of several manufacturers are currently undergoing rapid developments: in terms of performance, along with the current computing cores with a 32-bit architecture such as

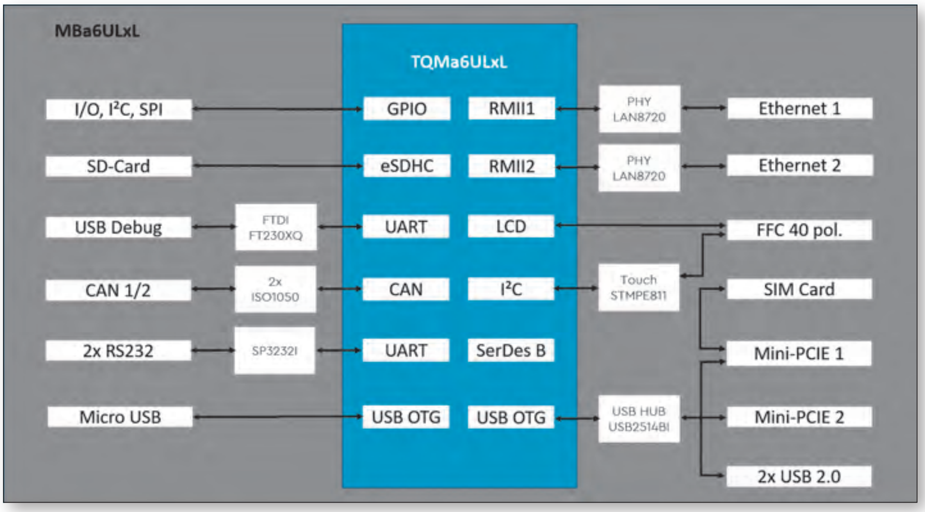

Figure 1. Example of an IoT gateway, expandable with WiFi, UMTS and LoRaWan

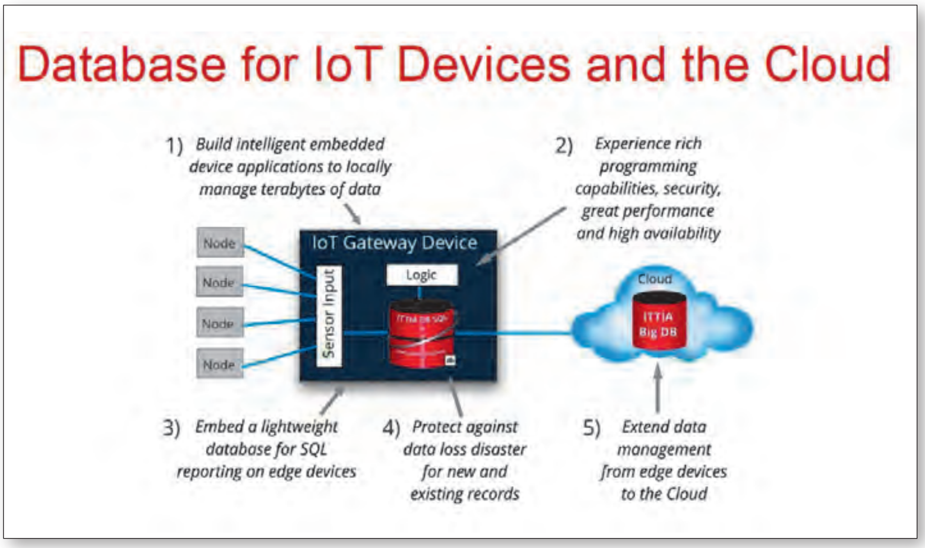

Figure 2. Database for IoT devices and the Cloud (Source: ITTIA)

Cortex A7, Cortex A8 and Cortex A9, ARM also offers computing cores that are based on a 64-bit architecture, such as Cortex A53 or Cortex A72. They continue to show a very good relationship between computing power and power loss despite the increasing performance.

The ARM chip manufacturers use this advantage and integrate the corresponding application-specific interfaces for every market in order to keep up with the new market demands, particularly in the networking area, while taking the highest security standards into account. A cost-efficient and function-optimized alternative based on different ARM computing cores is available for almost all industries, whether for the automobile industry, the networking area, automation or control engineering. It also sets itself apart in that, in the future, other security functions can be integrated to meet the market demands even better in terms of secure data transfer. More and more wireless networks are gaining significance in the data transfer area: in addition to Wi-Fi and Zigbee, another emerging trend in the industry is known as LoRaWan (Long Range Wide Area Network), which is gaining acceptance.

The advantage of LoRaWan is that a range can be achieved for greater distances (for cities around 15km, up to 40km for rural areas). Another major advantage is the usage within buildings because good infiltration is achieved due to the frequency range. Also, the power consumed by LoRaWan end devices is around 10mA in operation and approximately 100nA in idle mode. This also allows use in battery-operated devices. Communication between the end devices and the gateways occurs on different frequency channels with different data rates that are between 0.3 Kbit/s and 50 Kbit/s. Those are exactly the features in the IoT area that make wireless networking easier and more cost-effective. The connection of a LoRaWan module can also occur via USB.

Many interfaces such as graphics, Ethernet, CAN, ADCs, I²C, SPI and digital IOs are already integrated into the CPUs in the ARM-based microcontrollers from various manufacturers. Due to the versatility of the interfaces, most system requirements to connect suitable sensors and systems for data recording can be implemented without major additional effort. ARM-based processors can be used universally due to the interface versatility and the ability to freely choose an operating system. More and more devices are developed based on this architecture, prompted by good application support by the MCU manufacturers for different market segments.

Adapted operating systems are used for the ARM MCUs especially for operating systems adapted to this processor type. Depending on the project requirements, a corresponding OS such as Linux, QNX, VxWorks or a real-time OS by Green Hills or Bare Metal can be selected. This has the advantage that the user is provided with optimum performance. Thus, also complex control systems can be achieved in the automation area, even with very appealing graphics performance, that can do without the large overhead of an operating system.

The TQ embedded specialists have taken advantage of the benefits in terms of power dissipation, the functional scope, safety concepts and the price advantages of the ARM architecture: based on available CPUs, they have developed and planned new embedded modules and systems to continue to provide customers with innovative products for applications in the IoT and Industry 4.0 area. In addition to secure and rugged hardware, a major component of an IoT/Industry 4.0 solution is the software. This results in the requirement that all data should be accessible everywhere and at any time. Everything should also be securely protected against attacks or manipulation. One possibility is a private cloud to which only one certain user segment has exclusive access. However, this requires increasing computing power, which results in undesirable higher power dissipation. There are databases that can meet these requirements, now also for small computing cores in the ARM area. All necessary information is retained for users and authorized users from the generated data with little computing power.

In IoT, sensor devices generate an incredible volume of data, which is distributed over countless decentralized networks. While a majority of this data is sent to centralized cloud services, routers and gateways (edge devices) are empowered to save and manage data for local analyses and queries. Relying completely on back-end or cloud services would limit the volume of information that could be captured and would pose a serious security risk.

SQL database enables embedded systems with lower performance to compress the raw data into meaningful information. By identifying recurring information and comparing certain patterns across different data sources, an embedded system can make intelligent decisions and offer helpful recommendations for keeping the information available. Database indices ensure that data can be processed with uniform performance and without overhead, regardless of the data volumes that are logged on each individual device. Database transactions protect the data and prevent corruption after an unexpected system failure at the same time. The use of an SQL database allows to simultaneously perform several actions through a multitasking process. A single database file is distributed reliably and efficiently.

If at all possible, users should not implement a data management framework that is customized, because this is usually very expensive and also often does not bring about the desired results. A market trend can be noted here: it is advisable to implement the requirements via a library solution that is well-supported and tested by the manufacturer. This offers easy development and maintenance in conjunction with an embedded ARM module. If developers use a TQ module or a platform with a previously modified ITTIA-SQL database solution for a development effort, this allows them to focus primarily on their application development and rely on a solution component to obtain the best data management configuration for the respective planned application.

Starting with Industry 1.0 through to Industry 4.0 the automation industry has seen an immense and rapid development. The most effective implementation is best achieved with partners that can rely on many years of development experience and solution expertise. Particularly in the area of embedded solutions, the ARM architecture constitutes a reliable, solid platform with long-term availability for the solutions of the future with an ecosystem best suited for this. ■