Case Study – Collect and visualize data
with the TQMa65xx/MBa65xx

A head below the cloud – a clear view in the fog

Technology
in Quality

Smart specialization – improved computing power and communication capability

In automation, the classic approach of hierarchically structured field, control and operator levels is increasingly dissolving. Concepts such as edge & cloud computing are being supplemented by fog computing – which are also three "levels", but with a different weighting of intelligence and communication. Depending on requirements, an IIoT/edge device may have more intelligence than an upstream server in the cloud. This does not always have to be achieved with raw computing power, but can also be achieved through smart specialization. The semiconductor industry has been stimulating this development for years with its higher and higher levels of integration processors or systems on chip (SoC).

In addition to this smart computing power, communication capability is also playing an increasingly important role – and here Ethernet is the clear driver of development: with one communication protocol from the sensor all the way up to the management system or even the sales computer – keyword series production with lot size one, an objective of Industry 4.0.

In addition to the shifts in the levels of abstraction, changes are also emerging in the real world: Intelligence is moving progressively closer to the place where things happen, i.e. it is built into the IIoT device at the edge. As a result, size and heat generation are playing an increasingly important role. The solution is scalable device families that have integrated in the chip exactly what is really needed in the application – everything that unnecessarily consumes space and power is removed. This is with the constraint of identifying efficiency potential at the system and network level.

Consolidate visualization

be connected?' If not, the graphics unit and the display interfaces are omitted – we also speak of "headless" applications in this context. The visualization of status and processes is purposefully made remotely accessible. In theory, the visual representation can take place in the cloud, but in practice, the user might want to have a display on site – not necessarily on each individual device, but close to them, so that they can intervene if something does not meet expectations. Experienced users often "feel" that something in their production is starting to get out of control and then want to take countermeasures.

This task could also be performed by the "visualization computer" or anamoly detection in the fog. However, it needs the appropriate bandwidth to collect the data from the IIoT devices and the computing power to evaluate it using predictive maintenance methods. In addition, this computer can also take on higher-level control or coordination tasks, i.e. the usual tasks of the classic operator level. The entity is like the director of an orchestra – it does not have to know each sheet of music of the individual musicians, but must connect and coordinate them to perform as a unit.

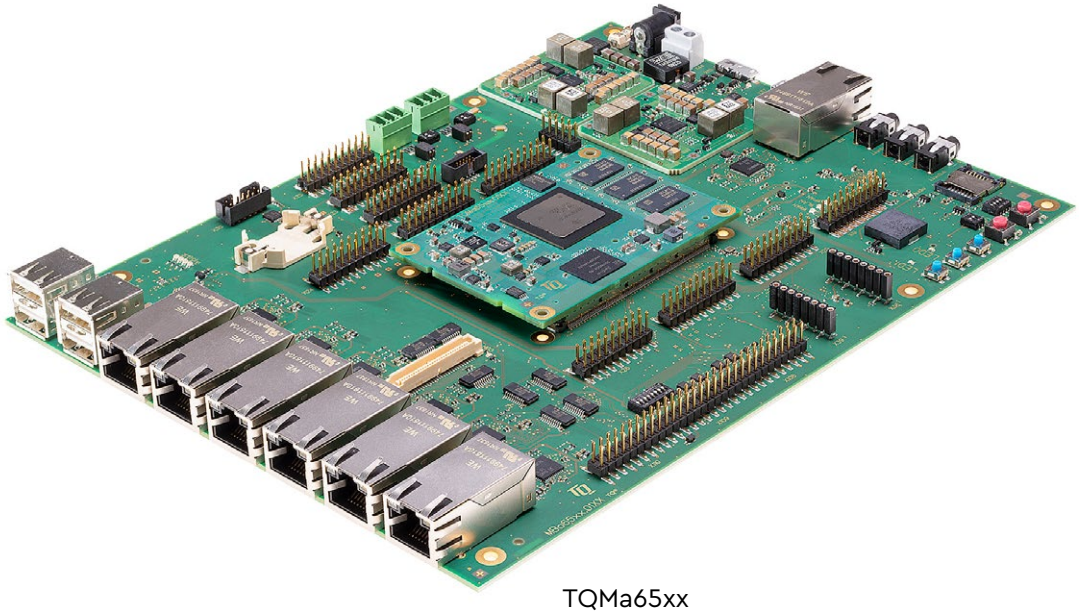
Clear separation of operational technology through Fog calculator

Sometimes a fog computer must also be able to separate devices and networks, especially when data security is at risk: The networks of OT (Operational Technology) and IT should be clearly kept apart and additional payloads such as encryption must not burden the deterministic latency of the OT networks. A computer in the fog that serves as a gateway and firewall – i.e., only allows the necessary data through and encrypts and decrypts it accordingly – is often the favored solution. This means that many real-time capable Ethernet interfaces are required to evaluate the individual lines of the OT and, in addition, at least one additional Ethernet port that connects to the cloud. Thanks to the latter, the real-time Ethernet channels can be freed from the cryptographic overhead, which can be non-deterministic in its timing.

The most obvious task for a fog computer, however, remains visualization. It places high demands on the hardware, since high resolutions and 3D graphics are often required to clearly display the running processes. In addition, there have to be suitable interfaces for the respective displays or monitors.

Important factors in choosing the right computing platform

Beyond the application-specific functions, other factors play a significant role in choosing the right computer platform. A fog computer that collects, selects, coordinates and visualizes data is in continuous use and the power consumption is a cost factor that should not be underestimated. Every watt counts twice, on the one hand at the utility meter, and on the other hand also in the cooling effort. The latter is made up of the material and installation costs for the heat dissipation measures, the cooling costs for the room charged with waste heat, and the maintenance costs for replacing filter mats and fans.



TQMa65xx
with mainboard MBa65xx

Scalable – even across product families

The paradigm shift in automation towards edge/fog/cloud concepts means a realignment of tasks and competencies and thus changing performance requirements for the electronics used. The best way to approach the challenges is with a very widely scaling processor family. In this way, the most diverse applications can be provided with the most suitable performance and interfaces. A success factor that should not be underestimated is the appropriate software development environment, which enables developers to create solutions quickly and efficiently without having to change tools, which requires a lot of training – in other words, a tool chain across the entire processor platform and for several product families.

Even if the fog computer is decoupled from the real-time applications of the individual edge devices, real-time responsiveness may well be required as part of the overall system. Here, too, an end-to-end software development chain from the edge device to the fog computer will score points.

The location of a fog computer must also be taken into consideration. For example, many factory floors have a much harsher climate than the usual IT-installed enterprise desktop computer can withstand:

» Temperatures that are too high or too low, in combination with dust and vibrations, take their toll on the electronics. «

If these have to be encapsulated against the particularly harsh environment, then the size quickly becomes an issue.

An overview of the most important requirements for a fog computer:

- Many real-time capable Ethernet channels
- High screen resolution
- Real-time capability
- Optimized power consumption
- Scalable architecture
- Consistent development tools
- Withstand harsh environmental conditions
- Long lifetime

Practical solution with modular technology

TQ-Embedded meets these diverse requirements with the embedded module TQMa65xx and the mainboard MBa65xx. They are based on the Texas Instruments AM65x processor. It combines four or two Arm® Cortex®-A53 cores with a dual Arm Cortex-R5F MCU subsystem that includes functional safety features and three Gigabit industrial communications (PRU_ICSSG) subsystems into a system-on-chip. TQ enhances this CPU to an executable system, among other things with memories, security elements and power management. For visualization tasks, the AM65x has a 3D GPU supporting a resolution of up to 1920 × 1200 pixels. The TQMa65xx is capable of dual-display output via 24-bit RGB LCD and LVDS interfaces. In addition, with MIPI-CSI2 and 16-bit video IN, two camera inputs are available for video communication or monitoring tasks.

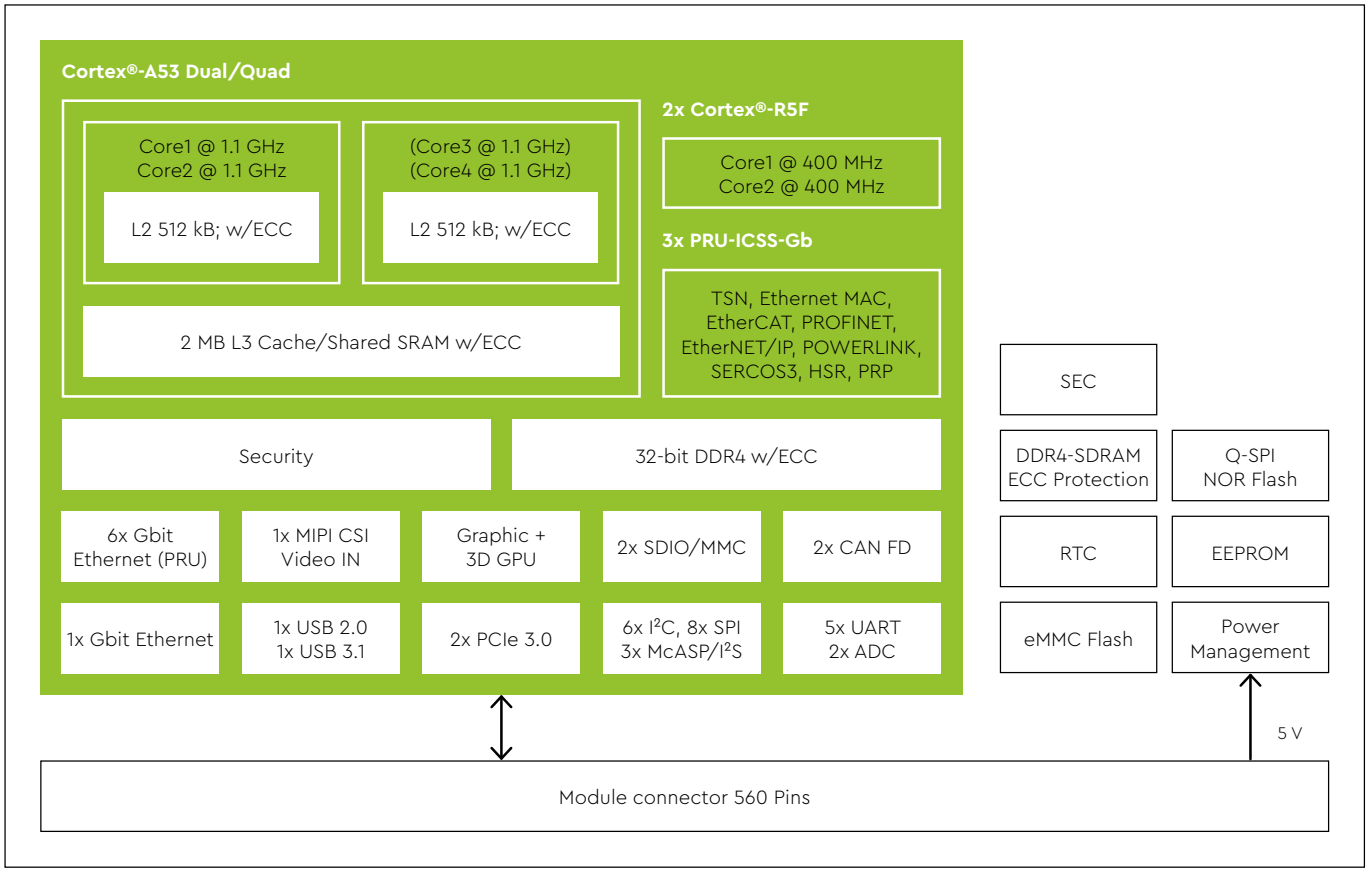
» With up to six real-time capable Gbit Ethernet ports (industrial Ethernets incl. TSN), even more extensive industrial applications can be realized. «

Those who want it to be particularly deterministic can connect only one transmitter/receiver to each of these ports and are thus freed from network collisions.

In addition, there is an additional TSN capable Gigabit Ethernet port for communication with the cloud/IT. In the case of the MBa65xx, the Ethernet connectors are also clearly physically separated: On one side are the six real-time capable ports, on the other side is the socket for the Ethernet for the cloud – anyone who wants literally to pull the plug here in a hurry will find it immediately.

» The processor is already well equipped for security «

Cryptographic acceleration and secure booting are available on the AM65x in addition to granular firewalls managed by the DMSC (Device Management and Security Controller). The Arm Cortex-M3-based DMSC acts as the master for system security and protects security assets at runtime. This is supplemented on the TQMa65xx by a secure element as an additional chip.



With its size of 77 mm x 55 mm, the TQMa65xx requires very little space and is therefore also suitable for difficult installation conditions. The power consumption is typ. 6 W. The standard temperature range is from -25 °C to +85 °C, optionally available in an extended temperature range of -40 °C to +85 °C.

Thanks to the Cortex R5F cores, TQMa65xx and MBa65xx can also take on real-time tasks and thus extend the usual narrow range of tasks of an operator level computer to flexible fog solutions. Adaptability in particular is the key to realizing the Software Defined Factory concept: The individual devices can be configured accordingly for the respective manufacturing task – from the cloud or with a suitable Fog computer.

Exemplary scalability

The scalability of the AM65x series from Texas Instruments is greater when you include two other series, the AM64x and AM24x. They are both designed for headless applications, so they do not have a power-intensive GPU and display/monitor interfaces. Thanks to their Arm R5F cores, they are excellent for real-time applications. Not only do they share many hardware components with the AM65 series, the software development environment is the same. This allows developers to work with the same tools with the different device families.

The following table shows the scalability in practical use as TQ modules:

	TQMa65xx				TQMa64xxL						TQMa243xL		
Feature	AM6548	AM6546	AM6528	AM6526	AM6442	AM6441	AM6422	AM6421	AM6412	AM6411	AM2434	AM2432	AM2431
Number of Cortex A53	2 x Dual Core	2 x Dual Core	Dual Core	Dual Core	Dual Core	Single Core	Dual Core	Single Core	Dual Core	Single Core	–	–	–
Clock rate A53	1,1 GHz	1,1 GHz	1,1 GHz	1,1 GHz	1 GHz	1 GHz	1 GHz	1 GHz	1 GHz	1 GHz	–	–	–
Number of Cortex R5F	1 x Dual Core Cluster	1 x Dual Core Cluster	1 x Dual Core Cluster	1 x Dual Core Cluster	2 x Dual Core Cluster	2 x Dual Core Cluster	1 x Dual Core Cluster	1 x Dual Core Cluster	Single Core	Single Core	2 x Dual Core Cluster	2 x Single Core	Single Core
Clock rate R5F	400 MHz	400 MHz	400 MHz	400 MHz	800 MHz	800 MHz	800 MHz	800 MHz	800 MHz	800 MHz	800 MHz	800 MHz	800 MHz
Number of Cortex M4F	–	–	–	–	1	1	1	1	1	1	1	1	1
Clock rate M4F	–	–	–	–	400 MHz	400 MHz	400 MHz	400 MHz	400 MHz	400 MH	400 MHz	400 MHz	400 MHz
Number of Gbit Eth	1	1	1	1	2	2	2	2	2	2	2	2	2
Number of real-time Gbit Eth (PRU based)	6	6	6	6	4	4	4	4	0	0	4	4	4
Number of CAN-FD	2	2	2	2	2	2	0	2	0	0	2	2	2
Number of PCIe	2	2	2	2	1 x shared with USB3.0	1 x shared with USB3.0	1 x shared with USB3.0	1 x shared mit USB3.0	1 x shared mit USB3.0	1 x shared mit USB3.0	1 x shared mit USB3.0	1 x shared mit USB3.0	1 x shared mit USB3.0
Number of USB3.0	1	1	1	1	1 x shared mit PCIe	1 x shared mit PCIe	1 x shared mit PCIe	1 x shared mit PCIe	11 x shared mit PCIe	1 x shared mit PCIe	1 x shared mit PCIe	1 x shared mit PCIe	1 x shared mit PCIe
Number of USB2.0	1	1	1	1	1	1	1	1	1	1	1	1	1
Number of UART	5	5	5	5	9	9	9	9	9	9	9	9	9
Number of I2C	6	6	6	6	6	6	6	6	6	6	6	6	6
Number of Q/OSPI	2 x QSPI	2 x QSPI	2 x QSPI	2 x QSPI	1*	1*	1*	1*	1*	1*	1*	1*	1*
Number of SPI	8	8	8	8	7	7	7	7	7	7	7	7	7
Number of GPIO	GPIO	GPIO	GPIO	GPIO	GPIO	GPIO	GPIO	GPIO	GPIO	GPIO	GPIO	GPIO	GPIO
Number of ADC (12bit)	2	2	2	2	1	1	1	1	1	1	1	1	1
Number of Display	1 x RGB 1 x LVDS	1 x RGB 1 x LVDS	1 x RGB 1 x LVDS	1 x RGB 1 x LVDS	–	–	–	–	–	–	–	–	–
Graphic accelerator	3D GPU	–	3D GPU	–	–	–	–	–	–	–	–	–	–
Number of MIPI-CSI	1	1	1	1	–	–	–	–	–	–	–	–	–
Operationg system	Linux				Linux / Real-time OS Support						Real-time OS Support		
Compatibility	PPin & software compatible on one connector-module design				Pin & software compatible on a LGA design						Pin & software compatible on a LGA design		
Module expansion	DDR4 up to 4 GB, eMMC up to 64 GB, EEPROM 64 kB, NOR Flash up to 512 MB, RTC, Security Element				LPDDR4 up to 2GB, eMMC up to 64 GB, EEPROM 64 kB, NOR Flash up to 512 MB, RTC, Security Element								
Applications	Industrial control with real-time application, fieldbus slave applications, industrial process monitoring/control, measurement technology, industrial gateways, home automation, data collectors, cloud applications, smart grid, infrastructure, medical technology, aviation, railroad technology												

*reserved for NOR Flash

TQMa65xx also suitable for classic use suitable for field, process and control levels

The modules are not only suitable for the modern automation approach with edge/fog/cloud, they can also easily handle the tasks of the classic field, control and operator level concept. In this way, they bridge the gap between the old and new solution approaches, enabling an almost seamless transition. After all, converting an existing and producing manufacturing plant requires considerably more than putting a new concept with a new factory on a greenfield site – in this case, a conversion is to be carried out in the least invasive steps possible.

Users of TQ's modular technology are therefore well equipped for existing plants and future projects. With a long-term availability of more than 15 years, there is also delivery reliability even in the event of unwanted project delays and very long operating times. With a sophisticated obsolescence management strategy, TQ protects its products, such as the TQMa65xx and MBa65xx, from unexpected changes and discontinuations – which in the current market situation is an essential part of the product life cycle measures. This means that the products are available even for very long project durations.

›› Long-term availability for long-term success ‹‹

Darüber hinaus unterstützt TQ die Kunden gerne mit diversen In addition, TQ is happy to support customers with various obsolescence management services. As an experienced E²MS company and system provider, the TQ Group can offer numerous services in addition to the modules, providing support in many phases of product development and manufacturing. This is of particular importance for start-up companies that have limited manufacturing resources and see their core competence more in software and cloud services – the hardware part of their projects is gladly taken over by TQ. In addition, the company's own Product Compliance Center is approved to perform electromagnetic compatibility testing, product safety testing and environmental testing.

TQMa65xx
Arm® Family

Your contact

Andreas Willig
Product Management

P +49 8153 9308–290
M +49 176 109 309 13
@ Andreas.Willig@tq-group.com

Contact now.

TQ-Systems GmbH
Gut Delling | Mühlstraße 2 | 82229 Seefeld
www.tq-embedded.com | embedded@tq-group.com

Technology
in Quality