Weighing Data Integration

Future-Proof Weighing Data Integration

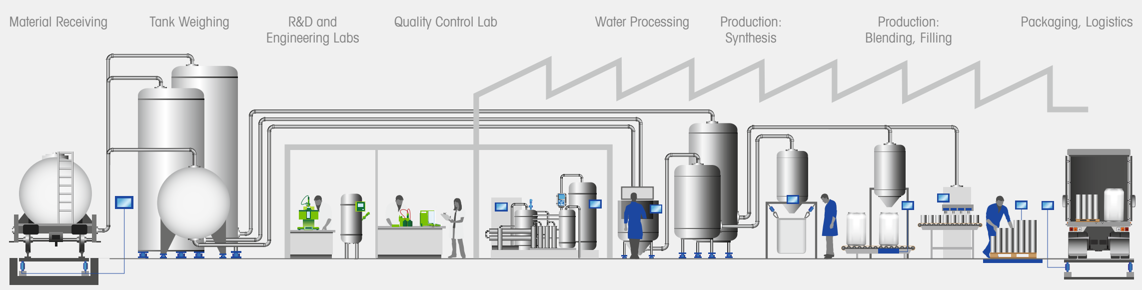
Cloud, IT and Control System Connectivity

Standardization is the prerequisite for successful digitalization. New data exchange standards offer possibilities that change the traditional device and data hierarchies through the merger of operational technology (OT), information technology (IT) and Cloud-based applications and storage. This whitepaper provides an orientation about up-to-date weight-data integration for machine and instrument manufacturers, system integrators and end users.

Content:

METTLER TOLEDO

1 Weight Data Environment



1.1 Weight data uses

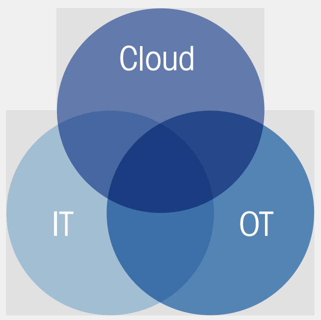
Weight measurements are often an important part of manufacturing or system design. Though not exclusive, there are typically two key uses for weight information:

1. To register a financial transaction where weight is an agreed measurement and exchange medium for either business-to-business (b2b) or business-to-consumer (b2c) transactions.
2. To use as a control variable in a manufacturing system. For example, weight is one of the most accurate and repeatable methods of filling containers for both b2b and b2c transactions when compared to other technologies.

Because these uses influence the cost and/or quality of manufactured products, the smart integration of weight data in manufacturing or system-integration operations is critical.

1.2 Overlapping technology families for data integration

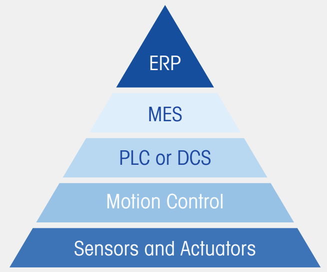
In today's manufacturing, OT, IT and Cloud technologies converge and it is often not easy to determine which functionality should be realized with which technology family.



Cloud, Operational and IT-Technologies overlap more and more over time.

In general, there is no rule that can be applied for all situations. The ideal solution can be different for the same application in different industries or even in the same industry for different customers. This paper will address various data-exchange technologies and their potential uses in Section 2.

1.3 New communication pathways



“The traditional ISA95-Pyramid illustrating the hierarchy in Automation is being substituted by any to any communication.”

New technologies now enable the design of new device network architecture enabling any-to-any communication. The future will show when and if any-to-any provides benefits and becomes a reality on the manufacturing floor. However, it is certain that the traditional ISA95 hierarchy will be replaced by a less rigid, more flexible structure allowing users to connect any device to any device depending on their specific requirements such as the requirement for more data.

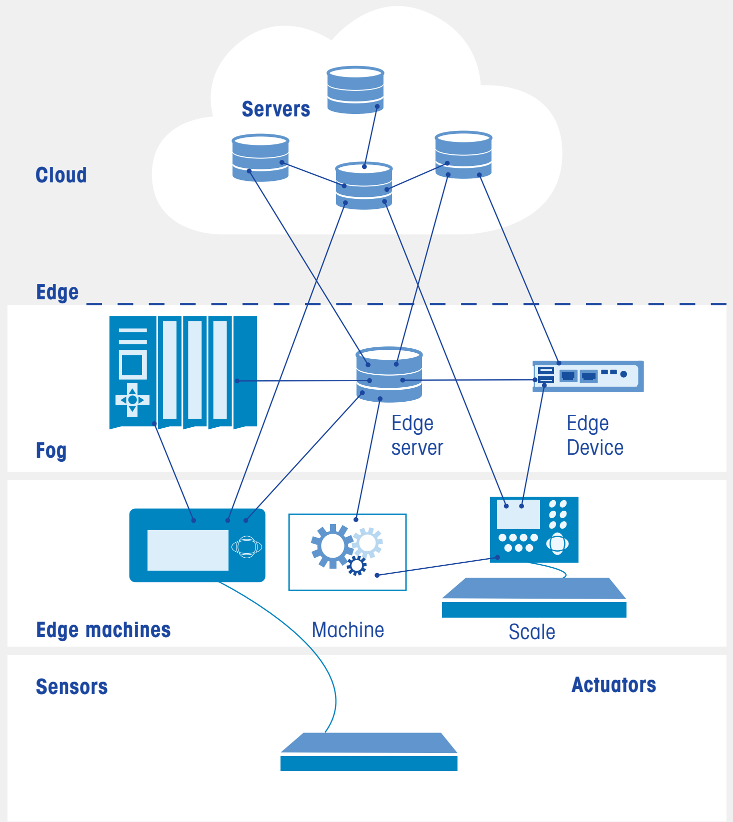


Illustration of "any-to-any" communication architecture.

2 Data Exchange Technologies

Weight data is now available in two Ethernet-based server or cloud-oriented protocols: Open Platform Communications Unified Architecture (OPC UA) and Message Queuing Telemetry Transport (MQTT). These technologies interact with existing industrial protocols, often at the point of programmable logic control as noted in section 2.3. These existing machine-to-machine (m2m) technologies are often preferable inside processes for their ease of integration.

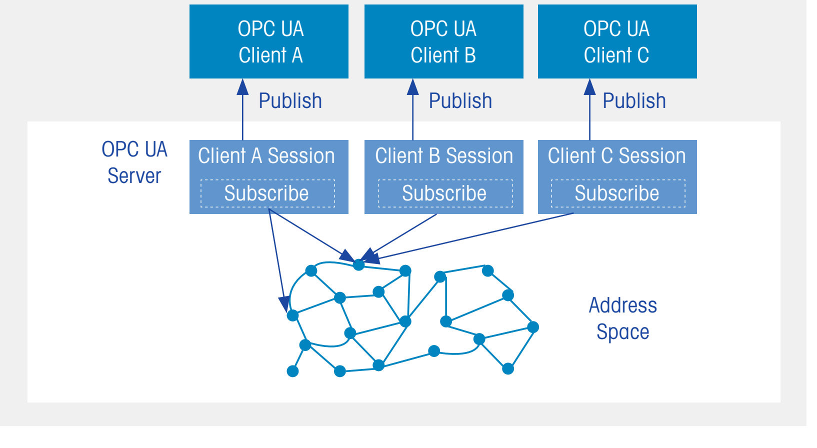
The sections that follow review the current capabilities and typical use of each technology.

2.1 Open Platform Communications Unified Architecture (OPC UA)

#	Server	Node Id		Display Name	Value	Datatype
1	10 MTIC Primary (PreConfigured)	NS5	Numeric	Device Class	Weighing Device	LocalizedText
2	10 MTIC Primary (PreConfigured)	NS5	Numeric	Manufacturer	Mettler Toledo	LocalizedText
3	10 MTIC Primary (PreConfigured)	NS5	Numeric	Model	ICS689	LocalizedText
4	10 MTIC Primary (PreConfigured)	NS5	Numeric	SerialNumber	2482741673	Null
5	10 MTIC Primary (PreConfigured)	NS5	Numeric	SoftwareRevision	4,7	Null
6	10 MTIC Primary (PreConfigured)	NS5	Numeric	DeviceManual	www.mt.com/ind-xxxxxxxxxx	String
7	10 MTIC Primary (PreConfigured)	NS5	Numeric	DeviceHealth	Run	Int32
8	10 MTIC Primary (PreConfigured)	NS5	Numeric	Gross	763,1	Double
9	10 MTIC Primary (PreConfigured)	NS5	Numeric	Net	500,0	Double
10	10 MTIC Primary (PreConfigured)	NS5	Numeric	Tare	263,1	Double
11	10 MTIC Primary (PreConfigured)	NS5	Numeric	RegisteredWeight	500,0	Double
12	10 MTIC Primary (PreConfigured)	NS5	Numeric	WeightUnit	g	Null
13	10 MTIC Primary (PreConfigured)	NS5	Numeric	WeightStable	true	Boolean
14	10 MTIC Primary (PreConfigured)	NS5	Numeric	InsideZero	true	Boolean
15	10 MTIC Primary (PreConfigured)	NS5	Numeric	Invalid	false	Boolean
16	10 MTIC Primary (PreConfigured)	NS5	Numeric	TareMode	true	Boolean
17	10 MTIC Primary (PreConfigured)	NS5	Numeric	Underload	false	Boolean
18	10 MTIC Primary (PreConfigured)	NS5	Numeric	Overload	false	Boolean

Live view with OPC UA client showing data nodes and weight variables.

OPC UA currently uses a client-server model for data exchange. The OPC Foundation has completed an enhancement that uses a publisher-subscriber model with a broker. This enables a sensor or scale to provide, or consume, even more customer and process-relevant data to many servers either in the facility (inside the "Edge") or in the Cloud. Data is provided in an easily usable format that considers both machines and humans.

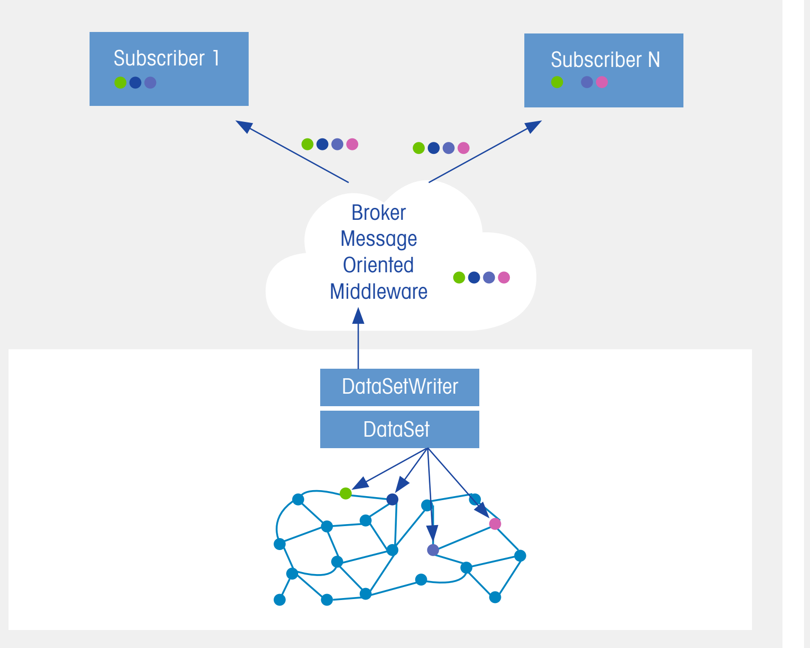


An OPC UA server is able to provide data for a multitude of clients inside and outside of the facility.

2.2 Message Queuing Telemetry Transport (MQTT)

MQTT is a compact, easy-to-implement standard that is ideal for connecting devices with small computing capabilities to the Industrial Internet of Things. MQTT first rose to prominence within the oil and gas industry as a means of remotely managing pipelines. Today, MQTT is the core protocol used to connect millions of varying devices in all nature of industries.

MQTT uses a publish-subscribe communication model where all information passes through a broker.



In MQTT, a broker distributes data.

MQTT uses a broker as a server to route published messages to the subscribers.

2.3 Industrial protocols

For many customers the cloud connection starts at the programmable logic control due to the necessity to make sense of multiple sensor inputs such as speed, temperature, pressure, etc. Below the control system, manufacturing weight data used for control purposes must be fast and deterministically available. Speed in m2m communication is measured in the millisecond range. However, for repetitive processes such as filling, the data must be available in consistent, known and predictable time periods. This is called determinism. The following industrial protocols are typically used at the machine level because of their ability to provide the required determinism repetitive manufacturing processes rely on.

2.3.a. Industrial Ethernet (IE)

This class of automation networks is higher bandwidth meaning that it can transfer more data both quickly and deterministically; therefore, IE is widely accepted in factory automation for almost every control function. Unlike typical TCP/IP Ethernet, there are many specifications for IE where the sponsorship, or primary driver, is usually is an automation company such as Rockwell, Siemens, or Beckhoff or an organization like the Open Device Vendors Association (ODVA). Unfortunately, there is no commonality between these quasi-proprietary networks.

There are two types of operations in an IE-based system: Acyclical and cyclical. Acyclical allows one-time data transfer for functions such as reading a data array or facilitating a command such as "zero the scale". Cyclical protocols allow a control system to see streaming data from the weighing system or sensor. This data stream includes the weight values as well as the status including alarm conditions, heartbeat and data-okay. The stream can also include motion, temperature, and center-of-zero indications.

IE device drivers facilitate easy, seamless integration of devices such as scales into automation systems. Device drivers make it easy to integrate third-party devices to reduce the amount of programming required to initialize a new system. These files are made available either in engineering tools or on the vendor website.

Most vendors claiming compatibility to one of these IE networks must be laboratory-certified in order to claim compatibility. This assures that the automation infrastructure is robust and failure-free. Certification certificates are available on each organization's website.

Self configuring drivers facilitate easy, and seamless integration of devices such as scales or weigh modules into automation systems.

2.3.b. EtherNet/IP

EtherNet/IP (EIP) was originally sponsored by Rockwell Automation, though it is now managed by the ODVA. Many additional suppliers such as Schneider, Keyence and Omron have adopted EIP into their programmable automation controls. Device drivers for EIP are called Electronic Data Sheets (EDSs). Rockwell promotes Add on Profiles (AOPs) and Custom AOPs. EDS files should work on the machines of all automation manufacturers but AOPs will only work on Rockwell machines.

2.3.c. PROFINET

PROFINET is available in two forms. The first is PROFINET which is ideal for weighing devices. PROFINET IRT is another form used for time-critical activities such as drive and robot control.

Many automation companies either support PROFINET as their primary network or offer it as an alternative in their programmable automation controls. PROFINET device drivers are called Generic Station Device Markup Language (GSDML) files and are available from Profibus International.

2.3.d. EtherCAT

EtherCAT was introduced by Beckhoff Automation to be an extremely fast and deterministic network managed by the EtherCAT Technology Group. EtherCAT is found in many high-performance machines and robots. EtherCAT drivers are available in the form of .esi files.

2.3.e CC-Link IE Field Basic

CC-Link IE Field Basic is one of the simplest forms of CC-Link communication introduced by Mitsubishi Electric and the CC-Link Partner Association with focus on cyclical (repetitive) communication. CC-Link is found in many automation systems in the automotive market. CC-Link IE drivers are available in the form of CSPP files.

2.3.f ModBus TCP

Modbus TCP is one of the oldest Industrial Ethernet variants and is found in systems products produced by Group Schneider. Modbus TCP uses its own protocol definition meaning that it does not use the Standard Automation Interface protocol (mentioned below) promoted by METTLER TOLEDO for weight data.

2.4 Control Systems - Standard Automation Interface (SAI)

The Standard Automation Interface has been developed specifically for handling the exchange of weighing data.

This protocol is designed and optimized by METTLER TOLEDO for very high-speed IE communication such as PROFINET and EtherNet/IP (Profibus is also supported). SAI was designed to make it easy for customers to quickly connect to METTLER TOLEDO industrial automation components such as indicators, transmitters and automatic precision weighing sensors. It also facilitates the use of lab balance mass comparators, bench, floor and weigh module systems so that the systems engineers see the same weight data from one microgram up to several thousand tons without changing the automation controller program. The use of scientific units (metric) and floating-point weight values makes weight integration simple through cyclical and acyclic data transfer and control.

SAI supports condition monitoring and Smart5™ alarming that automatically notifies the automation system when the sensor or scale is incapable of sending accurate weight. Smart5™ is not polluted with distracting low-level nuisance alarms.

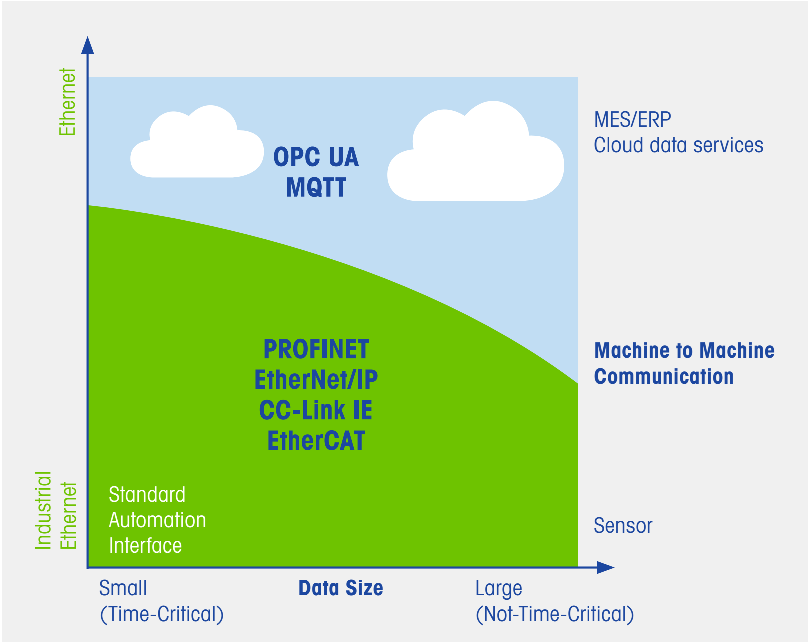
2.5 Overview of data exchanges, industrial protocols and their uses

It is generally accepted that very time-critical digital input/output (IO) data should be exchanged via PROFINET or EtherNet/IP, EtherCAT, PROFINET, CC-Link IE Field Basic, Modbus TCP on a micro- or machine-level, while large data volumes should be exchanged via OPC UA, MQTT or any Ethernet protocol. In between these extremes, however, is a gray zone. The right decision requires thoughtful evaluation of aspects such as time criticality, data volumes, installed base and integration efforts.

In theory, it is possible to operate time-critical technologies as PROFINET or EtherNet/IP and non-time-critical technologies such as OPC UA in the same network.

As detailed in Appendix A, various types of weighing data are used for control functions within the machine or manufacturing environment. Functions such as zero, tare, clear, and motion must often be communicated using time-critical methods in cyclical formats to ensure that actions are not repeated.

In practice there is an overlapping zone between the different network technologies. The ideal solution depends on time criticallity, data volume and already installed base.



For automated control systems in OT, this data transmission can be a handshake exchange via digital I/O. For IT or Cloud systems, OPC UA methods are available that eliminate the need to program handshakes. The only thing necessary is a call for the method (e.g. Preset Tare Weight). The OPC UA server then ensures input is received correctly and that the scale or sensor is ready for the next operation.

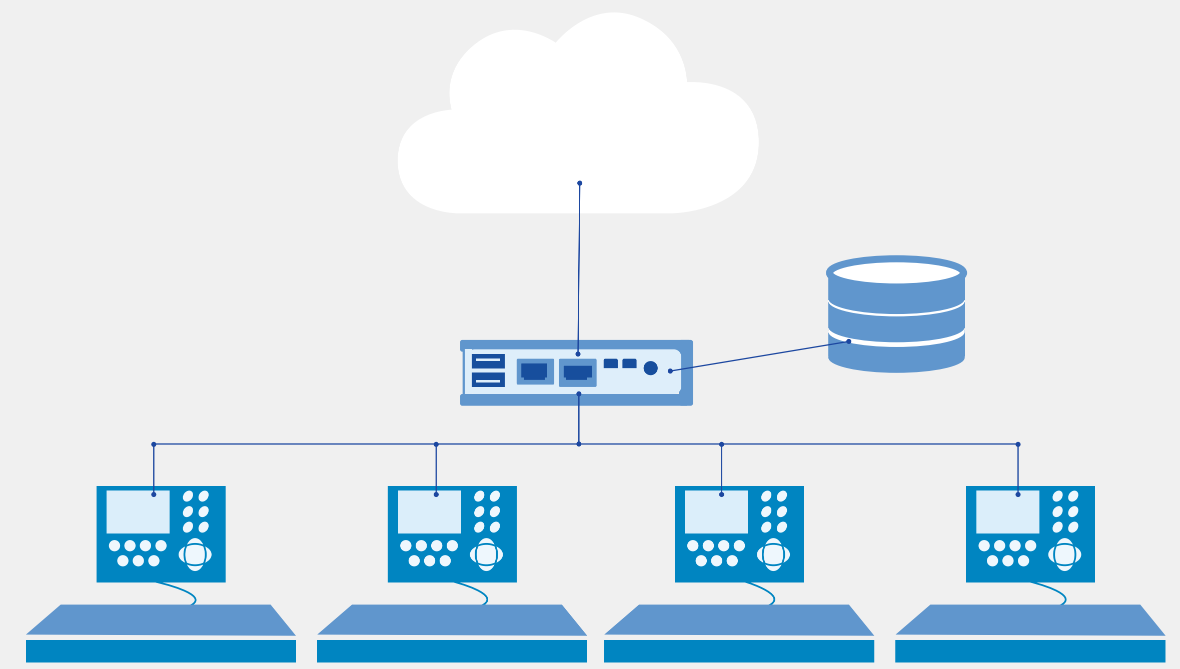
2.6 Gateways for OPC UA and MQTT

Gateways consists of software installed on dedicated hardware or on hardware with other applications. It converts data from one data-communication standard to another.

Gateways are helpful when a product does not have the required communication technology onboard. Gateways are also used to upgrade existing equipment with state-of-the-art data communication to update existing brownfield installations and extend their profitable life.

3 Updating Brownfield / Legacy Installations

Legacy communication technology can be the bottleneck when upgrading existing equipment with state-of-the-art condition monitoring and data collection. Gateways offering communication via OPC UA and MQTT standards can update existing brownfield installations to extend their profitable life.



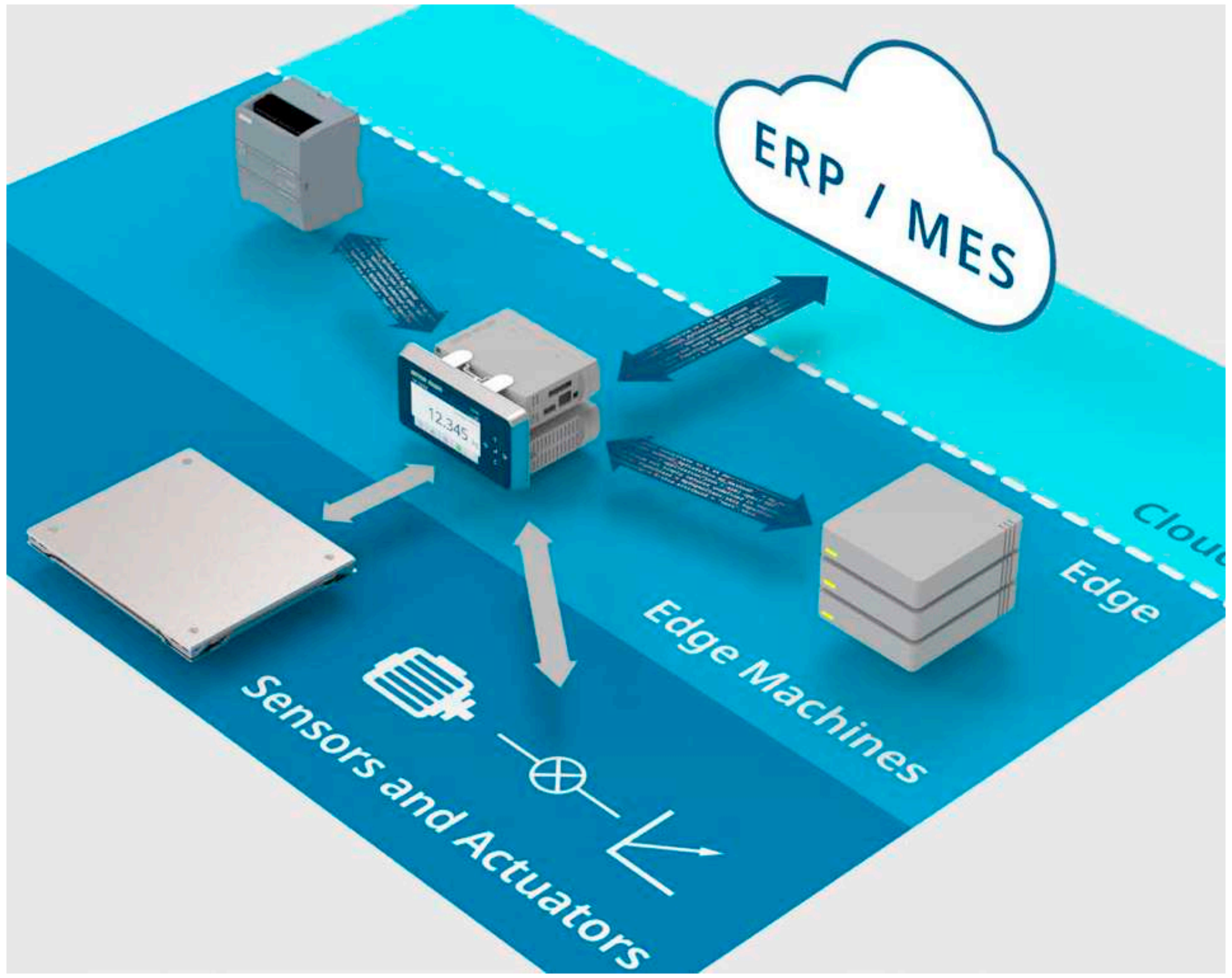
New or existing scales, connected to an edge device, offering server and cloud conectivity.

Edge devices offering communication via OPC UA and MQTT standards can update existing brownfield installations to extend their profitable life.

4 Smart Factories – Green Field Installations

Many new factories share automation control data and information data on the same networks simultaneously communicating with a Programmable Automation Controller and a server running the Enterprise Resource Planning (ERP) or Manufacturing Execution System (MES) software.

This means that now automation networks such as EtherNet/IP and PROFINET carry valuable weight information, device condition and production data via OPC UA. A new weighing indicator eliminates the necessity to use protocol converters and edge gateways to reduce the cost and complexity of each production scale.



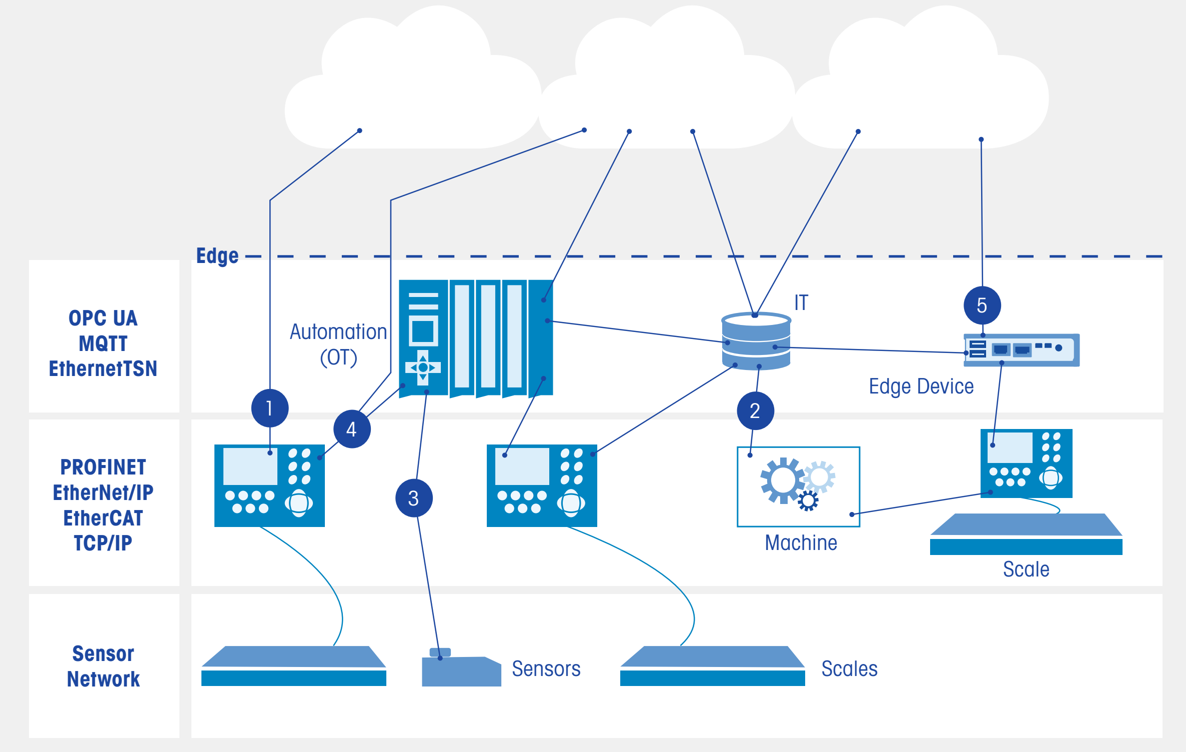
One device combines automation and control functions for simplicity and cost savings

5 METTLER TOLEDO Offerings

METTLER TOLEDO offers different solutions for each technology but also creates the possibility of intelligently combining them.

Standalone, human-powered scales should include IT and Cloud connectivity via OPC UA or MQTT, while machine-integrated weighing devices mostly communicate with the control system via PROFINET or EtherNet/IP.

In the event transaction and condition data must be sent out of the integrated weighing device to IT systems or the Cloud, values are typically transferred via the control system. However, METTLER TOLEDO offers solutions that can connect to either PROFINET or EtherNet/IP and OPC UA or MQTT in parallel.



Overview of connectivity choices for standalone and machine-integrated weighing devices.

The following sections describe the METTLER TOLEDO technologies that enable such communication.

1. Direct connection to Cloud.
2. Direct connection to IT and indirect to Cloud.
3. Direct connection to the control system and indirect connection to IT/Cloud.
4. Direct connection to control system and IT/Cloud in parallel.
5. Connection through Edge Device with OPC UA / MQTT Gateway.

5.1 ACI400 IIoT Edge Device

The ACI400 IIoT Edge includes an OPC UA server and MQTT client to ensure seamless and secure data integration with IT and Cloud systems. Each ACI400 Edge facilitates connection of up to four weighing devices. Building on weighing-device communication protocols that have been in use by METTLER TOLEDO for decades, the ACI400 Edge connects to older weighing devices, extending their service life.

METTLER TOLEDO offers different solutions for each technology and intelligently combining them.

ACI400 IIoT Edge Device

5.2 Weight Indicators

Weight indicators offer a human-machine interface (HMI) allowing an operator to view the measurement, device status and alarm information. In addition, they may start an automatic application or perform control functions such as zeroing or tare operations. A weight indicator can include automated applications such as filling, dosing, tank / vessel, dynamic parcel weighing and rate control. HMIs are a requirement for legal-for-trade applications to visualize the weight information according to legislative frameworks such as NIST Handbook 44 or OIML. Generally speaking, weighing devices must include a display to gain local approval. New indicators such as the IND360 facilitate direct connection to a control system, server or cloud without an edge device to reduce cost and complexity.

Weight indicators provide both OT and IT data with condition monitoring and smart alarms.

IND360 Weight indicators with HMI and Industrial Ethernet

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5.3 Weight Transmitters

A transmitter is the most cost-effective connection between a control system and a weighing device when the control is provided by programmable automation/logic controller. Modern transmitters communicate with traditional strain-gauge, precision and POWERCELL® sensors and scales. Setup, configuration, calibration and adjustment are provided through an internal web interface. Fast weight calculation and communication via IE provides more precise control, heightened quality, and cost savings.

METTLER TOLEDO transmitters meet global weights-and-measures requirements and are now available for hazardous-area use.

METTLER TOLEDO globally approved and indicators deliver weight and status information to a control system in miliseconds.

ACT350 and IND360 transmitters with high speed Industrial Ethernet

5.4 Sensor

METTLER TOLEDO led the way by introducing sensors with IE connectivity "inside" using the same communication protocols as the transmitter series so that programmers can integrate devices using almost the same code. Fast to ultra-fast stable weight data allows machine builders to increase the efficiency, precision and speed of their machines.

Fast to ultra-fast stable weight data allows machine builders to increase efficiency.

WMF (4 units) and SPC "Smart" sensors include Industrial Ethernet, real-time weight and condition monitoring

Appendix A: Control Provided by Most Weighing Devices

The following are provided by weighing technology in an automated system. Each one is either an automatic action, or a value that is measured to ensure the system provides weighing accuracy.

Gross Zero or Center of Zero
Center of zero indicates that the scale is in an unloaded state. The tolerance of zero is one quarter (1/4) of a measurement interval or division. For example, consider a 1000-kilogram floor scale with a measurement interval is 500 grams; the zero indication range is 0.000 +/-125g. Note that zero commands must not be used to tare the scale because in many weights-and-measures regulated applications, the zero range is limited and does not extend to the full range of the scale. Unlike tare, zero cannot be cleared; it must be reset or adjusted.

Tare
Tare mathematically eliminates the weight value of a container, or other weight, from the gross weight to achieve net weight. In most commercial weighing transactions, the net weight determines the value of the goods. In factory automation, tare is also used also to eliminate component weights when multiple ingredients are added in a formula or batch.

Gross Weight – Tare Weight = Net Weight

Tare clears either when the operator completes the transaction (automatically), or by command from the control system or server.

Zero, Tare and Clear
Zero, tare and clear are normally transmitted acyclically (once). Cyclical commands (repetitive) require that the command be sent only one time to eliminate negative actions resulting from successive commands. In control systems, be sure to use the "immediate" (zero, tare) command, to ignore the scale's motion detector described below. A previously determined tare value can also be transmitted from the host as a numeric value instead; for example, a full container would have the tare value listed on the packing label, barcode, or radio frequency identification. This value would be deducted from the scale's gross weight to arrive at net weight.

Motion
Motion inhibits recording of the weight until vibration, or settling of the object to be weighed, has stabilized. This is a requirement in situations where legal-for-trade is specified. In automated systems, motion indicates that the weight value is in a state of transition. The sensitivity of this in weight units / time can be adjusted in most weighing devices. Motion inhibits zero, tare and print (transact) functions in work places where humans operate the scale.

Minimum Weight
Minimum weight indicates that the item to be weighed has less mass than the measurement capability of the scale expressed as measurement certainty. In non-technical language, the scale is too large for the item to be weighed.

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6 Summary

Future-proof weighing devices enable connectivity to both control systems and clouds using the latest industry standards following demands for more data and speed. METTLER TOLEDO offers many possibilities to join the industry 4.0 revolution and take benefit from weighing products that meet all your current and future needs.
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