

Industrial Data Communication for Automotive Manufacturing

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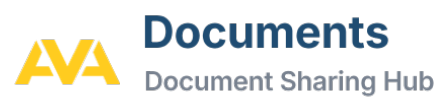


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1. SCOPE

The provisions of this document, attachments, and supplements apply to the creation of a universal methodology for data communication, machine language, and reporting to and from manufacturing devices in the automotive production (Smart Manufacturing) environment.

Universal connectivity is one of the foundational technologies enabling data sharing among participating components of an Industrial Internet of Things (IIoT) system. Connectivity provides the ability to exchange data among participants within a functional domain, across functional domains within a system, and across systems. The data exchanged may include sensor updates, events, alarms, status changes, commands, and configuration updates. Connectivity is a crosscutting function in the Industrial Internet Reference Architecture. It provides the ability to exchange data between participants within and across functional domains (control, operations, information, applications, and business).

2. INTRODUCTION AND BACKGROUND

For automotive companies to remain competitive in the era of Smart Manufacturing, data connectivity and integration between systems must utilize open standards. Supporting legacy proprietary closed systems on the manufacturing floor has created an unacceptable burden of lost time, talents, and profit.

The overarching goal of IIoT connectivity is to unlock data in isolated systems ("silos") to enable data sharing and interoperability between previously closed components and subsystems (brownfield), and new applications (greenfield), within and across industries.

The makers of industrial control equipment currently in use within the automotive industry fall along a continuum of readiness to adopt open standards. To determine the feasibility of establishing a machine data communication standard, a benchmarking exercise was conducted.

Twenty manufacturing equipment OEMs, eleven entities that comprise standards organizations and companies from other relevant industries, plus several industry-recognized subject matter experts were surveyed and benchmarked as inputs to the Concept Feasibility Milestone of a machine data communications standard.

Some of the largest makers of automation controllers actively resist the adoption of open standards as it threatens their longstanding revenue model. Conversely, a market group of process controller companies is aggressively pursuing open standards and innovative product strategies to meet the requirements of Smart Manufacturing. Throughout this landscape two primary communication protocols dominate the marketplace: MQTT (**M**essage **Q**ueuing **T**elemetry **T**ransport: featured by innovative process controllers) and OPC UA (**O**pen **P**latform **C**ommunication **U**nified **A**rchitecture: favored by legacy automation controllers).

A number of integrators and systems experts, acknowledge both these protocols will exist for the foreseeable future, so therefore, efforts to standardize should be focused at the data syntax level, not on the protocol. The widely popular Sparkplug B data standard was proposed for consideration, and after internal discussions with their respective companies the team determined that it needed to develop its own standard starting in 2021.

Figure 1 depicts an overarching future state for Industrial Data that shows data flowing to and from the Industrial Data Sources through the MQTT Broker to and from the Smart Factory Solutions to be implemented.

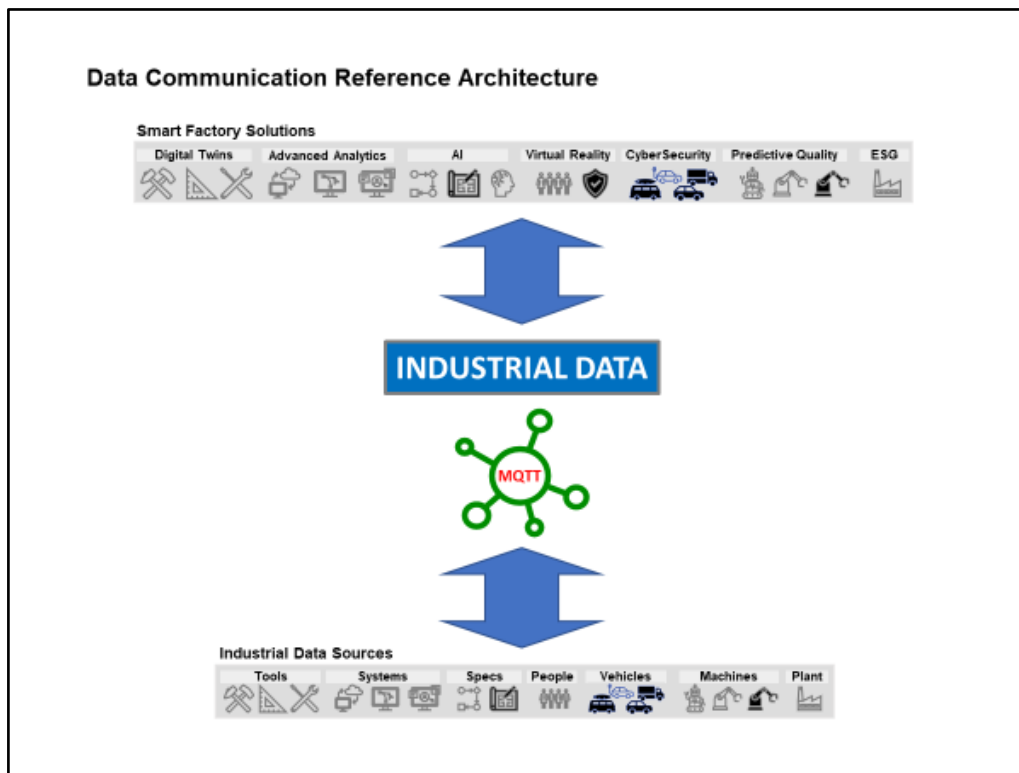


Figure 1 - Data communication reference architecture

2.1 Smart Manufacturing

Smart Manufacturing requires a high degree of automation and integration of systems on the shop floor to deliver optimal performance and ROI.

- These systems have evolved over decades in a highly proprietary, closed manner by the companies who design, build, and sell them.
- The resulting landscape of incompatible machine communication creates costly delays and complexity in product launches for automotive companies.
- Interoperability and extensibility of these machines is imperative to insure cost efficient operation and competitive viability.

2.2 Manufacturing Devices

Multiple devices present data to IT applications in varied and sometimes proprietary methods as defined by the equipment vendors.

- Collection of data from these devices is typically developed from scratch for each new device type or vendor.
- Some of the methods are inherently insecure due to the age or processing capabilities of the devices.
- Some methods are intentionally closed to enable vendors to sell additional software products or analytics services (typically cloud-based SaaS).

3. OBJECTIVES FOR THIS STANDARD

This is a standard specification for Operational Technology (OT) equipment data publishing to be included with Equipment Purchasing specifications Statement of Requirements (SOR). This is a specific Global Standard for the automotive industry and provides the ability to:

- Allow all new equipment to easily plug into manufacturing data analytic tools.
- Specify the Event Types for when data should be created and sent.
- Outline requirements for communication methods implemented and describe the data needed to perform analytics.
- Specify data formats within schemas.
- Devices that shall provide the capability to be configured with the MQTT brokers topics to which they publish and subscribe. Refer to [4].
- Specify Data transport and protocols for consumption by manufacturing data analytic tools.

This document defines the Common Data Model (CDM) Standard Specifications for structuring data from Industrial Control Systems such as Process and Automation Controllers, Sensors, and Actuators in a standard format so that a common IT and Controls solution aligns for all types of data to and from production manufacturing equipment and devices.

This specification provides general data communication requirements. This document shall be followed for all applications and protocols developed for the automotive industry Global standard compliance. This is an overarching standard that defines basic data communication methods but also allows OEMs and suppliers to have additional specifications.

4. INDUSTRIAL MACHINE DATA COMMUNICATION STANDARDS

Industrial Control System Devices including Automation Controllers (i.e., PLC, NC, Robot Controllers), Process Controllers (i.e., Tooling Controllers, Vision, Test), Sensors (i.e., vibration, temperature, current, pressure), and Sensor systems for Maintenance shall support:

4.1 Native Support for Open IIoT Protocols

- Pub/Sub; MQTT (Preferred) Client/Server
- OPC UA (by Exception)

4.2 Native Support for Encoding Dynamic Message Payload Formats

- JSON
- XML (by Exception)

4.3 Configuration Support for Customer Namespace

- Tools to Import Customer specified Namespaces
- Tools for Mapping Device Namespace to Customer Namespace

4.4 MQTT Topics

Devices shall provide the capability to be configured with the MQTT brokers topics to which they publish and subscribe. Refer to [4].

Emerging Best Practice Architecture

Industrial information is sent via the MQTT architecture as described in Figure 2. This enables multiple Enterprise systems to subscribe and ingest various manufacturing data via a pub/sub system known as MQTT. This allows devices to publish data to a broker and applications to subscribe to that data.

The focus of this standard is the portion of Figure 2 to the right of the MQTT broker. Any plant floor device whether legacy or Industrial IoT compliant communicates to an MQTT broker using JSON formatted payloads using the common data structure detailed in this Standard.

All Asset types shall publish its data in a JSON encoded payload to an MQTT broker, directly or via an edge gateway for legacy applications. The communication protocol between plant floor devices sending machine data to the collection system utilizes an MQTT transport via TCP/IP. All PLC and plant floor devices that publish messages shall be time synced to the central timeserver available to the plant. In addition to the Plant floor device sending time stamp data, a time stamp of the data insertion into the database is also stored.

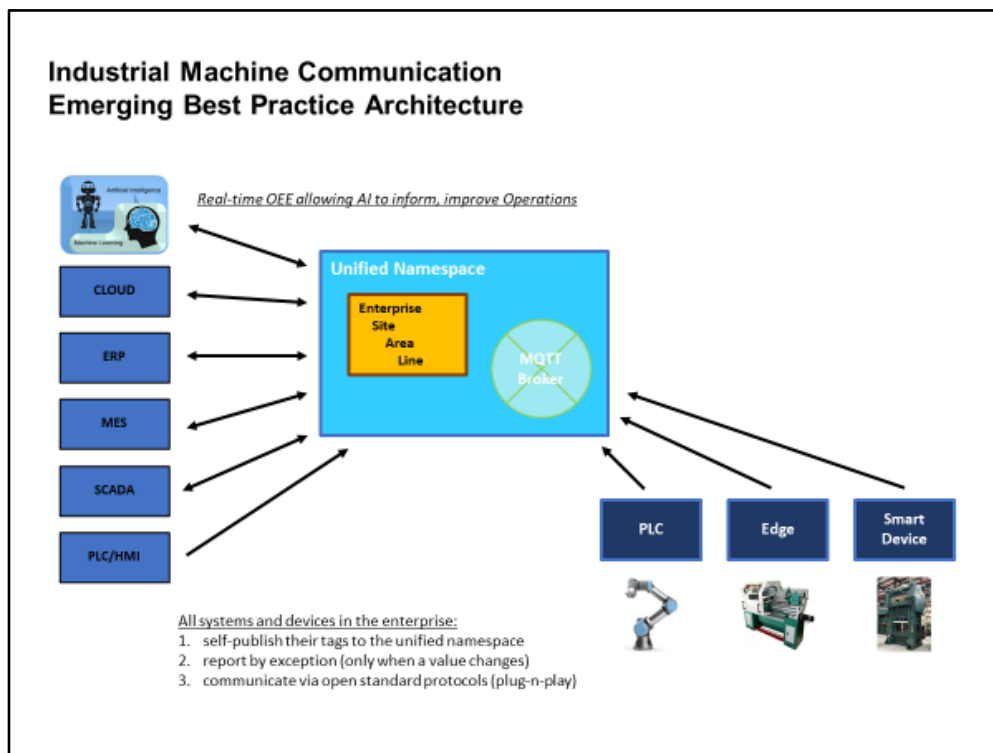


Figure 2 - Emerging best practice architecture

4.5 The Imperative for an Overarching Industrial Data Communication Standard

Smart Manufacturing requires a high degree of automation and integration of systems on the shop floor to deliver optimal performance and ROI. These systems have evolved over decades in a highly proprietary, closed manner by the companies who design and sell them. The resulting landscape of incompatible machine communication creates costly delays and complexity in product launches for automotive companies. Interoperability and extensibility of these machines is imperative to insure cost efficient operation and competitive viability.

After benchmarking the industry and evaluating existing IIoT standards initiatives, it became clear that a standard was needed that met the requirements of the Automotive Industry OEMs and Suppliers.

Figure 3 depicts the various levels of the industrial machine communication landscape; and while data communication standards are being developed within these various levels, the standards typically focus on the horizontal communication within the level. The challenge for the Automotive Manufacturers is the need for seamless data communication across the levels, as well as vertically throughout the industrial landscape.

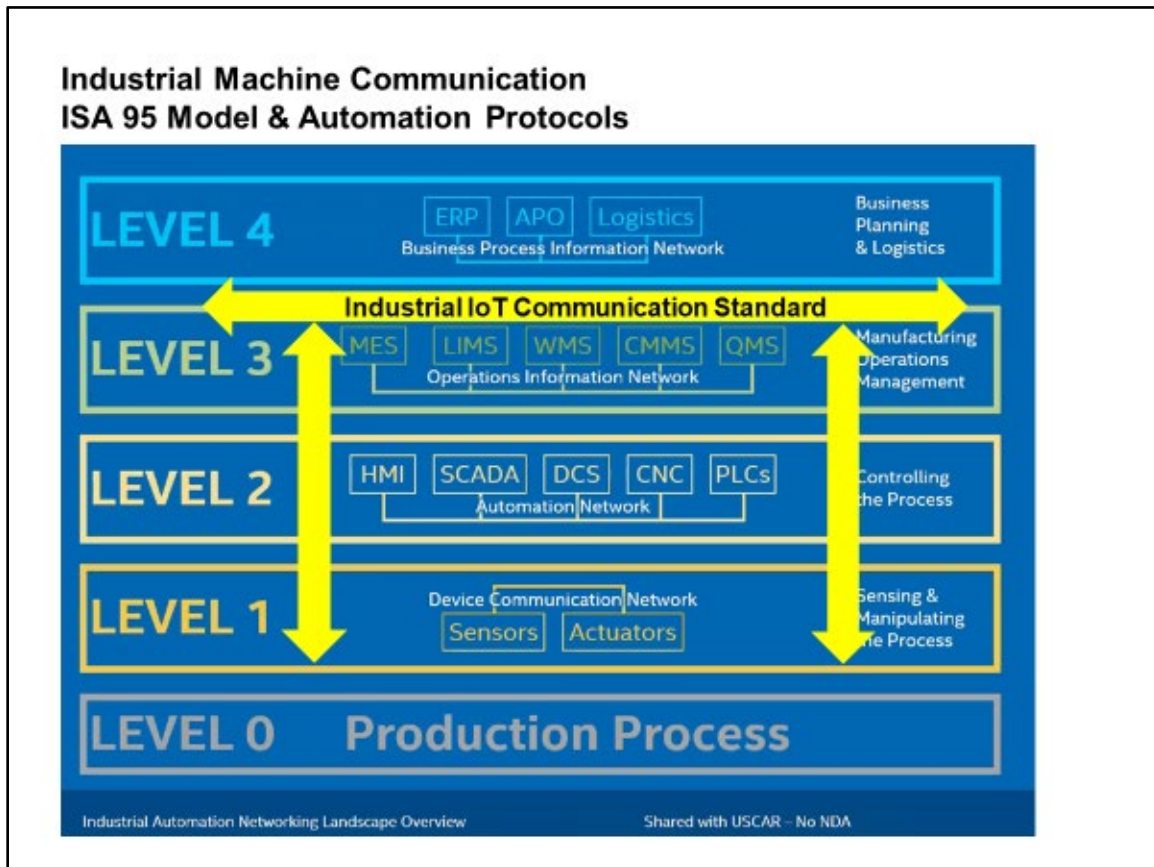


Figure 3 - Industrial IoT communication standard

5. INDUSTRIAL DATA ARCHITECTURE

Data Architecture and communication within a Smart Manufacturing environment allows for many different types of data along with different ways in which data is communicated from and to the manufacturing floor. A broad data classification diagram as shown in Figure 4 denotes the variety of data that may be communicated within this environment.

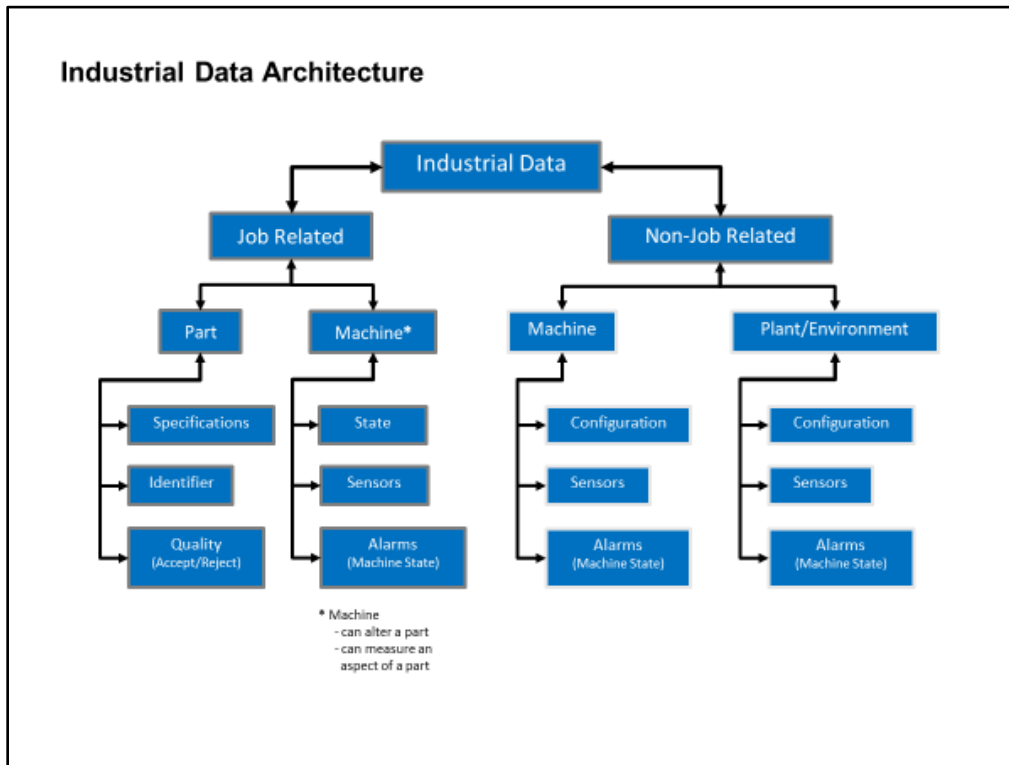


Figure 4 - Industrial data architecture

5.1 Industrial Data Classification

There are two kinds of Industrial Data: Job Related and Non-Job Related.

5.1.1 Job-Related

“Job” is defined as the act of making a part in production. Production of a part involves the part itself and the machine that acts on the part. A “machine” is defined as the entity that is capable of either modifying a part or measuring an attribute of it. Also, job related data can be categorized into Part and Machine data.

A part data further contains identifier, specification, and quality information. The part identifier is a unique entity that identifies a part, (e.g., a serial number). The specification data pertains to the requirements to which a part is to be made, (e.g., dimensions, tolerances, and any other metadata related to the part). After an action is taken on a part, it is expected to pass certain quality checks. These values could be quality attributes or a Boolean indicating pass or fail.

A machine has data pertaining to both job related and non-job related. The type of data reported is different in each category. The job related machine data is available when it is actively altering or making a part, and can include machine state, data from the sensor attached to the machine or an alarm. The state communicates the operating mode it is in with “idle” as a valid state and should technically indicate the associated data is not job related. When a machine is not idle, it is expected to record data from its sensors. These data may be (rarely) scalars, time-series signals, images, or video. When data is scalar, it could fetch a place in a database but the other types of data require some file format to package the data.