FieldComm Group™
Connecting the World of Process Automation

Process Automation Device Information Model

Technical White Paper

Executive Summary

Today's process automation field devices communicate with host systems over either analog 4-20mA connections, sometimes with embedded digital HART data; or via 2-wire digital fieldbus connections conforming generally to the FOUNDATION Fieldbus (FF) or PROFIBUS PA standards as well as wireless protocols like Wireless HART or ISA 100.

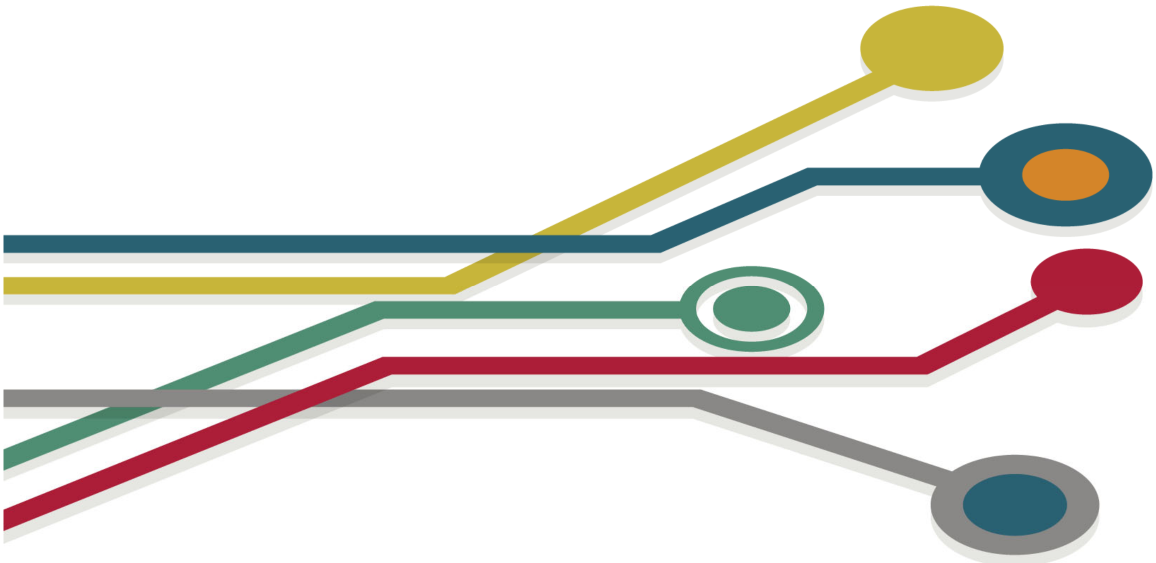
Initiatives all over the world such as Industrie 4.0 (I 4.0), Industrial Internet of Things (IIoT), Open Process Automation Forum (OPAF) and the NAMUR Open Architecture (NOA) are working on concepts for digital transformation.

The enormous installed base in the process industries requires a digital transformation solution which can make use of information from devices communicating via current field communication solutions. Each of these existing communication protocols employs different software structures, or information model, to represent the same information.

To ensure interoperability and seamless access to device information it is necessary to standardize on the form and basic contents of the information models for certain device classes independent of a specific communication protocol. Thus enabling seamless instrumentation information flow throughout the enterprise.

FieldComm Group (FCG), OPC Foundation (OPCF) and PROFIBUS/PROFINET International (PI) have taken the initiative to jointly standardize and specify the information model for Process Automation Devices - PA-DIM. The work is being performed in the working group structure of FCG with dedicated representatives from OPCF and PI.

Table of Contents



Technology Trends and Developments

Today’s process automation field devices communicate with host systems over either analog 4-20mA connections, sometimes with embedded digital HART data; or via 2-wire digital fieldbus connections conforming generally to the FOUNDATION Fieldbus (FF) or PROFIBUS PA standards as well as wireless protocols like Wireless HART or ISA 100.

Active development is now underway in the IEEE 802.3 committee to create a 2-wire Ethernet standard. When complete, this standard will allow for high-speed (10 Mbit/s) communications for process automation devices. This standard is known as APL or Advanced Physical Layer. Current projections expect availability of process automation devices supporting APL around 2020.

APL will allow the implementation of Ethernet based field communication protocols (e.g. PROFINET, HART IP) at the device level. It will also allow the implementation of OPCUA and the OPCUA information models directly at the device level, which would lead to simplified system architectures and allowing for seamless communication from device to cloud without the need for specific protocol gateways.

Initiatives all over the world such as Industrie 4.0 (I 4.0), Industrial Internet of Things (IIoT), Open Process Automation Forum (OPAF) and the NAMUR Open Architecture (NOA) are working on concepts for digital transformation and new automation system architectures. Information models are key in all of these approaches to make device information available to any kind of application in a well-structured and transparent way (figure 1). To ensure interoperability and seamless access to device information it is necessary to standardize on the form and basic contents of the information models for certain device classes independent of a specific communication protocol.

The enormous installed base in the process industries requires a solution which can make use of information from devices communicating via current field communication solutions such as HART, FF, and PROFIBUS PA. Each of these existing communication protocols employs different software structures to represent the same information. Information models shall be applied to provide seamless and interoperable access for software applications and other devices.

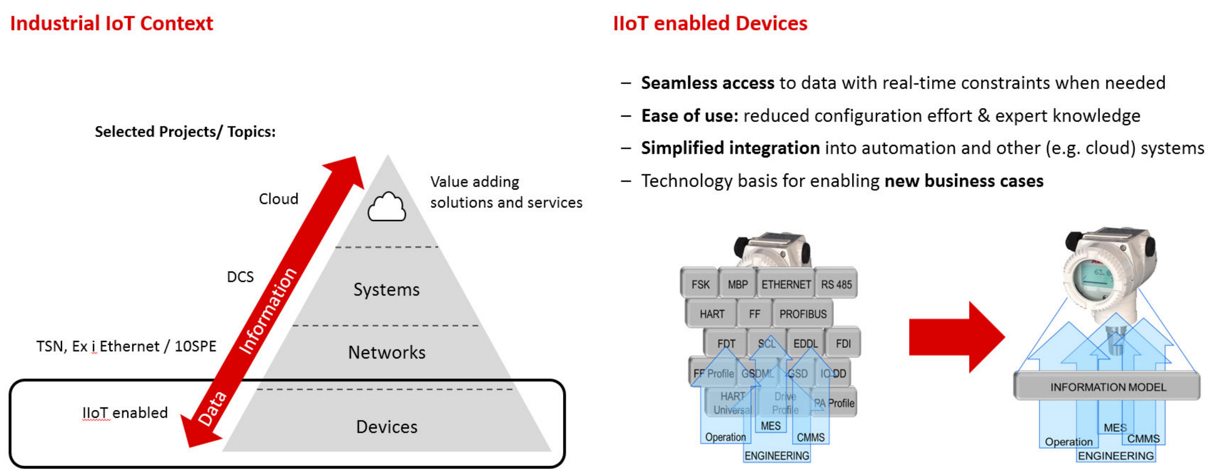


Figure 1: Convergence towards IP-connectivity & semantic integration in plant-wide communication

Unified Information Model - Protocol Agnostic Approach

FieldComm Group (FCG), OPC Foundation (OPCF) and PROFIBUS/PROFINET International (PI) have taken the initiative to jointly standardize and specify the information model for Process Automation Devices - PA-DIM. The work is being performed in the working group structure of FCG with dedicated representatives from OPCF and PNOPI.

PA-DIM is based on the NAMUR requirements for Open Architecture (under development), Self-Monitoring and Diagnosis of Field Devices (NE107) [1] and NAMUR standard device - Field devices for standard applications (NE 131) [2]. PA-DIM covers use cases such as:

- Provide/receive information to/from HMIs, information apps, reporting apps, etc.
- Provide information for inventory management and remote monitoring applications
- Provide information that is used by real time control applications
- Device configuration and parameterization
- Provide interfaces for configuring the security of a device, and for monitoring its current hardening status
- Provide information for device dashboards

The protocol agnostic unified information model will allow software applications to access device information without additional mapping or protocol specific knowledge. They just need to follow the standardized PA-DIM. The assignment of Semantic Identifiers according to the Common Data Dictionary (IEC 81987) will enable software applications to “understand” the meaning of PA-DIM contents.

The implementation will be done using OPCUA (IEC 62541 [3]) and the OPCUA for devices (DI, IEC 62541-100 [4]) standards. PA-DIM focuses on standardizing a set of information and behavior for specific classes of process automation devices as defined in [2] NE 131: NAMUR standard device - Field devices for standard applications independent of a certain communication protocol.

PA-DIM could be implemented directly on native OPCUA devices. This is expected to be the future approach, assuming process automation devices will support communication via Ethernet and the advanced physical layer, which will enable 2-wire Ethernet, power over the Ethernet wires and installation in hazardous areas.

For current devices the FDI technology [6] provides the means to set up PA-DIM as part of the FDI Information Model server through the respective device description (EDD). Fieldbus specific information will be mapped to the defined standard information model (PA-DIM) by the FDI server (Figure 2).

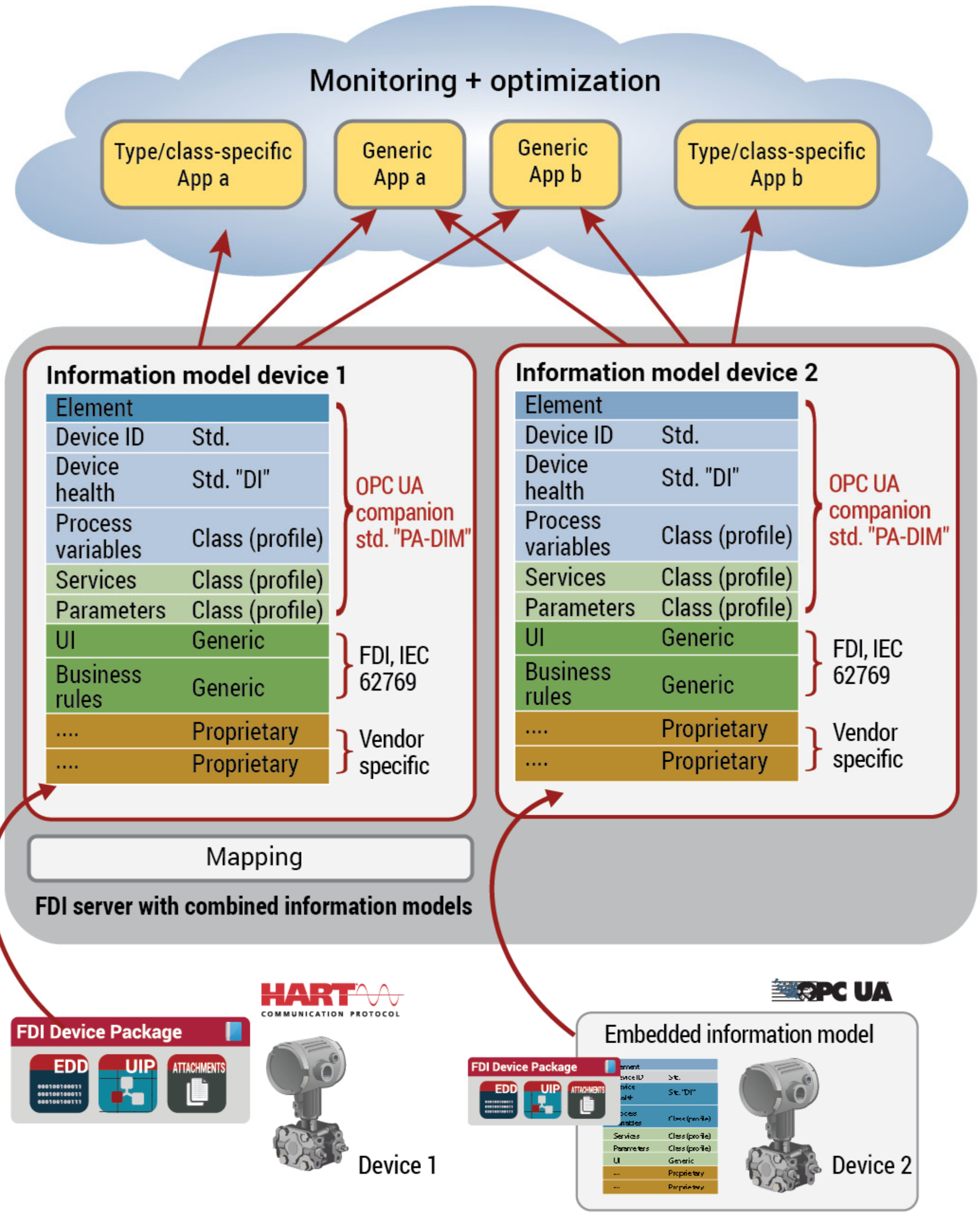


Figure 2: PA-DIM as part of an FDI Server or on a native OPCUA device

PA-DIM and Industrie 4.0

Another important input for PA-DIM is the idea of the Asset Administration Shell (AAS) as defined by the I4.0 consortium. Asset Administration Shell and Administration Shell are used synonymously.

The Asset Administration Shell is the standardized digital representation of the asset, cornerstone of the interoperability between the applications managing the manufacturing systems. It identifies itself and the assets represented by it, holds digital models of various aspects (sub models) and describes technical functionality exposed by the Administration shell or respective assets [5].

Sub models are used to structure the information and technical functionality of an Administration shell into distinguishable parts. Each sub model refers to a well-defined domain or subject matter. Sub models can become standardized and thus become sub models types [5].

PA-DIM shall fulfil the requirements for an AAS, it shall standardize sub models of the Administration Shell (Figure 3).

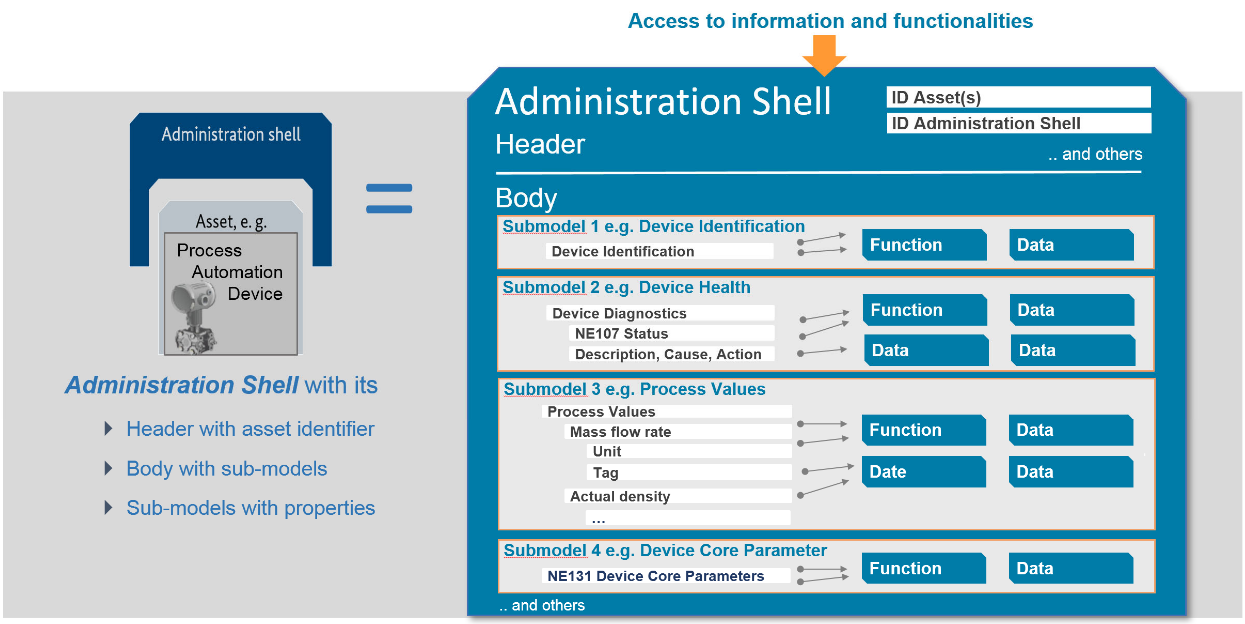


Figure 3: Asset Administration Shell for Process Automation Devices

Stepwise Approach

The PA-DIM shall be developed in a stepwise approach and allow for backward compatible extensions of the information model with further sub-models over time.

The first step of the PA-DIM specification (Figure 4) will be based on OPCUA DI (IEC 62541-100 [4]) and be published as an OPCUA companion specification. It will standardize certain sub-models for the typical process automation devices (flow, pressure, temperature, level, and positioner):

- Device Identification (OPCUA DI (IEC 61541) [4], IEC CDD (IEC 61987) [8])
- Device diagnosis (according to NE 107 [1] ,NE 131 [2])
- Basic Configuration through Standard Device Parameters (core parameters according to NE 131 [2]
- Process Variables, NE 131 [2]

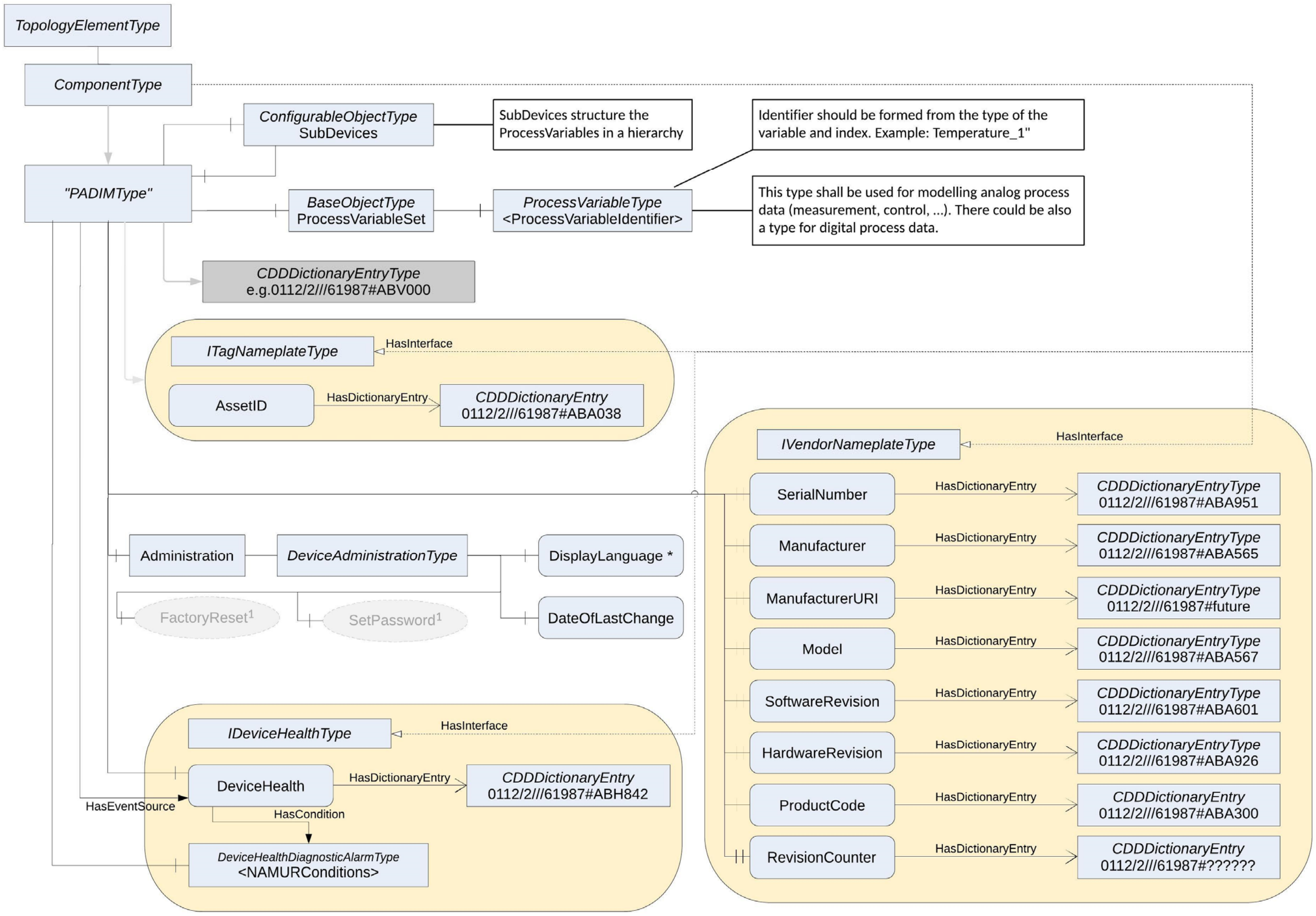


Figure 4: PA-DIM step 1

Future steps may include additional sub-models on comprehensive device configuration and parameterization, security mechanisms, or provide information for an HMI.

Installed Base

For the installed base of process automation devices the PA-DIM is supported by the FDI technology [6]. The FDI architecture foresees an OPCUA information model represented through an OPCUA server. The structure of the FDI Information Model is being created from the EDD which is part of the FDI Package and describes all device related information, business logic and user interfaces.

The overall information model for process automation devices (Figure 5) consists of:

- Standardized contents specified in PA-DIM
  - Device Identification
  - Device Diagnostics
  - Process Variables
  - Core Parameters
- Generic information as specified in the FDI standard
  - User interaction
  - Business rules

By using the FDI information model server, existing plants can be enhanced to expose information from HART, FOUNDATION Fieldbus or fieldbus devices through OPCUA and the standardized PA-DIM to any kind of OPCUA client. Information from existing field devices will be mapped to the PA-DIM by FDI mechanisms.

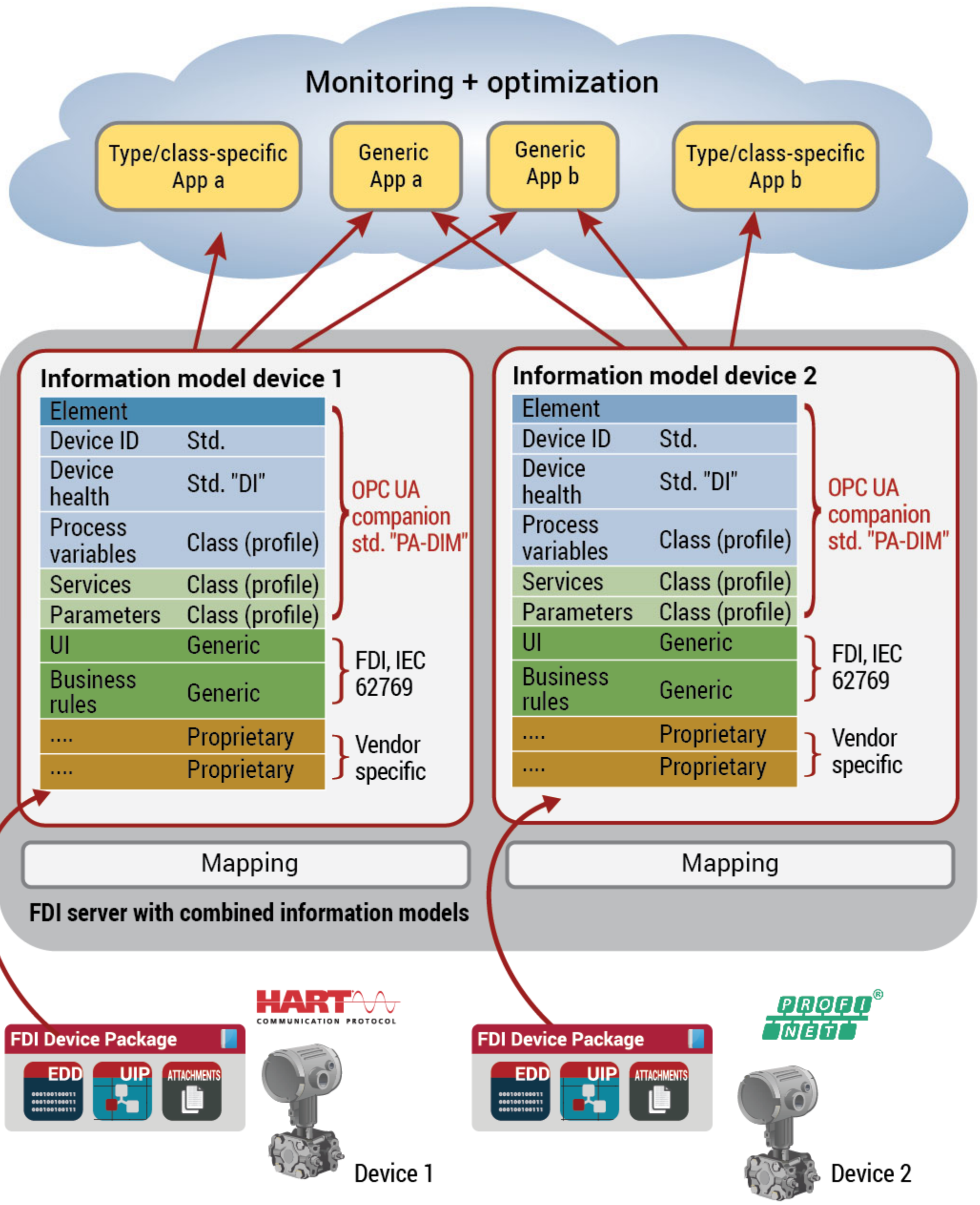


Figure 5: FDI technology enables access to PA-DIM for the installed base

Semantic Identifiers

PA-DIM specifies semantic information as required by the NAMUR Open Architecture and I4.0 AAS [5]. The upcoming editions of OPCUA specification, Part 5 - Information Model (IEC62541-5 [3]), FDI (FCG TS 62679 [6]) and EDDL (FCG TS 61804 [7]) enable the assignment of Semantic Identifiers. PA-DIM assigns Semantic Identifiers as specified in IEC 61987 Common Data Dictionary [8]. By this PA-DIM provides device information in a standardized, machine-readable format.

OPCUA provides the basic infrastructure to reference from an OPC UA *Information Model* to external data dictionaries like IEC Common Data Dictionary or eCl@ss. It defines *ObjectTypes* and *ReferenceTypes* and explains how they should be used [3].

The *ObjectTypes* are used to represent an external data dictionary in an OPC UA *Address Space*. The *ReferenceType* is used to reference from Nodes in the Address Space to the dictionary entries. Such dictionary entries can be seen as external classification or external semantic [3].

The types and instances defined in OPCUA part 5 are illustrated in Figure 6. The IEC61987DictionaryEntryType is an example which illustrates how a concrete subtype can be defined to reference dictionary entries in a concrete external data dictionary [3].

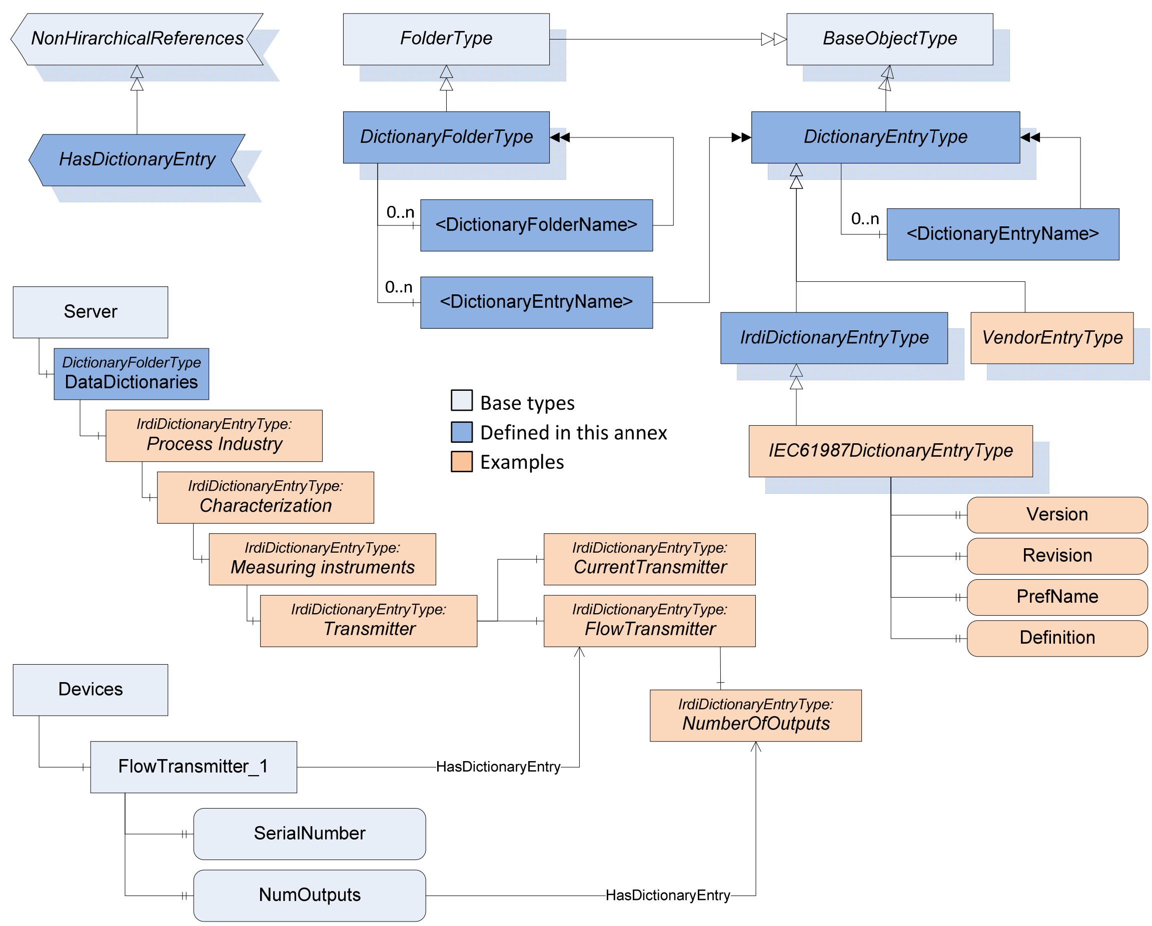


Figure 6: Semantic information dictionary reference types

Outlook

PA-DIM will be extended with new sub models, standardizing e.g. security aspects or user interface information for comprehensive device configuration.

There are trends to implement the OPCUA information model server on field device level. In this case the PA-DIM will be also embedded on native OPCUA devices. The mapping of protocol specific formats on the FDI server level will not be required anymore, information from individual native OPCUA devices can be accessed by OPCUA clients directly or indirectly through aggregated OPCUA servers (Figure 7).

For an OPCUA client there will no difference whether it accesses information from existing field devices mapped through an FDI server or if it accesses information directly from a native OPCUA field device. The PA-DIM structure will be the same.

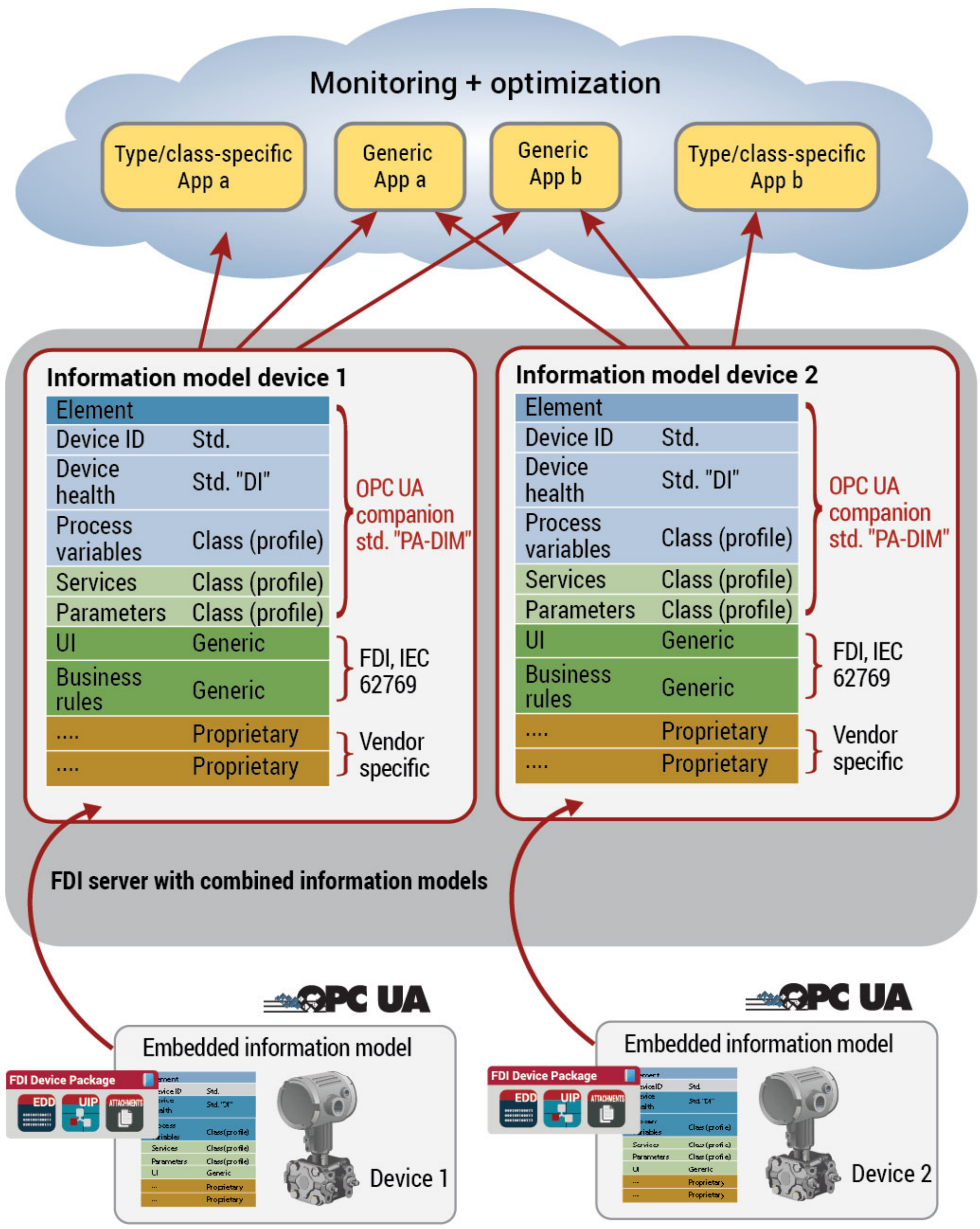


Figure 7: PA-DIM embedded in native OPCUA devices

Abbreviations

For the purposes of this document, the following abbreviations apply.

CDD	Common Data Dictionary
EDD	Electronic Device Description
EDDL	Electronic Device Description Language
FCG	FieldComm Group
FDI	Field Device Integration
IM	Information Model
IMS	Information Model Server
OPCUA	OPC Unified Architecture
PA-DIM	Process Automation Device Information Model
PI	PROFIBUS & PROFINET International
UID	User Interface Description
UIP	User Interface Plugin

References

[1] NE 107: Self-Monitoring and Diagnosis of Field Devices, NAMUR, 2017

[2] NE 131: NAMUR standard device - Field devices for standard applications, NAMUR, 2016

[3] IEC 62541: OPC Unified Architecture

[4] IEC 62541-100: OPC Unified Architecture for Devices (DI)

[5] Platform Industrie 4.0: Details of the Administration Shell, Platform Industrie 4.0, 2018

[6] IEC 62679: Field Device Integration

[7] IEC 61804: Electronic Device Description Language (EDDL)

[8] IEC 61987: Common Data Dictionary

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