

# INTERNATIONAL STANDARD



Field device integration (FDI) –  
Part 5: ~~FDI~~ Information Model

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Part 5: ~~FDI~~ Information Model

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## FIELD DEVICE INTEGRATION (FDI) –

Part 5: ~~FDI~~ Information Model

## FOREWORD

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International Standard IEC 62769-5 has been prepared by subcommittee 65E: Devices and integration in enterprise systems, of IEC technical committee 65: Industrial-process measurement, control and automation.

This second edition cancels and replaces the first edition published in 2015. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) support for generic protocol extension for faster adoption of other technologies;
- b) support of new protocols;
- c) generic protocol extension to allow adoption of other communication protocols;
- d) based on generic protocol extension: Modbus RTU.

The text of this International Standard is based on the following documents:

|              |                  |
|--------------|------------------|
| FDIS         | Report on voting |
| 65E/762/FDIS | 65E/772/RVD      |

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62769 series, published under the general title *Field Device Integration (FDI)*, can be found on the IEC website.

This standard contains attached files in the form of XML schema. These files are intended to be used as a complement and do not form an integral part of the standard.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

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## INTRODUCTION

~~The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of patents concerning~~

- ~~a) Method for the Supplying and Installation of Device-Specific Functionalities, see Patent Family DE10357276;~~
- ~~b) Method and device for accessing a functional module of automation system, see Patent Family EP2182418;~~
- ~~c) Methods and apparatus to reduce memory requirements for process control system software applications, see Patent Family US2013232186;~~
- ~~d) Extensible Device Object Model, see Patent Family US12/893,680.~~

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The IEC 62769 series has the general title *Field Device Integration (FDI)* and the following parts:

- Part 1: Overview
- Part 2: FDI Client
- Part 3: FDI Server
- Part 4: FDI Packages
- Part 5: FDI Information Model
- Part 6: FDI Technology Mapping
- Part 7: FDI Communication Devices

- Part 100: Profiles – Generic Protocol Extensions
- Part 101-1: Profiles – Foundation Fieldbus H1
- Part 101-2: Profiles – Foundation Fieldbus HSE
- Part 103-1: Profiles – PROFIBUS
- Part 103-4: Profiles – PROFINET
- Part 109-1: Profiles – HART and WirelessHART
- Part 115-2: Profiles – Protocol-specific Definitions for Modbus RTU
- Part 150-1: Profiles – ISA 100.11a

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## FIELD DEVICE INTEGRATION (FDI) –

### Part 5: ~~FDI~~ Information Model

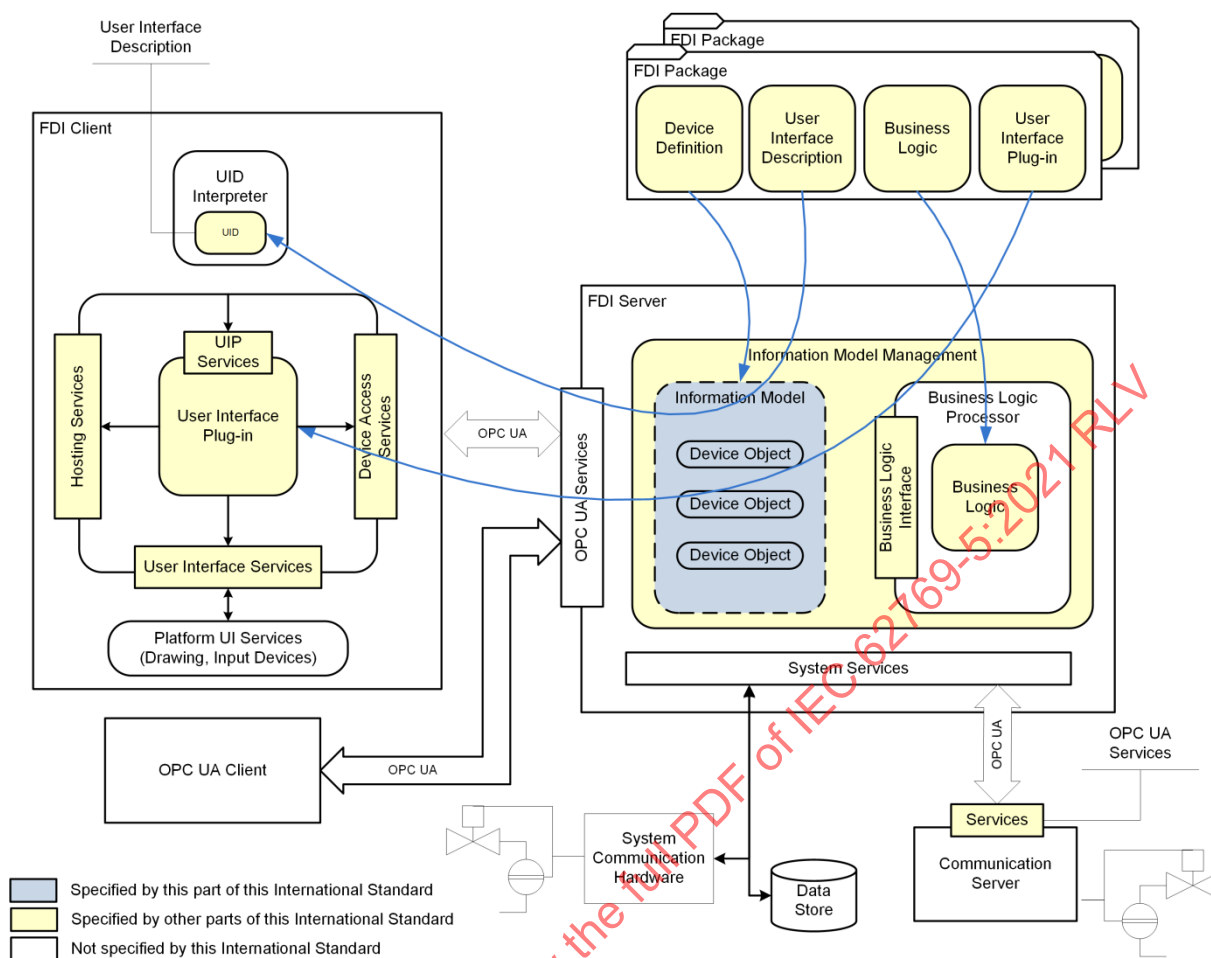
#### 1 Scope

This part of IEC 62769 defines the FDI Information Model. One of the main tasks of the Information Model is to reflect the topology of the automation system. Therefore, it represents the devices of the automation system as well as the connecting communication networks including their properties, relationships, and the operations that can be performed on them. The types in the AddressSpace of the FDI Server constitute a catalogue, which is built from *FDI Packages*.

The fundamental types for the FDI Information Model are well defined in OPC UA for Devices (IEC 62541-100). The FDI Information Model specifies extensions for a few special cases and otherwise explains how these types are used and how the contents are built from elements of DevicePackages.

The overall FDI architecture is illustrated in Figure 1. The architectural components that are within the scope of this document have been highlighted in this illustration.

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Figure 1 – FDI architecture diagram

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61784-1, *Industrial communication networks – Profiles – Part 1: Fieldbus profiles*

IEC 61804-3<sup>1</sup>, *Function blocks (FB) for process control and Electronic Device Description Language (EDDL) – Part 3: EDDL syntax and semantics*

IEC 61804-4, *Function blocks (FB) for process control and electronic device description language (EDDL) – Part 4: EDD interpretation*

IEC 62541-3, *OPC unified architecture – Part 3: Address Space Model*

IEC 62541-4, *OPC unified architecture – Part 4: Services*

<sup>1</sup> To be published.

IEC 62541-5, *OPC unified architecture – Part 5: Information Model*

IEC 62541-6, *OPC unified architecture – Part 6: Mappings*

IEC 62541-8, *OPC unified architecture – Part 8: Data Access*

IEC 62541-100<sup>2</sup>, *OPC unified architecture – Part 100: OPC UA for Devices*

IEC 62769-1, *Field Device Integration (FDI) – Part 1: Overview*

~~NOTE – IEC 62769-1 is technically identical to FDI-2021~~

IEC 62769-2, *Field Device Integration (FDI) – Part 2: FDI Client*

~~NOTE – IEC 62769-2 is technically identical to FDI-2022~~

IEC 62769-4, *Field Device Integration (FDI) – Part 4: FDI Packages*

~~NOTE – IEC 62769-4 is technically identical to FDI-2024~~

IEC 62769-7, *Field Device Integration (FDI) – Part 7: FDI Communication Devices*

~~NOTE – IEC 62769-7 is technically identical to FDI-2027~~

### **3 Terms, definitions, abbreviated terms, ~~acronyms~~ and conventions**

#### **3.1 Terms and definitions**

For the purposes of this document, the terms and definitions given in IEC 62769-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

#### **3.2 Abbreviated terms ~~and acronyms~~**

For the purposes of this document, the abbreviated terms ~~and acronyms~~ given in IEC 62769-1 as well as the following apply.

HMI Human Machine Interface  
SCADA Supervisory Control and Data Acquisition  
TCP Transmission Control Protocol

#### **3.3 Conventions**

For the purposes of this document, the conventions given in IEC 62769-1 apply.

#### **3.4 Conventions for graphical notation**

OPC UA defines a graphical notation for an OPC UA AddressSpace. It defines graphical symbols for all NodeClasses and how different types of References between Nodes can be

---

<sup>2</sup> ~~Under consideration.~~

visualized. Figure 2 shows the symbols for the NodeClasses used in this document. NodeClasses representing types always have a shadow.

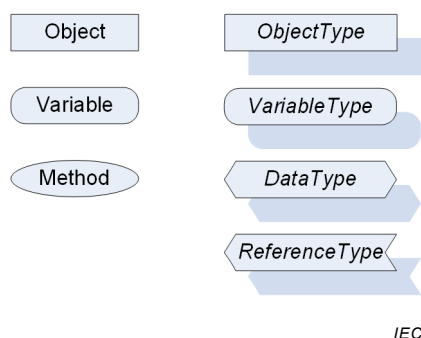


**Figure 2 – OPC UA Graphical Notation for NodeClasses**

Figure 3 shows the symbols for the ReferenceTypes used in this document. The Reference symbol is normally pointing from the source Node to the target Node. The only exception is the HasSubType Reference. The most important References such as HasComponent, HasProperty, HasTypeDefinition and HasSubType have special symbols avoiding the name of the Reference. For other ReferenceTypes or derived ReferenceTypes, the name of the ReferenceType is used together with the symbol.

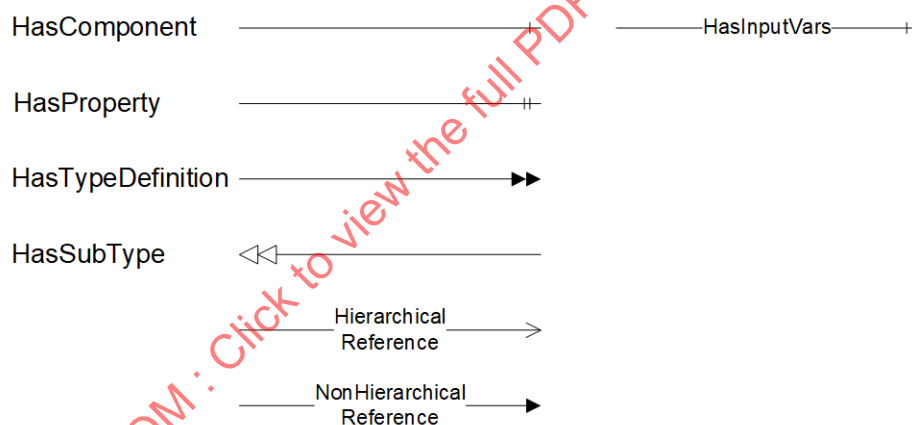


**Figure 3 – OPC UA Graphical Notation for References**

Figure 4 shows a typical example for the use of the graphical notation. Object\_A and Object\_B are instances of the ObjectType\_Y indicated by the HasTypeDefinition References. The ObjectType\_Y is derived from ObjectType\_X indicated by the HasSubType Reference. The Object\_A has the components Variable\_1, Variable\_2 and Method\_1.

To describe the components of an Object on the ObjectType the same NodeClasses and References are used on the Object and on the ObjectType such as for ObjectType\_Y in the example. The Nodes used to describe an ObjectType are instance declaration Nodes.

To provide more detailed information for a Node, a subset or all Attributes and their values can be added to a graphical symbol (see for example Variable\_1, the component of Object\_A in Figure 4).

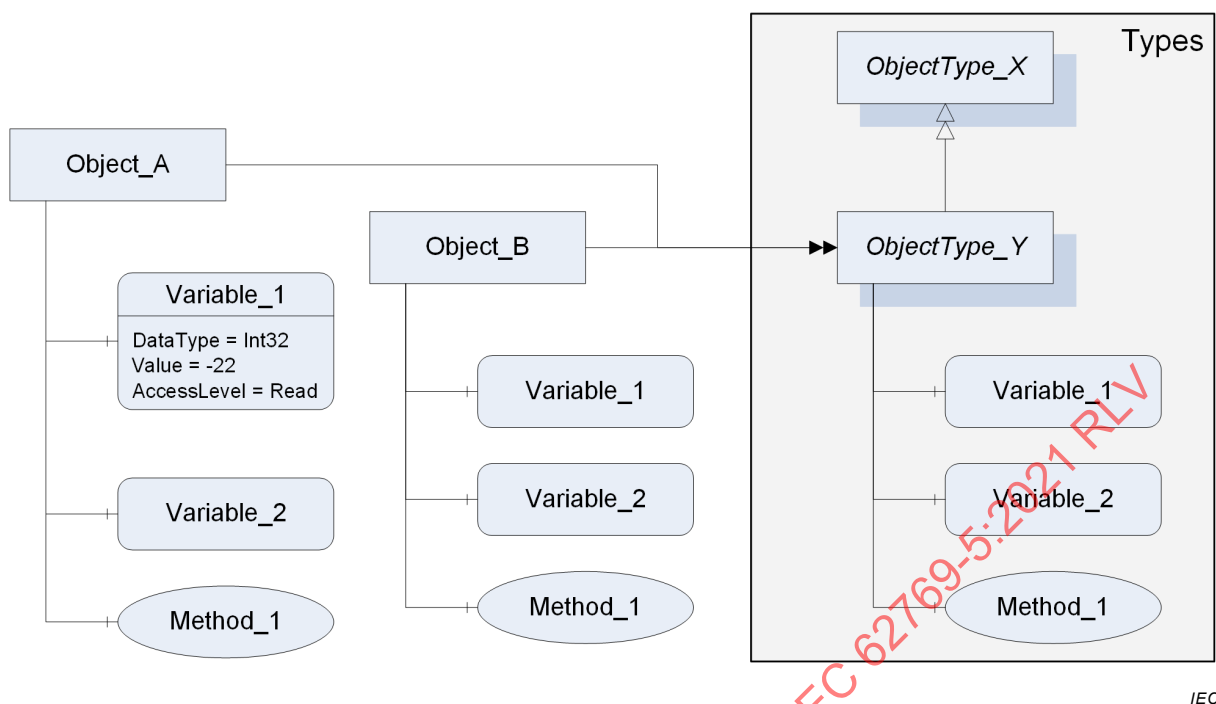


**Figure 4 – OPC UA Graphical Notation Example**

To improve readability, this document frequently includes the type name inside the instance box rather than displaying both boxes and a reference between them. This optimization is shown in Figure 5.

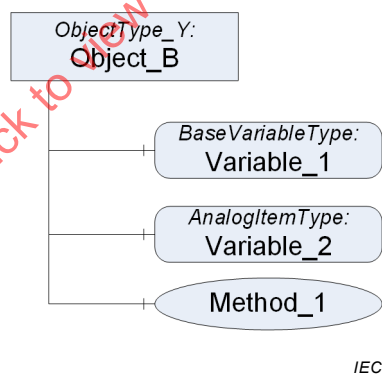


**Figure 5 – Optimized Type Reference**

## 4 Overview of OPC Unified Architecture

### 4.1 General

The main use case for OPC standards is the online data exchange between devices and HMI or SCADA systems. In this use case, the device data is provided by an OPC server and is consumed by an OPC client integrated in the HMI or SCADA system. OPC provides functionality to browse through a hierarchical namespace containing data items and to read, write and monitor these items for data changes. **Numeric identifiers for NodeIds are defined in Annex A.**

OPC UA incorporates features like Data Access, Alarms and Historical Data via platform independent communication mechanisms and generic, extensible and object-oriented modelling capabilities for the information a system wants to expose.

The current version of OPC UA defines an optimized binary TCP protocol for high-performance intranet communication as well as a mapping to Web Services. The abstract service model does not depend on a specific protocol mapping and allows adding new protocols in the future. Features like security, access control and reliability are directly built into the transport mechanisms. Based on the platform independence of the protocols, OPC UA servers and clients can be directly integrated into devices and controllers.

The OPC UA information model provides a standard way for Servers to expose Objects to Clients. Objects in OPC UA terms are composed of other Objects, Variables and Methods. OPC UA also allows relationships to other Objects to be expressed.

The set of Objects and related information that an OPC UA Server makes available to Clients is referred to as its AddressSpace. The elements of the OPC UA Object Model are represented in the AddressSpace as a set of Nodes described by Attributes and interconnected by References. OPC UA defines various classes of Nodes to represent AddressSpace components, most importantly Objects, Variables, Methods, ObjectTypes, DataTypes and ReferenceTypes. Each NodeClass has a defined set of Attributes.

Objects are used to represent components like folders, Devices or Networks. An Object is associated to a corresponding ObjectType that provides definitions for that Object.

Variables are used to represent values. Two categories of Variables are defined: Properties and DataVariables.

Properties are Server-defined characteristics of Objects, DataVariables and other Nodes. Properties are not allowed to have Properties defined for them. An example for Properties of Objects is the Manufacturer Property of a Device.

DataVariables represent the contents of an Object. DataVariables may have component DataVariables. This is typically used by Servers to expose individual elements of arrays and structures. This document uses DataVariables mainly to represent the Parameters of Devices.

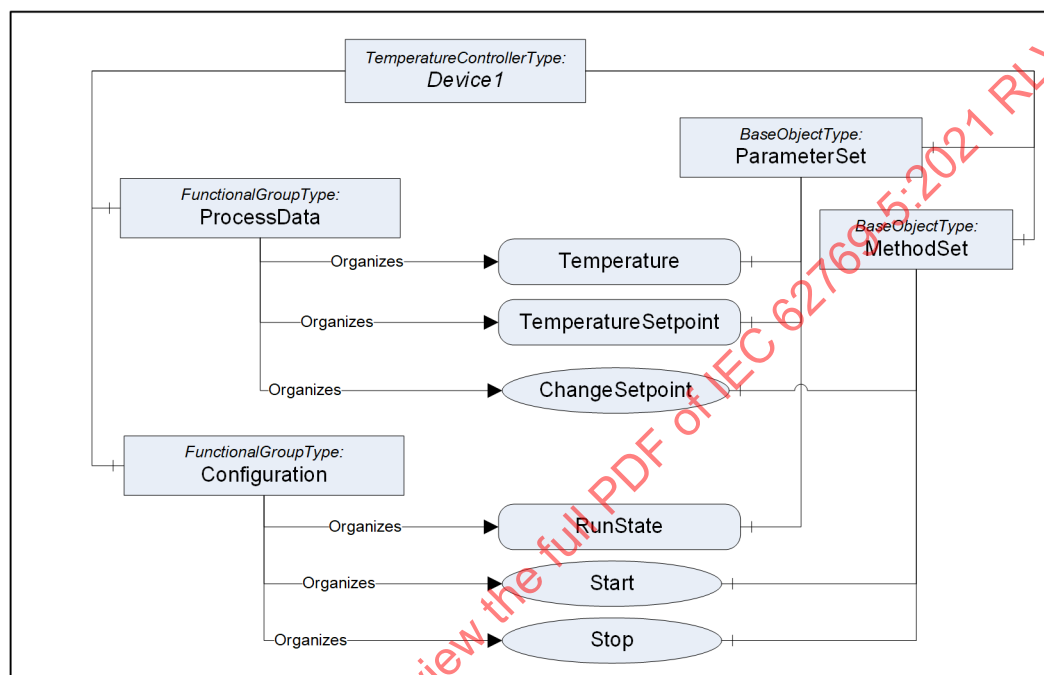
## 4.2 Overview of OPC UA Devices

The OPC Unified Architecture for Devices (DI) (IEC 62541-100) standard is an extension of the overall OPC Unified Architecture standard series and defines information models associated with Devices. IEC 62541-100 describes three models that build upon each other as follows:

- The (base) Device Model is intended to provide a unified view of devices irrespective of the underlying device protocols.
- The Device Communication Model adds Network and Connection information elements so that communication topologies can be created.
- The Device Integration Host Model finally adds additional elements and rules required for host systems to manage integration for a complete system. It allows reflecting the topology of the automation system with the devices as well as the connecting communication networks.

The Devices information model specifies different ObjectTypes and other AddressSpace elements used to represent Devices and related components such as the communication infrastructure in an OPC UA AddressSpace. The main use cases are Device configuration and diagnostic, but it allows a general and standardized way for any kind of application to access Device-related information.

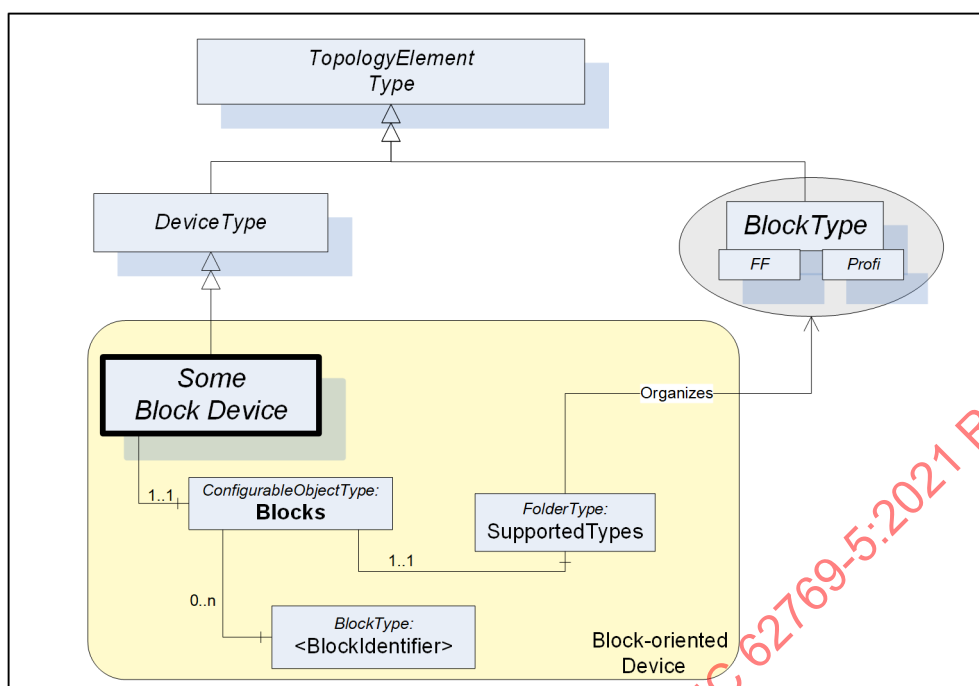
Figure 6 shows an example for a temperature controller represented as Device Object. It is a **DeviceType** Object that is a subtype of **TopologyElementType** and inherits all components of this type. The component **ParameterSet** contains all Variables describing the Device. The component **MethodSet** contains all Methods provided by the Device. ~~Both components are inherited from the TopologyElementType, which is the root Object type of the Device Object type hierarchy. Objects~~ Components of the **FunctionalGroupType** are used to ~~group~~ collect the Parameters and Methods of the Device into logical groups. The **FunctionalGroupType** and the grouping concept are defined in IEC 62541-100, but the groups are DeviceType-specific, i.e. the groups **ProcessData** and **Configuration** are defined by the **TemperatureControllerType** in this example.



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**Figure 6 – OPC UA Devices Example: Functional Groups**

Another IEC 62541-100 concept is illustrated in Figure 7. The **ConfigurableObjectType** is used to provide a way to group sub-components of a Device and to indicate which types of sub-components can be instantiated. The allowed types are referenced from the **SupportedTypes** folder. This information can be used by configuration clients to allow a user to select the type to instantiate as sub-component of the Device.



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**Figure 7 – OPC UA Devices example: Configurable components**

The SupportedTypes folder can contain different subsets of ObjectTypes for different instances of the Block-oriented Device depending on their current configuration, since the list contains only types that can be instantiated for the current configuration.

## 5 Concepts

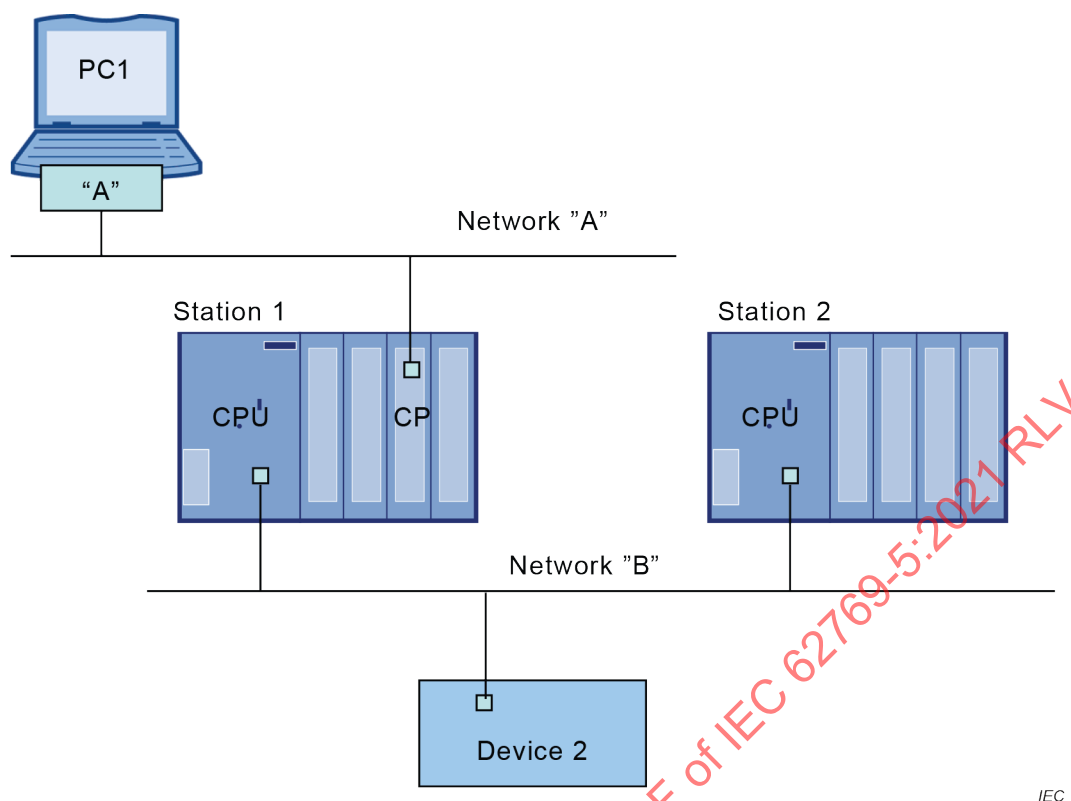
### 5.1 General

The FDI Server provides FDI Clients access to information about Device instances and Device types regardless of where the information is stored, for example, in the Device itself or in a data store. This information is provided via OPC UA Services and is called the FDI Information Model.

The FDI Information Model specifies the entities that may be accessed in the FDI Server, including their properties, relationships, and the operations that can be performed on them. Which types of Devices or other topological elements are available in a given FDI Server is driven largely by the information in the FDI Packages.

### 5.2 Device topology

One of the main tasks of the Information Model is to reflect the topology of the automation system. Therefore, the Information Model represents the devices of the automation system as well as the connecting communication networks. The entry point Device Topology is the starting point within the Information Model for the topology of the automation system. The entry point Communication Devices contains the communication devices that are used by the FDI Server to access the elements of the topology. Figure 8 and Figure 9 illustrate an example configuration and the configured topology as it will appear in the FDI Server AddressSpace (details left out).



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**Figure 8 – Example of an automation system**

The PC in Figure 8 represents the FDI Server box. The FDI Server communicates with devices connected to Network "A" via a Native Communication, and it communicates with devices connected to Network "B" via a Nested Communication.

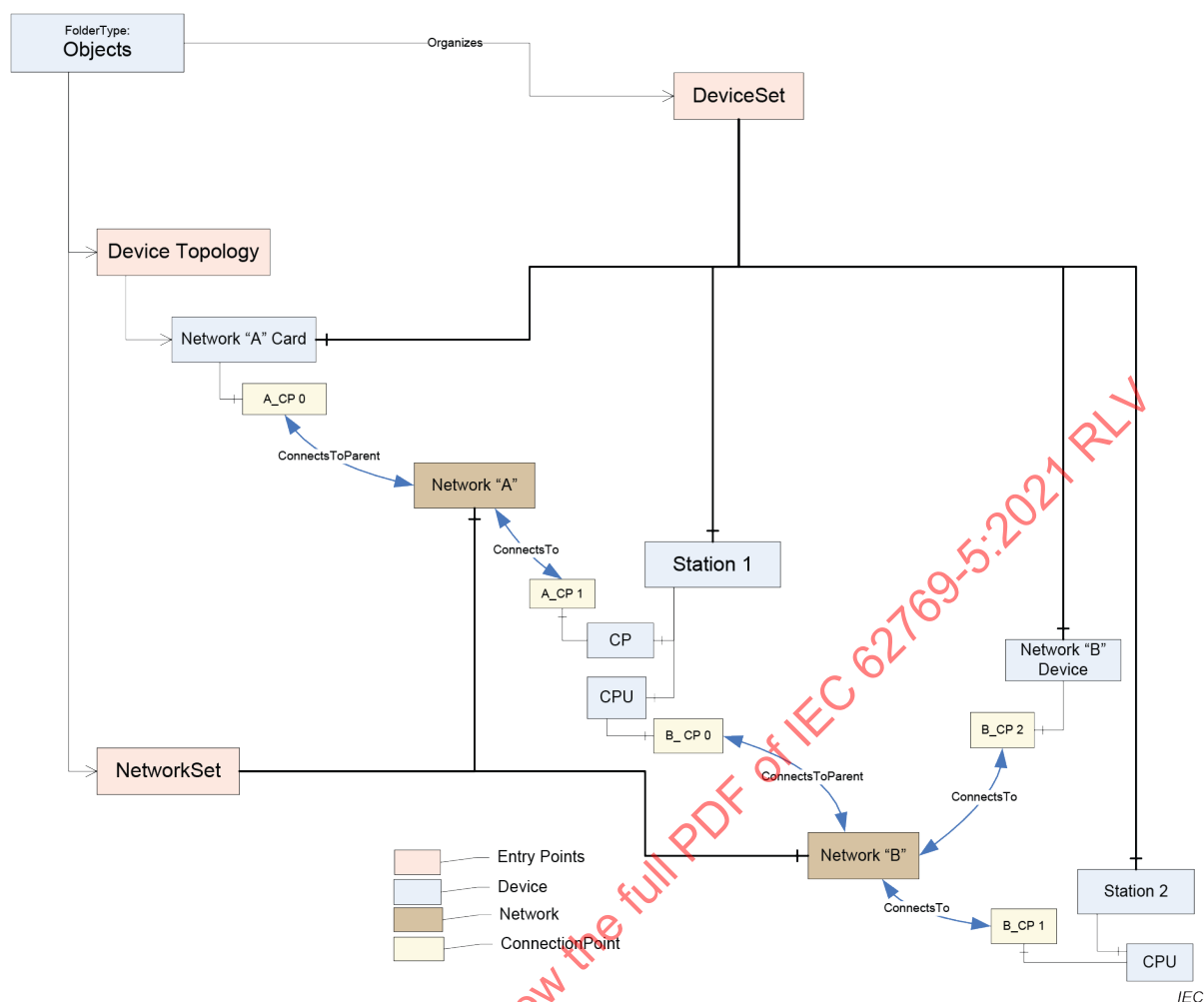


**Figure 9 – Example of a Device topology**

Coloured boxes are used to easily recognize the various types of information.

Brown boxes represent the networks. Light blue boxes represent the Devices and light yellow is used for Connection Points.

Light pink boxes represent the entry points that assure common behaviour across different implementations:

- DeviceTopology: Starting node for the topology configuration.
- DeviceSet: All instantiated Devices are components of this Object, i.e. they exist in the AddressSpace independently of the Device Topology.
- NetworkSet: All Networks are components of this Object.

### 5.3 Online/offline

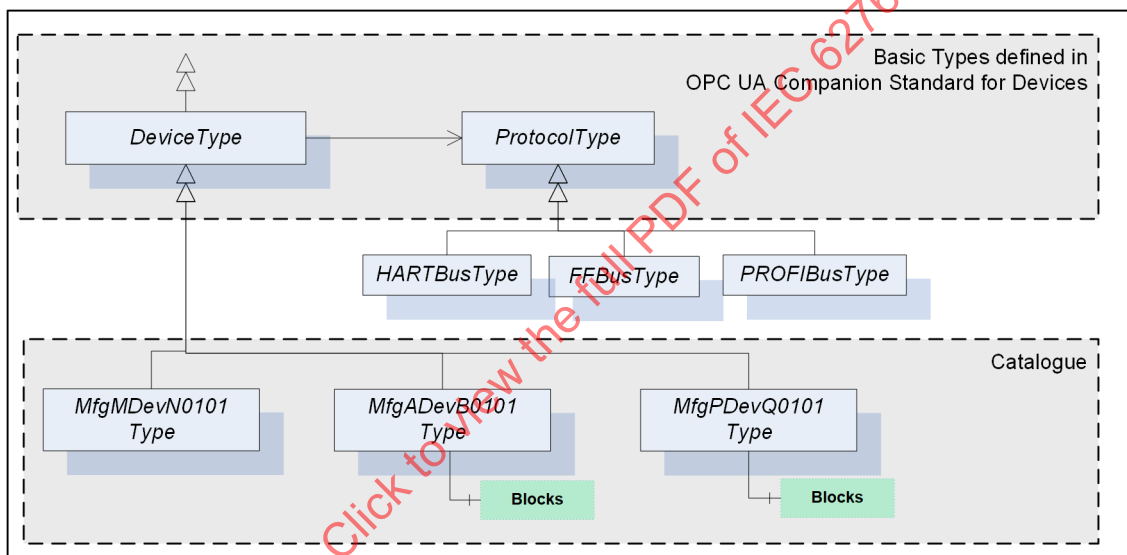
Management of the Device Topology is a configuration task, i.e. the elements in the topology (Devices, Networks, and Connection Points) are usually configured "offline" and – at a later time – will be validated against their physical representative in a real network.

To support explicit access to either the online or the offline information, each element is represented by two instances that are schematically identical, i.e., there exists a ParameterSet, FunctionalGroups, and so on. A Reference connects the online and offline representation and allows navigating between them.

#### 5.4 Catalogue (Type Definitions)

The supported (sub-types of) TopologyElements are organised as Type definitions in the OPC UA AddressSpace, forming a kind of catalogue. These definitions typically are generated based on descriptive information from FDI Packages. The Type definitions contain the Parameters, and default values for Parameters, Methods, Actions and Functional Groups including user interface elements. The FDI Server can include folders in the type model to organise the types according to the manufacturer or other criteria.

Type definitions can then be used to create instances of Devices in the OPC UA AddressSpace. Instances can be created either offline or based on data determined by Scanning. Figure 10 illustrates an example of some Type definitions (details left out) as they may exist in the AddressSpace.



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Figure 10 – Example Device Types representing a catalogue

#### 5.5 Communication

In order to integrate Devices, the FDI Server needs to be able to communicate to them. This can be done using Native Communication or Nested Communication.

The example in Figure 9 above for instance specifies that the FDI Server has direct access to the PROFINET Network using its PROFINET network card. In order to access "Station 2", the FDI Server has to go through Station 1, which provides the communication services for the PROFIBUS DP Network (see IEC 61784-1, CPF 3). This can be achieved through Nested Communication, which is specified in IEC 62769-4. Communication Devices and Communication Servers are specified in IEC 62769-7.

### 6 AddressSpace organization

To promote interoperability of FDI Clients and FDI Servers, a set of Objects and relationships are defined in Clauses 7, 8, 9, and 10. FDI Servers can implement a subset of these standard Nodes, depending on their capabilities.

Based on OPC UA rules, an OPC UA Server separates the AddressSpace into two parts:

- The Types-part contains information about all components that have been generated based on descriptive information from FDI Packages (see 5.4).
- The Objects-part contains the Device Topology with all instantiated components. All instances of the AddressSpace are related to a type of the Types folder
  - The entry points DeviceSet, NetworkSet, and DeviceTopology are formally defined in IEC 62541-100.
    - DeviceTopology is used to aggregate the top level Networks that provide access to all instances that constitute the Device Topology ((sub-)networks, devices and communication elements). Some example elements are shown in Clause 7 and highlighted using the green colour.
    - All instantiated Devices are components of the DeviceSet Object, i.e. they exist in the AddressSpace independently of the Device Topology. All Networks are components of the NetworkSet Object.

FDI Servers can either automatically create Device Objects or they may only show the available types (SupportedTypes folder) and leave it to the user to create proper instances. When using native communication, the system will typically provide the Device Topology without having to have it configured by the FDI Client.

## 7 Device Model for FDI

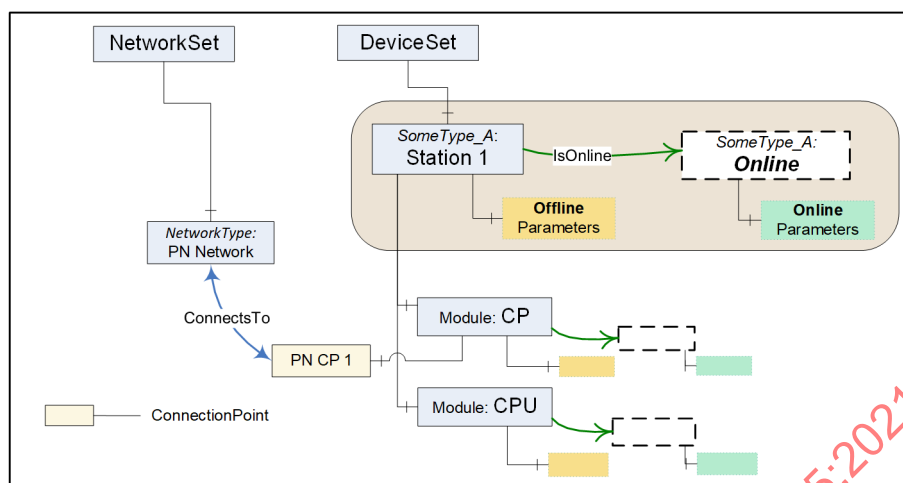
### 7.1 General

As mentioned in Clause 6, IEC 62541-100 specifies the fundamental types needed for FDI, like the TopologyElementType, the DeviceType and the ProtocolType (the fieldbus protocol). Clause 7 briefly repeats important design elements specified in IEC 62541-100 and specifies additional types that are not in IEC 62541-100.

### 7.2 Online/offline

All elements that appear in the Device Topology (Devices, Networks, and Connection Points) including their relationship correspond to information stored in the FDI Server's configuration database. Management of these elements most commonly requires access to the physical component/device (called online data in this standard) and also the storage and administration of related data in a configuration database (called offline data).

To support explicit access to either the online or the offline information, each element is represented by two instances that are schematically identical, i.e. there exists a ParameterSet, FunctionalGroups, and so on. A Reference connects online and offline representation and allows navigation between them. This is illustrated in Figure 11.



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**Figure 11 – Online component for access to device data**

Support of online/offline is mandatory for FDI Servers. Detailed information of the model and the formal definitions are specified in IEC 62541-100.

### 7.3 Device health

#### 7.3.1 DeviceHealth Mapping

The DeviceHealth Property indicates the status of a device as defined by NAMUR NE107. FDI Clients can read or monitor this Property to determine the device condition.

Servers determine the health status using the EDD METHOD GetHealthStatus defined in IEC 62769-4. The frequency at which Servers actually examine the health status may vary from several seconds up to minutes.

~~Support of the DeviceHealth Property is mandatory for Device Objects. Detailed information of the model and the formal definition are in IEC 62541-100.~~

The mapping of the GetHealthStatus return values to OPC UA is specified in Table 1.

**Table 1 – DeviceHealth Mapping**

| GetHealthStatus                                                                                                     | OPC UA                                                                                                                                                                                                                                                                                                                                                          |
|---------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0 – Indeterminate                                                                                                   | Indeterminate is not defined in the the DeviceHealth data type in IEC 62541-100. Servers that cannot determine the health status of the device shall return the OPC UA Read operation for this Property with an appropriate OPC UA status code, for example:<br><br>Bad_NotConnected<br><br>Bad_OutOfService<br><br>Bad_NoCommunication<br><br>Bad_NotSupported |
| The following values can be mapped to corresponding values defined for the DeviceHealth data type in IEC 62541-100. |                                                                                                                                                                                                                                                                                                                                                                 |
| GetHealthStatus                                                                                                     | DeviceHealth data type values                                                                                                                                                                                                                                                                                                                                   |
| 1 – Failure                                                                                                         | FAILURE_1                                                                                                                                                                                                                                                                                                                                                       |
| 2 – Function Check                                                                                                  | CHECK_FUNCTION_2                                                                                                                                                                                                                                                                                                                                                |
| 3 – Out of Specifications                                                                                           | OFF_SPEC_3                                                                                                                                                                                                                                                                                                                                                      |
| 4 – Maintenance Required                                                                                            | MAINTENANCE_REQUIRED_4                                                                                                                                                                                                                                                                                                                                          |
| 5 – Good                                                                                                            | GOOD_0                                                                                                                                                                                                                                                                                                                                                          |

Different to OPC UA for Devices (IEC 62541-100), support of the DeviceHealth Property is mandatory for Device Objects in FDI. This is illustrated in Table 2. The complete DeviceType model and its formal definition are in IEC 62541-100.

**Table 2 – DeviceType definition (excerpt applicable to this clause)**

| Attribute                                                   | Value      |              |              |                      |               |
|-------------------------------------------------------------|------------|--------------|--------------|----------------------|---------------|
| BrowseName                                                  | DeviceType |              |              |                      |               |
| IsAbstract                                                  | True       |              |              |                      |               |
| References                                                  | NodeClass  | BrowseName   | DataType     | TypeDefinition       | ModellingRule |
| Subtype of the TopologyElementType defined in IEC 62541-100 |            |              |              |                      |               |
| .....                                                       |            |              |              |                      |               |
| HasComponent                                                | Variable   | DeviceHealth | DeviceHealth | BaseDataVariableType | Mandatory     |
| .....                                                       |            |              |              |                      |               |

### 7.3.2 DeviceHealth Diagnostics

In certain cases, a Device may have additional information associated with the health status, e.g. the possible cause of an abnormal DeviceHealth status and suggested actions to return to normal.

This additional information is available with the DeviceHealthDiagnostics Variable. It is formally defined in Table 3.

**Table 3 – DeviceType definition with DeviceHealth and DeviceHealthDiagnostics**

| Attribute                                                   | Value      |                           |               |                      |               |
|-------------------------------------------------------------|------------|---------------------------|---------------|----------------------|---------------|
| BrowseName                                                  | DeviceType |                           |               |                      |               |
| IsAbstract                                                  | True       |                           |               |                      |               |
| References                                                  | NodeClass  | BrowseName                | DataType      | TypeDefinition       | ModellingRule |
| Subtype of the TopologyElementType defined in IEC 62541-100 |            |                           |               |                      |               |
| .....                                                       |            |                           |               |                      |               |
| HasComponent                                                | Variable   | DeviceHealth              | DeviceHealth  | BaseDataVariableType | Mandatory     |
| HasComponent                                                | Variable   | DeviceHealthDiagnostics[] | LocalizedText | BaseDataVariableType | Mandatory     |
| .....                                                       |            |                           |               |                      |               |

DeviceHealthDiagnostics is an array of LocalizedText. Each array element contains related diagnostic information. The language shall match the requested locale specified in the OPC UA Session. See 15.2.1 on how to select the proper language for the current OPC UA Session.

When DeviceHealth is requested, the Server shall always also fetch the matching DeviceHealthDiagnostics. The Server shall ensure that the values are synchronized by executing GetHealthStatus first and then reading the DeviceHealthDiagnostics. The Server will cache the DeviceHealthDiagnostics as part of the OPC UA Session until DeviceHealth is requested again.

If DeviceHealthDiagnostics is read with a separate service request, the Server shall return the diagnostic information associated with the most recently read DeviceHealth status. If the DeviceHealth status has not been read in the current OPC UA Session the Server shall return Bad\_NotReadable.

If no diagnostic information is available, the returned Value is Null.

See IEC 62769-4 on how DeviceHealthDiagnostics maps to the corresponding EDD information.

Example of a DeviceHealthInformation value with two array elements:

- [0]:  
"Critical Power Failure\n  
Possible cause: Critical Power failure has occurred\n  
Suggested action: Please check device/surroundings/process.\n"
- [1]:  
"Device Malfunction\n  
Possible Cause: The device has detected a serious hardware error or failure.\n  
Suggested action: Check detailed device diagnosis if possible and/or replace device hardware if necessary.\n"

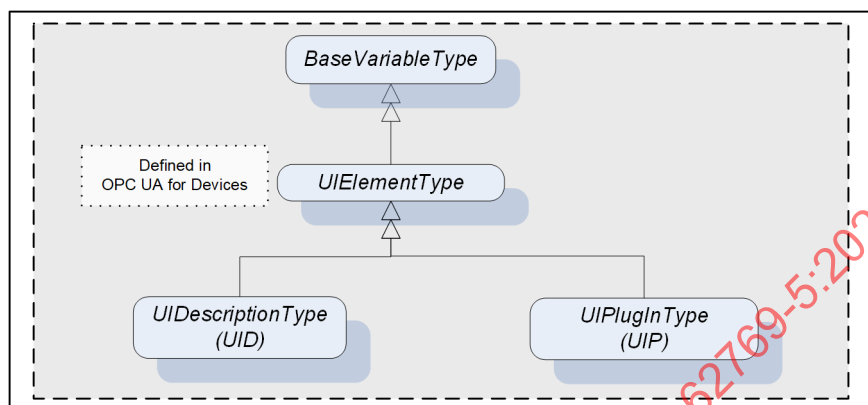
## 7.4 User interface elements

### 7.4.1 General

IEC 62541-100 defines, in an abstract way, how Servers can expose user interface elements for Clients to display a user interface specific to a FunctionalGroup of a TopologyElement.

Subclause 7.4 specifies two concrete user element types: descriptive user interface elements (UIDs) and programmed (executable) user interface elements (UIPs). UIPs are never referenced directly from a FunctionalGroup. They are always indirectly referenced from a UID by means of their UipId.

Figure 12 illustrates the type hierarchy of the user interface elements defined in IEC 62541-100 and in this document.



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**Figure 12 – Hierarchy of user interface Types**

#### 7.4.2 UI Description Type

FDI Servers may provide a descriptive user interface element (a UID) for each FunctionalGroup. Such an element will be rendered by the FDI Client. The UIDescriptionType is formally specified in Table 4.

**Table 4 – UIDescriptionType Definition**

| Attribute                                                              | Value             |            |          |                |               |
|------------------------------------------------------------------------|-------------------|------------|----------|----------------|---------------|
| BrowseName                                                             | UIDescriptionType |            |          |                |               |
| DataType                                                               | String            |            |          |                |               |
| IsAbstract                                                             | False             |            |          |                |               |
| References                                                             | NodeClass         | BrowseName | DataType | TypeDefinition | ModellingRule |
| Inherits the Properties of the UIElementType defined in IEC 62541-100. |                   |            |          |                |               |

The Value Attribute provides the UID as a String containing an XML Element. See IEC 62769-2 for the syntax of UID elements. The XML Schema for the UID Value of all exposed devices adheres to the same FDI Technology Version as indicated by the FDIServerVersion Property (see Clause 14).

#### 7.4.3 UI Plug-in Type

A User Interface Plug-in (UIP) is a software module that is hosted and run by an FDI Client. In contrast to a User Interface Description (UID), it is an executable UI element.

Details on hosting and running Plug-ins are specified in IEC 62769-2. The UIPlugInType is formally specified in Table 5.

**Table 5 – UIPluginType Definition**

| Attribute                                                              | Value                                                 |                      |          |                |               |
|------------------------------------------------------------------------|-------------------------------------------------------|----------------------|----------|----------------|---------------|
| BrowseName                                                             | UIPluginType                                          |                      |          |                |               |
| DataType                                                               | Byte                                                  |                      |          |                |               |
| ValueRank                                                              | 1 – one dimensional array                             |                      |          |                |               |
| ArrayDimensions                                                        | UInt32[1] – the length (number of bytes) of the array |                      |          |                |               |
| IsAbstract                                                             | False                                                 |                      |          |                |               |
| References                                                             | NodeClass                                             | BrowseName           | DataType | TypeDefinition | ModellingRule |
| Inherits the Properties of the UIElementType defined in IEC 62541-100. |                                                       |                      |          |                |               |
| HasProperty                                                            | Variable                                              | UIPVariantVersion    | String   | PropertyType   | Mandatory     |
| HasProperty                                                            | Variable                                              | FDITechnologyVersion | String   | PropertyType   | Mandatory     |
| HasProperty                                                            | Variable                                              | RuntimeId            | String   | PropertyType   | Mandatory     |
| HasProperty                                                            | Variable                                              | CpuInformation       | String   | PropertyType   | Mandatory     |
| HasProperty                                                            | Variable                                              | PlatformId           | String   | PropertyType   | Mandatory     |
| HasProperty                                                            | Variable                                              | Style                | String   | PropertyType   | Mandatory     |
| HasProperty                                                            | Variable                                              | StartElementName     | String   | PropertyType   | Mandatory     |
| HasComponent                                                           | Object                                                | Documentation        |          | FolderType     | Optional      |

UIPs may exist in multiple variants for different platforms or supporting different versions. The UipId (a unique identifier defined in the FDI package) identifies the UIP, not a specific variant.

UIPs do not have to be exposed in the AddressSpace. With the UipId, the FDI Client can retrieve the NodeIds of UIP Variants and their Properties by calling the OPC UA TranslateBrowsePathToNodeIds Service with the Device NodeId as the startingNode and the following list of relative names:

- "UIPSet/<UipId>"
- "UIPSet/<UipId >/RuntimeId"
- "UIPSet/<UipId >/CpuInformation"
- "UIPSet/<UipId >/PlatformId"
- "UIPSet/<UipId >/FDITechnologyVersion"
- "UIPSet/<UipId >/Style"
- "UIPSet/<UipId >/StartElementName"
- "UIPSet/<UipId >/UIPVariantVersion"

NOTE "UIPSet" is an identifier for the Server and does not have to be a Node in the AddressSpace.

The FDI Server returns arrays of NodeIds for each relative name. The number of entries in each array matches the number of UIP Variants for the UipId. The FDI Client can read the property values using the received NodeIds and choose the appropriate UIP Variant based on FDITechnologyVersion, RuntimeId, CpuInformation, and PlatformId.

The Value Attribute provides the UIP executable. The exact representation is technology dependent (see IEC 62769-6). The ArrayDimensions Attribute shall specify the size (number of bytes) of the UIP.

FDI Clients need to be able to handle large UIPs. Reading large UIPs with a single Read operation may not be possible due to configured limits in either the FDI Client or the FDI Server stack. The default maximum size for an array of bytes is 1 MegaByte. FDI Clients can use the IndexRange in the OPC UA Read Service (see IEC 62541-4) to read a UIP in – for instance – one-megabyte chunks. It is up to the FDI Client whether it starts without index and repeats with an indexRange only after an error or whether it always uses an indexRange.

The following Properties help the FDI Client to identify which UIP fits best to its environment:

- **UIPVariantVersion:**  
The version of this UIP Variant.
- **FDITechnologyVersion:**  
FDI Technology Version according to which the UIP is developed. A UIP shall always be capable of running in a client/server system with the same major version and different minor/maintenance version.
- **RuntimeId:**  
Runtime environment of the UIP as specified in IEC 62769-6.
- **CpuInformation:**  
Provides additional information about the execution environment associated with the RuntimeId. The allowed values are specified in IEC 62769-6.
- **PlatformId** defines the type of platform on which this UIP Variant is supported. An FDI Client can choose a particular UIP Variant if it matches the FDI Client's platform (see IEC 62769-4 for the concrete definitions).
  - "Workstation"– with regular screen resolution capabilities, memory capabilities, input devices available (like mouse and keyboard)
  - "Mobile"– limited screen resolution, memory and input devices possible
- **Style:**  
Defines whether the UIP shall be run "modal" or "modeless" as defined in IEC 62541-4. Currently, the values "Dialog" and "Window" are defined. While "Dialog" requires a modal window, a UIP with style "Window" will be invoked either in a modal or a non-modal window as defined in IEC 62769-2.
- **StartElementName:**  
Element needed to start this UIP Variant. IEC 62769-6 specifies how this information is used when activating the UIP.

Documents provided for a UIP Variant are exposed as Variables organized in the Documentation folder. In most cases, they will represent a product manual, which can exist as a set of individual documents. The information can be retrieved by reading the Variable value which is represented as a ByteString. The complete ByteString shall be interpreted as a PDF file. FDI Clients need to be aware that the contents that these variables represent may be large. Reading large values with a single Read operation may not be possible due to configured limits in either the FDI Client or the FDI Server stack. The default maximum size for an array of bytes is 1 MegaByte. It is recommended that FDI Clients use the IndexRange in the OPC UA Read Service (see IEC 62541-4) to read these Variables in chunks, for example, one-megabyte chunks.

## 7.5 Type-specific support information

Each DeviceType may have a set of additional data. These are mainly images, documents, or protocol-specific data. The various types of information are organized into different folders.

See IEC 62541-100 for the formal definition of support information.

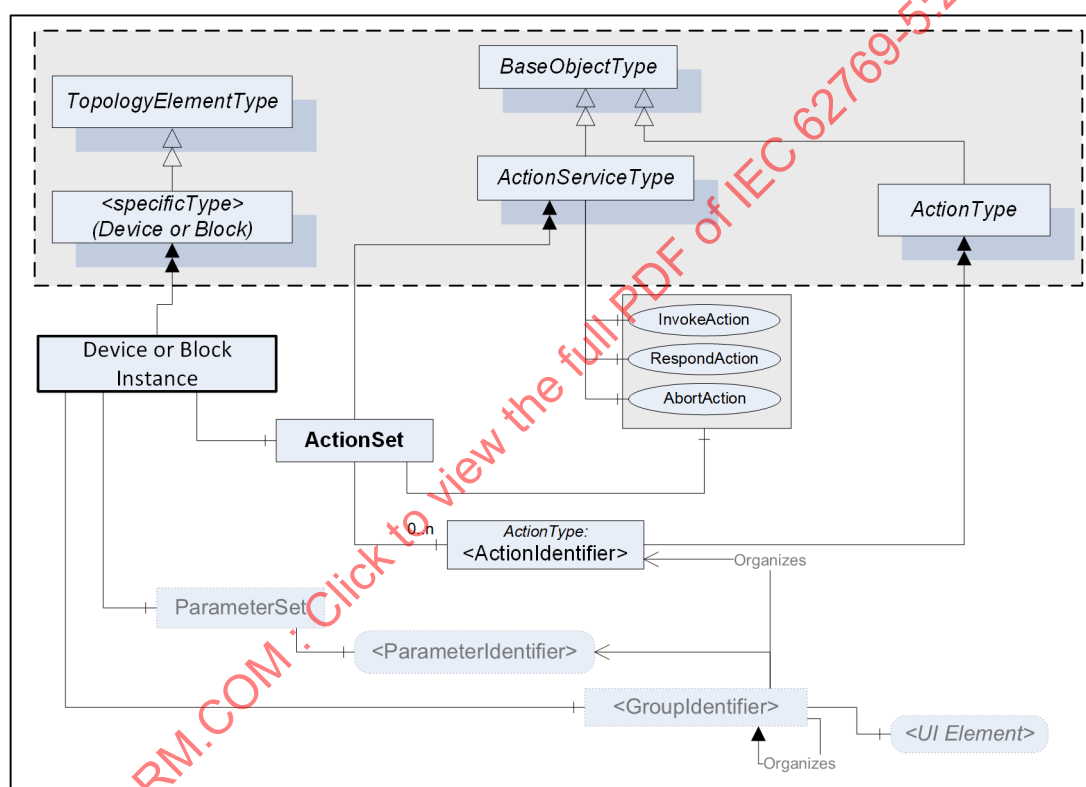
## 7.6 Actions

### 7.6.1 Overview

Actions are operations that are executed in the FDI Server on behalf of a topology element. Once invoked with the InvokeAction Method, Actions can make various state transitions until completed. The actual state is accessible via a transient, non-browsable Variable the NodeId of which is returned by the InvokeAction Method.

FDI Clients can subscribe to this Variable to receive updates concerning the Action execution (Action data). Action data may report a state transition or a request to the FDI Client that input is necessary for continuation. The FDI Client can resume the execution with the RespondAction Method and submit the requested data.

Figure 13 illustrates how Actions are integrated into a TopologyElement. ~~It is formally defined in Table 3.~~



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Figure 13 – Integration of Actions within a TopologyElement

**Table 3 – TopologyElementType with additions for Actions**

| Attribute                                                              | Value               |                   |          |                     |                     |
|------------------------------------------------------------------------|---------------------|-------------------|----------|---------------------|---------------------|
| BrowseName                                                             | TopologyElementType |                   |          |                     |                     |
| IsAbstract                                                             | True                |                   |          |                     |                     |
| References                                                             | NodeClass           | BrowseName        | DataType | TypeDefinition      | ModellingRule       |
| Inherits the Properties of the BaseObjectType defined in [IEC 62541-5] |                     |                   |          |                     |                     |
| HasComponent                                                           | Object              | ParameterSet      |          | BaseObjectType      | Optional            |
| HasComponent                                                           | Object              | MethodSet         |          | BaseObjectType      | Optional            |
| HasComponent                                                           | Object              | <GroupIdentifier> |          | FunctionalGroupType | OptionalPlaceHolder |
| HasComponent                                                           | Object              | Identification    |          | FunctionalGroupType | Optional            |
| HasComponent                                                           | Object              | Lock              |          | LockingServicesType | Optional            |
| HasComponent                                                           | Object              | ActionSet         |          | ActionServiceType   | Optional            |

ActionSet is used to aggregate the Actions for a specific TopologyElement. ~~It is added to the TopologyElementType so that it can be used on any sub-type as well.~~ This Object is not available on the Type and is only available in an instance if Actions exist for this TopologyElement.

~~Action related extensions to the FunctionalGroup ObjectType are formally defined in Table 4.~~

**Table 4 – FunctionalGroupType with additions for Actions**

| Attribute                                                          | Value               |                       |              |                      |                     |
|--------------------------------------------------------------------|---------------------|-----------------------|--------------|----------------------|---------------------|
| BrowseName                                                         | FunctionalGroupType |                       |              |                      |                     |
| IsAbstract                                                         | False               |                       |              |                      |                     |
| References                                                         | NodeClass           | BrowseName            | DataType     | TypeDefinition       | ModellingRule       |
| Inherits the Properties of the FolderType defined in [IEC 62541-5] |                     |                       |              |                      |                     |
| HasComponent                                                       | Object              | <GroupIdentifier>     |              | FunctionalGroupType  | OptionalPlaceHolder |
| Organizes                                                          | Variable            | <ParameterIdentifier> |              | BaseDataVariableType | OptionalPlaceHolder |
| Organizes                                                          | Method              | <MethodIdentifier>    |              |                      | OptionalPlaceHolder |
| HasComponent                                                       | Variable            | UIElement             | BaseDataType | UIElementType        | Optional            |
| Organizes                                                          | Object              | <ActionIdentifier>    |              | ActionType           | Optional            |

~~<ActionIdentifier> refers to Actions available and exposed for this FunctionalGroup.~~

Actions can also be referenced from FunctionalGroup Objects.

### 7.6.2 Action Type

This ObjectType defines the structure of an Action. It is formally defined in Table 6.

**Table 6 – ActionType Definition**

| Attribute                                                | Value      |            |          |                |               |
|----------------------------------------------------------|------------|------------|----------|----------------|---------------|
| BrowseName                                               | ActionType |            |          |                |               |
| IsAbstract                                               | True       |            |          |                |               |
| References                                               | NodeClass  | BrowseName | DataType | TypeDefinition | ModellingRule |
| Subtype of the BaseObjectType is defined in IEC 62541-5. |            |            |          |                |               |

The FDI Client determines the required invocation arguments for an Action from the UID.

### 7.6.3 ActionService Type

The ActionServiceType defines the Methods to invoke and control Actions. Instances of this type aggregate the Actions for a specific topology element. The ActionServiceType is formally defined in Table 7. Its use is illustrated in Figure 13.

**Table 7 – ActionServiceType Definition**

| Attribute                                             | Value             |                    |          |                |               |
|-------------------------------------------------------|-------------------|--------------------|----------|----------------|---------------|
| BrowseName                                            | ActionServiceType |                    |          |                |               |
| IsAbstract                                            | False             |                    |          |                |               |
| References                                            | NodeClass         | BrowseName         | DataType | TypeDefinition | ModellingRule |
| Subtype of the BaseObjectType defined in IEC 62541-5. |                   |                    |          |                |               |
| HasComponent                                          | Method            | InvokeAction       |          |                | Mandatory     |
| HasComponent                                          | Method            | RespondAction      |          |                | Mandatory     |
| HasComponent                                          | Method            | AbortAction        |          |                | Mandatory     |
| HasComponent                                          | Object            | <ActionIdentifier> |          | ActionType     | Optional      |

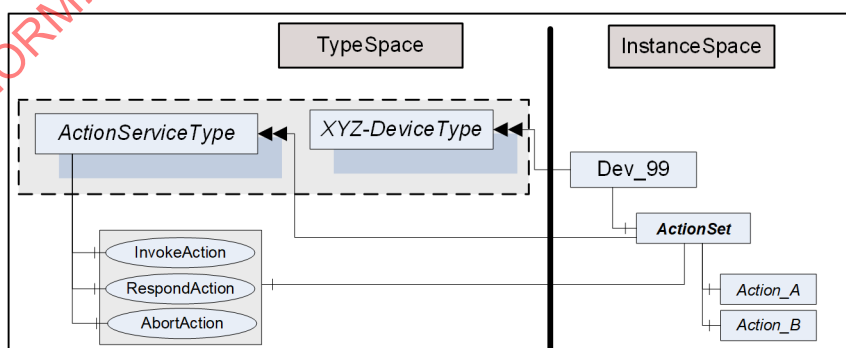
The ActionServiceType and each instance of this Type share the same Methods. The NodeId of these Methods will be fixed and defined in this document. FDI Clients therefore do not have to browse for these Methods. They can use the fixed NodeId as the MethodId of the Call Service.

The OPC UA StatusCode Bad\_MethodInvalid shall be returned from the Call Service for elements where the ActionService Methods are not supported.

<ActionIdentifier> stands for one or several Actions. Actions (Objects of ActionType) exist only in instances of the ActionServiceType, i.e. when an instance of this ObjectType is added to a TopologyElement. No Actions (Objects of ActionType) exist in the ActionServiceType itself.

### 7.6.4 ActionService Object

The support of the ActionService for an Object is declared by aggregating an instance of the ActionService Type as illustrated in Figure 14.



IEC

**Figure 14 – Action Service**

This Object is used as container for the ActionService Methods and shall have the BrowseName ActionSet. It is formally defined in Table 29. HasComponent is used to reference from a TopologyElement (for example, a Device) to its "ActionService" Object.

The ActionServiceType and each ActionSet Object share the same Methods. Actions will typically be shared by all instances of the same Device Type.

### 7.6.5 InvokeAction Method

InvokeAction is used to start an Action. It immediately returns after the state machine has been created. The "ActionSet" component of the TopologyElement (Device) on behalf of which the Action shall be invoked is specified via the ObjectId argument of the Call Service.

Explicit locking is required. If the Device has not been locked, the FDI Server will reject the request.

After InvokeAction returns, the FDI Client shall subscribe to the Value Attribute of the ActionNodeId. The Value Attribute contains an XML element (DataType = String) that reflects the current state of the Action as well as additional data (depending on state). The FDI Client therefore will get a DataChange notification whenever the state of the Action changes.

See IEC 62769-2 for the Action state diagrams as well as the XML Schema of the ActionNodeId value.

FDI Servers shall cache Action state data for an appropriate period of time (a few seconds) so that no state information is lost until the FDI Client has had a chance to subscribe.

The signature of this Method is specified below. Table 8 and Table 9 specify the arguments and AddressSpace representation, respectively.

#### Signature

```
InvokeAction (
    [in] String      ActionName,
    [in] String      MethodArguments,
    [out] NodeId     ActionNodeId,
    [out] Int32      InvokeActionError);
```

**Table 8 – InvokeAction Method Arguments**

| Argument          | Description                                                                                                                                                            |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ActionName        | String portion of the BrowseName of the Action as used in the ActionServiceType instance.                                                                              |
| MethodArguments   | XML document that contains the Action input arguments (if any). The ListOfActionArguments XML Schema defined in IEC 62769-2 is used for the MethodArguments parameter. |
| ActionNodeId      | Non-browsable node of type Variable. This node is used both to identify the instance of the Action state machine and for access to the Action state information.       |
| InvokeActionError | 0 – OK.<br>-1 – E_LockRequired – the element is not locked as required<br>-2 – E_UnknownAction – the passed name is not a valid action for this element.               |

**Table 9 – InvokeAction Method AddressSpace Definition**

| Attribute   | Value        |                 |            |                |               |
|-------------|--------------|-----------------|------------|----------------|---------------|
| BrowseName  | InvokeAction |                 |            |                |               |
| References  | NodeClass    | BrowseName      | Data Type  | TypeDefinition | ModellingRule |
| HasProperty | Variable     | InputArguments  | Argument[] | PropertyType   | Mandatory     |
| HasProperty | Variable     | OutputArguments | Argument[] | PropertyType   | Mandatory     |

### 7.6.6 RespondAction Method

RespondAction is used by the FDI Client to provide the requested value or selection of a UI function request (if applicable). The "ActionSet" component of the TopologyElement on behalf of which the Action had been invoked is specified via the ObjectId argument of the Call Service.

The signature of this Method is specified below. Table 10 and Table 11 specify the arguments and AddressSpace representation, respectively.

#### Signature

```
RespondAction (
    [in]   NodeId           ActionNodeId,
    [in]   String           Response,
    [out]  Int32            RespondActionError);
```

**Table 10 – RespondAction Method Arguments**

| Argument           | Description                                                                                                                                                    |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ActionNodeId       | NodeId of a transient Variable that represents and identifies the executing Action. This Id is returned by the InvokeAction Method.                            |
| Response           | XML document that contains the response (value or selection). See IEC 62769-2 for the XML Schema for the Response parameter.                                   |
| RespondActionError | 0 – OK<br>-1 – E_InvalidAction – the NodeId does not refer to an existing action<br>-2 – E_InvalidResponse – the passed response data could not be interpreted |

**Table 11 – RespondAction Method AddressSpace Definition**

| Attribute   | Value         |                 |            |                |               |
|-------------|---------------|-----------------|------------|----------------|---------------|
| BrowseName  | RespondAction |                 |            |                |               |
| References  | NodeClass     | BrowseName      | Data Type  | TypeDefinition | ModellingRule |
| HasProperty | Variable      | InputArguments  | Argument[] | PropertyType   | Mandatory     |
| HasProperty | Variable      | OutputArguments | Argument[] | PropertyType   | Mandatory     |

### 7.6.7 AbortAction Method

AbortAction is used by the FDI Client to abort an Action execution. This Method call immediately returns. The FDI Client is informed via a notification event on the ActionNodeId Variable when the Action enters the Aborting state.

The "ActionSet" component of the TopologyElement on behalf of which the Action had been invoked is specified via the ObjectId argument of the Call Service.

The signature of this Method is specified below. Table 12 and Table 13 specify the arguments and AddressSpace representation, respectively.

### Signature

```

AbortAction(
    [in]  NodeId      ActionNodeId,
    [out] Int32       AbortActionError);

```

**Table 12 – AbortAction Method Arguments**

| Argument         | Description                                                                                                                         |
|------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| ActionNodeId     | NodeId of a transient Variable that represents and identifies the executing Action. This Id is returned by the InvokeAction Method. |
| AbortActionError | 0 – OK<br>-1 – E_InvalidAction – the NodeId does not refer to an existing action                                                    |

**Table 13 – AbortAction Method AddressSpace Definition**

| Attribute   | Value       |                 |            |                |               |
|-------------|-------------|-----------------|------------|----------------|---------------|
| BrowseName  | AbortAction |                 |            |                |               |
| References  | NodeClass   | BrowseName      | DataType   | TypeDefinition | ModellingRule |
| HasProperty | Variable    | InputArguments  | Argument[] | PropertyType   | Mandatory     |
| HasProperty | Variable    | OutputArguments | Argument[] | PropertyType   | Mandatory     |

## 8 Network and connectivity

Network and connection information elements are required to create communication topologies.

A Network represents the communication means for Devices that are connected to it. It includes wired and wireless technologies. ConnectionPoints represent the interface (interface card) of a Device to a Network. A specific sub-type shall be defined for each protocol.

These elements are described and formally defined in IEC 62541-100.

## 9 Utility functions

### 9.1 Overview

Clause 9 provides specific services for certain FDI information elements.

### 9.2 Locking

Locking is the means to avoid concurrent modifications to a Device or Network and their components. FDI Clients shall use the Locking Services for any changes (e.g. write operations and Action invocations).

The main purpose of locking a Device is to avoid concurrent device modifications. The main purpose of locking a Network is to avoid concurrent topology changes.

When locking a Device, the lock always applies to both the online and the offline versions.

When locking a Modular Device, the lock applies to the complete Device (including all modules). Equally, when locking a Block Device, the lock applies to the complete Device (including all blocks).

If no lock is applied to the top-level Device (for Modular Device or for Block Device), the sub-devices or blocks, respectively, can be locked independently.

When locking a Network, the lock applies to the Network and all connected Devices. If any of the connected Devices provides access to a sub-ordinate Network (such as a Gateway), the sub-ordinate Network and its connected Devices are locked as well.

The LockingService is fully described and formally defined in IEC 62541-100.

### **9.3 EditContext**

#### **9.3.1 Overview**

An EditContext can be used to make changes to Variable values visible to the Server without applying them to the Device. The FDI Server provides the EditContext concept to support Clients in their editing task.

The EditContext is specified in IEC 62541-3. Following is the OPC UA Information Model including the Methods to maintain EditContext instances.

EditContext is exposed as an AddIn capability, which is comparable to the interface technology found in some programming languages. The EditContext service is modelled as an ObjectType and instances of this type are added to the Device with a pre-defined BrowseName. Additional AddIn examples are defined in IEC 62541-100.

When reading or subscribing to Variable values registered in an EditContext, the following FDI-specific StatusCodes may occur (see Clause 11):

- Good\_Edited distinguishes values that have been edited but have not been written to the Device.
- Uncertain\_DominantValueChanged indicates that dependent values are invalid and will be recalculated after the dominant value has been applied to the device. In the offline case, the dependent value has to be written by the Client as well.
- Good\_DependentValueChanged indicates that a dependent value has been changed but the change has not been applied to the device.

#### **9.3.2 EditContext Type**

The EditContextType comprises the EditContext Methods. It is formally defined in Table 14.

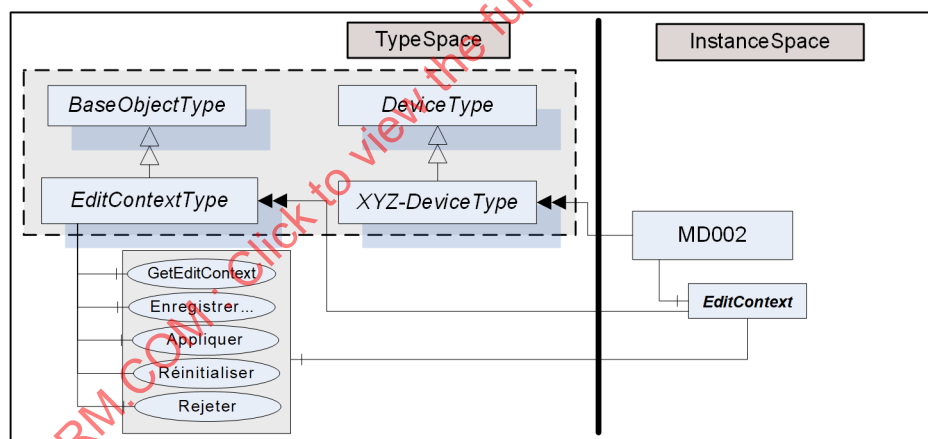
**Table 14 – EditContextType Definition**

| Attribute                                             | Value           |                             |          |                |               |
|-------------------------------------------------------|-----------------|-----------------------------|----------|----------------|---------------|
| BrowseName                                            | EditContextType |                             |          |                |               |
| IsAbstract                                            | False           |                             |          |                |               |
| References                                            | NodeClass       | BrowseName                  | DataType | TypeDefinition | ModellingRule |
| Subtype of the BaseObjectType defined in IEC 62541-5. |                 |                             |          |                |               |
| HasComponent                                          | Method          | GetEditContext              |          |                | Mandatory     |
| HasComponent                                          | Method          | RegisterNodesById           |          |                | Mandatory     |
| HasComponent                                          | Method          | RegisterNodesByRelativePath |          |                | Mandatory     |
| HasComponent                                          | Method          | Apply                       |          |                | Mandatory     |
| HasComponent                                          | Method          | Reset                       |          |                | Mandatory     |
| HasComponent                                          | Method          | Discard                     |          |                | Mandatory     |

The StatusCode Bad\_MethodInvalid shall be returned from the Call Service for elements where the EditContext Methods are not supported. Bad\_UserAccessDenied shall be returned if the Client User does not have the permission to call the Methods.

### 9.3.3 EditContext Object

The support of EditContext for an Object is declared by aggregating an instance of the EditContextType as illustrated in Figure 15.



IEC

**Figure 15 – EditContext type and instance**

This Object is used as container for the EditContext Methods and shall have the BrowseName EditContext. HasComponent is used to reference from a Device to its "EditContext" Object.

The EditContextType and each instance may share the same Methods.

### 9.3.4 GetEditContext Method

Returns an EditContext as specified in IEC 62541-3.

The signature of this Method is specified below. Table 15 and Table 16 specify the arguments and AddressSpace representation, respectively.

**Signature**

```

GetEditContext(
    [in] String      ParentId,
    [in] WindowMode TargetWindowMode,
    [out] String     EditContextId,
    [out] Int32      GetEditContextStatus);

```

**Table 15 – GetEditContext Method Arguments**

| Argument             | Description                                                                                                                                                                  |
|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ParentId             | If Null, a root instance is requested.<br><br>Otherwise, the Client passes the identifier of a previously acquired EditContext, indicating that it will create a sub-window. |
| TargetWindowMode     | An enumeration that indicates the User Interface element used for this context.<br>1 – Modal Window<br>2 – NonModal Window<br>3 – UIP                                        |
| EditContextId        | A string identifier created by the Server.                                                                                                                                   |
| GetEditContextStatus | 0 – OK<br><br>-1 – E_NotSupported – the element does not support the EditContext Service                                                                                     |

**Table 16 – GetEditContext Method AddressSpace Definition**

| Attribute   | Value          |                 |            |                |               |
|-------------|----------------|-----------------|------------|----------------|---------------|
| BrowseName  | GetEditContext |                 |            |                |               |
| References  | NodeClass      | BrowseName      | DataType   | TypeDefinition | ModellingRule |
| HasProperty | Variable       | InputArguments  | Argument[] | PropertyType   | Mandatory     |
| HasProperty | Variable       | OutputArguments | Argument[] | PropertyType   | Mandatory     |

**9.3.5 RegisterNodes Method**

This Method is used to register Nodes with an EditContext. It returns new NodeIds that have to be used to address this Node within the EditContext.

The signature of this Method is specified below. Table 17 and Table 18 specify the arguments and AddressSpace representation, respectively.

## Signatures

```

RegisterNodes (
    [in] String EditContextId,
    [in] RegistrationParameters[] NodesToRegister,
    [out] RegisterNodesResult RegisterNodesStatus);

```

**Table 17 – RegisterNodes Method Arguments**

| Argument            | Description                                                                           |
|---------------------|---------------------------------------------------------------------------------------|
| EditContextId       | Identifier of an EditContext that was previously acquired with a GetEditContext call. |
| NodesToRegister     | An array of structures for each node to register.                                     |
| RegisterNodesStatus | A structure with overall execution status and result data for each Node to register.  |

**Table 18 – RegisterNodes Method AddressSpace Definition**

| Attribute   | Value         |                 |            |                |               |
|-------------|---------------|-----------------|------------|----------------|---------------|
| BrowseName  | RegisterNodes |                 |            |                |               |
| References  | NodeClass     | BrowseName      | Data Type  | TypeDefinition | ModellingRule |
| HasProperty | Variable      | InputArguments  | Argument[] | PropertyType   | Mandatory     |
| HasProperty | Variable      | OutputArguments | Argument[] | PropertyType   | Mandatory     |

The RegistrationParameters DataType defines a single Node to be registered. Its elements are defined in Table 19.

**Table 19 – RegistrationParameters DataType Structure**

| Name                   | Type                    | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |           |                  |             |                        |             |                       |             |                         |             |                        |
|------------------------|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|------------------|-------------|------------------------|-------------|-----------------------|-------------|-------------------------|-------------|------------------------|
| RegistrationParameters | structure               | This structure specifies one of the nodes to register.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |                  |             |                        |             |                       |             |                         |             |                        |
| path                   | RelativePath            | RelativePath for this Node to register.<br>The RelativePath type is defined in IEC 62541-4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |           |                  |             |                        |             |                       |             |                         |             |                        |
| selectionFlags         | UInt32                  | <p>A bit mask that identifies the EditContext-specific NodeIds to be returned in the RegisterNodesResult structure.</p> <p>The value of this parameter shall contain at least one of the following values. No value will be rejected with E_InvalidSelectionFlags.</p> <table><tr><th>Bit Value</th><th>NodeId to return</th></tr><tr><td>0x0000 0001</td><td>Online / ContextNodeId</td></tr><tr><td>0x0000 0002</td><td>Online / DeviceNodeId</td></tr><tr><td>0x0000 0004</td><td>Offline / ContextNodeId</td></tr><tr><td>0x0000 0008</td><td>Offline / DeviceNodeId</td></tr></table> | Bit Value | NodeId to return | 0x0000 0001 | Online / ContextNodeId | 0x0000 0002 | Online / DeviceNodeId | 0x0000 0004 | Offline / ContextNodeId | 0x0000 0008 | Offline / DeviceNodeId |
| Bit Value              | NodeId to return        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |                  |             |                        |             |                       |             |                         |             |                        |
| 0x0000 0001            | Online / ContextNodeId  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |                  |             |                        |             |                       |             |                         |             |                        |
| 0x0000 0002            | Online / DeviceNodeId   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |                  |             |                        |             |                       |             |                         |             |                        |
| 0x0000 0004            | Offline / ContextNodeId |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |                  |             |                        |             |                       |             |                         |             |                        |
| 0x0000 0008            | Offline / DeviceNodeId  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |                  |             |                        |             |                       |             |                         |             |                        |

The RegisterNodesResult DataType includes overall status information and result data for each Node to be registered. Its elements are defined in Table 20.

**Table 20 – RegisterNodesResult DataType Structure**

| Name                 | Type             | Description                                                                                                                                                                                    |
|----------------------|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| RegisterNodesResult  | structure        | This structure specifies the registration result.                                                                                                                                              |
| status               | Int32            | 0 – OK – the field registeredNodes contains a result for each Node to register<br>-1 – E_InvalidId – the specified EditContext is unknown<br>the registeredNodes field is empty                |
| registeredNodes      | RegisteredNode[] | The list contains EditContext-specific NodeIds for the registered Node. The Client has to use these NodeIds for all subsequent OPC UA Service calls                                            |
| nodeStatus           | Int32            | 0 – OK<br>-1 – E_InvalidNode – an invalid Node has been registered. See IEC 62541-3 for details.<br>-2 – E_InvalidSelectionFlags – the RegistrationParameters for this Node contained no value |
| onlineContextNodeId  | NodeId           | This NodeId shall be used to address the online representation of the Node in the EditContext. See IEC 62541-3 for details.                                                                    |
| onlineDeviceNodeId   | NodeId           | This NodeId shall be used to address the online representation of the Node in the Device. See IEC 62541-3 for details.                                                                         |
| offlineContextNodeId | NodeId           | This NodeId shall be used to address the <del>online</del> offline representation of the Node in the EditContext. See IEC 62541-3 for details.                                                 |
| offlineDeviceNodeId  | NodeId           | This NodeId shall be used to address the <del>online</del> offline representation of the Node in the Device. See IEC 62541-3 for details.                                                      |

### 9.3.6 Apply Method

This Method is used to apply values that have been modified in the EditContext.

The signature of this Method is specified below. Table 21 and Table 22 specify the arguments and AddressSpace representation, respectively.

#### Signature

```

Apply(
    [in] String      EditContextId,
    [out] ApplyResult ApplyStatus);

```

**Table 21 – Apply Method Arguments**

| Argument      | Description                                                                                     |
|---------------|-------------------------------------------------------------------------------------------------|
| EditContextId | Identifier of an EditContext that was previously acquired with a GetEditContext call.           |
| ApplyStatus   | A structure with overall execution status and status information for each transferred Variable. |

**Table 22 – Apply Method AddressSpace Definition**

| Attribute   | Value     |                 |            |                |               |
|-------------|-----------|-----------------|------------|----------------|---------------|
| BrowseName  | Apply     |                 |            |                |               |
| References  | NodeClass | BrowseName      | DataType   | TypeDefinition | ModellingRule |
| HasProperty | Variable  | InputArguments  | Argument[] | PropertyType   | Mandatory     |
| HasProperty | Variable  | OutputArguments | Argument[] | PropertyType   | Mandatory     |

The ApplyResult DataType includes overall Apply status information and status information for each Variable that could not be transmitted. Its elements are defined in Table 23.

**Table 23 – ApplyResult DataType Structure**

| Name              | Type               | Description                                                                                                                                                                                                                                                      |
|-------------------|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ApplyResult       | structure          | This structure is returned in case of errors. No result data are returned. Further calls with the same TransferId are not possible.                                                                                                                              |
| status            | Int32              | 0 – OK – the transferIncidents field may include individual Variables that failed<br>-1 – E_InvalidId – the specified EditContext is unknown                                                                                                                     |
| transferIncidents | TransferIncident[] | If the service returns normally and the TransferIncidents list is empty, all changes have been applied and the edited values are cleared.<br>Otherwise, the list contains Variables that could not be transferred successfully. The edited Values are preserved. |
| contextNodeId     | NodeId             | The NodeId returned from RegisterNodesById or RegisterNodesByRelativePath.                                                                                                                                                                                       |
| statusCode        | StatusCode         | OPC UA StatusCode as defined in IEC 62541-4 and in IEC 62541-8.                                                                                                                                                                                                  |
| diagnostics       | DiagnosticInfo     | Diagnostic information. This parameter is empty if diagnostics information was not requested in the request header or if no diagnostic information was encountered in the processing of the request. The DiagnosticInfo type is defined in IEC 62541-4.          |

### 9.3.7 Reset Method

Clears all modified values in the EditContext

The signature of this Method is specified below. Table 24 and Table 25 specify the arguments and AddressSpace representation, respectively.

#### Signature

```
Reset (
    [in] String      EditContextId,
    [out] Int32      ResetStatus);
```

**Table 24 – Reset Method Arguments**

| Argument      | Description                                                                           |
|---------------|---------------------------------------------------------------------------------------|
| EditContextId | Identifier of an EditContext that was previously acquired with a GetEditContext call. |
| ResetStatus   | 0 – OK<br>-1 – E_InvalidId – the specified EditContext is unknown                     |

**Table 25 – Reset Method AddressSpace Definition**

| Attribute   | Value     |                 |            |                |               |
|-------------|-----------|-----------------|------------|----------------|---------------|
| BrowseName  | Reset     |                 |            |                |               |
| References  | NodeClass | BrowseName      | DataType   | TypeDefinition | ModellingRule |
| HasProperty | Variable  | InputArguments  | Argument[] | PropertyType   | Mandatory     |
| HasProperty | Variable  | OutputArguments | Argument[] | PropertyType   | Mandatory     |

### 9.3.8 Discard Method

This Method releases the EditContext. Any modified values that have not been applied are lost.

The signature of this Method is specified below. Table 26 and Table 27 specify the arguments and AddressSpace representation, respectively.

#### Signature

```
Discard(
    [in] String      EditContextId,
    [out] Int32      DiscardStatus);
```

**Table 26 – Discard Method Arguments**

| Argument      | Description                                                                                                                                                               |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| EditContextId | Identifier of an EditContext that was previously acquired with a GetEditContext call.                                                                                     |
| DiscardStatus | 0 – OK<br>-1 – E_InvalidId – the specified EditContext is unknown<br>-2 – E_ChildExists – the specified EditContext cannot be discarded, because a child instance exists. |

**Table 27 – Discard Method AddressSpace Definition**

| Attribute   | Value     |                 |            |                |               |
|-------------|-----------|-----------------|------------|----------------|---------------|
| BrowseName  | Discard   |                 |            |                |               |
| References  | NodeClass | BrowseName      | DataType   | TypeDefinition | ModellingRule |
| HasProperty | Variable  | InputArguments  | Argument[] | PropertyType   | Mandatory     |
| HasProperty | Variable  | OutputArguments | Argument[] | PropertyType   | Mandatory     |

## 9.4 Direct Device Access

### 9.4.1 General

DirectDeviceAccess provides the means to communicate with a device in the Device Topology. It will be used by UIPs for operations that cannot, or at least not easily, be performed through Information Model access. Use cases include the transmission of large data buckets from or to the device, for example, historical data or firmware. It is generally assumed that directly accessed data will not be reflected in the Information Model as well. DirectDeviceAccess shall not influence the structure and the data integrity of the Information Model. FDI Servers may be restrictive about when they enable the use of these Methods.

A DirectDeviceAccess Object shall exist for every Device where the FDI Server allows direct access via a UIP.

The following behaviour applies when using DirectDeviceAccess:

- Only one FDI Client can use DirectDeviceAccess at a given time.
- DirectDeviceAccess requires a lock. If the Device has not been locked, the request will be rejected.
- Due to the lock, no write operations and no Method invocations from other FDI Clients are permitted during DirectDeviceAccess. This includes the execution of Actions.

- If Attribute values of Parameters might have changed due to DirectDeviceAccess, the UIP shall set the InvalidateCache in the EndDirectAccess argument to True.

### 9.4.2 DirectDeviceAccess Type

The DirectDeviceAccessType provides the Methods needed to open and close a connection and to transfer data. Figure 16 shows the DirectDeviceAccessType definition. It is formally defined in Table 28.

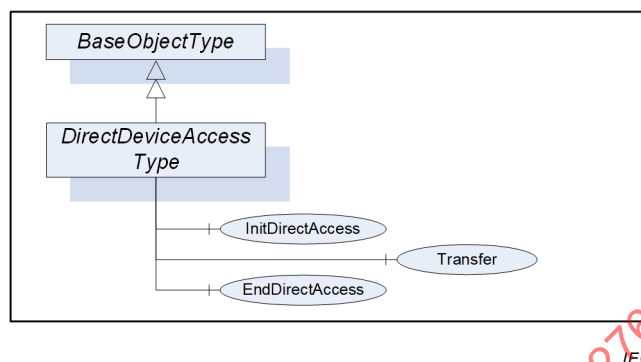


Figure 16 – DirectDeviceAccessType

Table 28 – DirectDeviceAccessType Definition

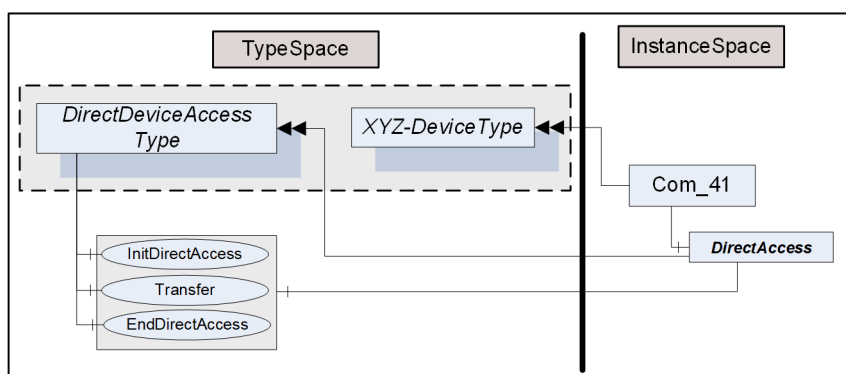
| Attribute                                             | Value                  |                  |          |                |               |
|-------------------------------------------------------|------------------------|------------------|----------|----------------|---------------|
| BrowseName                                            | DirectDeviceAccessType |                  |          |                |               |
| IsAbstract                                            | False                  |                  |          |                |               |
| References                                            | NodeClass              | BrowseName       | DataType | TypeDefinition | ModellingRule |
| Subtype of the BaseObjectType defined in IEC 62541-5. |                        |                  |          |                |               |
| HasComponent                                          | Method                 | InitDirectAccess |          |                | Mandatory     |
| HasComponent                                          | Method                 | Transfer         |          |                | Mandatory     |
| HasComponent                                          | Method                 | EndDirectAccess  |          |                | Mandatory     |

The DirectDeviceAccessType and each instance of this Type share the same Methods. The NodeId of these Methods will be fixed and defined in this document. FDI Clients therefore do not have to browse for these Methods. They can use the fixed NodeId as the MethodId of the Call Service.

The OPC UA StatusCode Bad\_MethodInvalid shall be returned from the Call Service for elements where the DirectDeviceAccess Methods are not supported.

### 9.4.3 DirectDeviceAccess Object

The support of DirectDeviceAccess for an Object is declared by aggregating an instance of the DirectDeviceAccess Type as illustrated in Figure 17.



IEC

**Figure 17 – DirectDeviceAccess instance**

This Object is used as container for the DirectDeviceAccess Methods and shall have the BrowseName DirectAccess. It is formally defined in Table 29. HasComponent is used to reference from a TopologyElement (for example, a Device) to its "DirectDeviceAccess" Object.

The DirectDeviceAccessType and each DirectAccess Object share the same Methods.

**Table 29 – DirectDeviceAccess Instance Definition**

| Attribute         | Value        |                        |                   |                |               |
|-------------------|--------------|------------------------|-------------------|----------------|---------------|
| BrowseName        | DirectAccess |                        |                   |                |               |
| References        | NodeClass    | BrowseName             | DataType          | TypeDefinition | ModellingRule |
| HasTypeDefinition | ObjectType   | DirectDeviceAccessType | Defined in 9.4.2. |                |               |

#### 9.4.4 InitDirectAccess Method

InitDirectAccess opens a logic communication channel. The Device to access is specified via the ObjectID argument of the Call Service.

It is up to the FDI Server whether this Method already opens a connection to the physical device.

The signature of this Method is specified below. Table 30 and Table 31 specify the arguments and AddressSpace representation, respectively.

## Signature

```
InitDirectAccess (
    [in] String      Context,
    [out] Int32      InitDirectAccessError);
```

**Table 30 – InitDirectAccess Method Arguments**

| Argument              | Description                                                                                                                                                                                                |
|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Context               | A string used to provide context information about the current activity going on in the FDI Client/UIP.                                                                                                    |
| InitDirectAccessError | 0 – OK<br>-1 – E_NotSupported – the device can not be directly accessed<br>-2 – E_LockRequired – the element is not locked as required<br>-3 – E_InvalidState – the device is already in DirectAccess mode |

**Table 31 – InitDirectAccess Method AddressSpace Definition**

| Attribute   | Value            |                 |            |                |               |
|-------------|------------------|-----------------|------------|----------------|---------------|
| BrowseName  | InitDirectAccess |                 |            |                |               |
| References  | NodeClass        | BrowseName      | Data Type  | TypeDefinition | ModellingRule |
| HasProperty | Variable         | InputArguments  | Argument[] | PropertyType   | Mandatory     |
| HasProperty | Variable         | OutputArguments | Argument[] | PropertyType   | Mandatory     |

## 9.4.5 EndDirectAccess Method

EndDirectAccess ends direct access. The directly accessed Device is specified via the ObjectId argument of the Call Service.

The signature of this Method is specified below. Table 32 and Table 33 specify the arguments and AddressSpace representation, respectively.

## Signature

```
EndDirectAccess (
    [in] Boolean      InvalidateCache,
    [out] Int32      EndDirectAccessError);
```

**Table 32 – EndDirectAccess Method Arguments**

| Argument             | Description                                                                                                                                                   |
|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| InvalidateCache      | If True, the FDI Server will invalidate any cached values for Device Parameters. This means that these Parameters will be re-read before they are used again. |
| EndDirectAccessError | 0 – OK<br>-1 – E_InvalidState – the device is not in DirectAccess mode.                                                                                       |

**Table 33 – EndDirectAccess Method AddressSpace Definition**

| Attribute   | Value           |                 |            |                |               |
|-------------|-----------------|-----------------|------------|----------------|---------------|
| BrowseName  | EndDirectAccess |                 |            |                |               |
| References  | NodeClass       | BrowseName      | DataType   | TypeDefinition | ModellingRule |
| HasProperty | Variable        | InputArguments  | Argument[] | PropertyType   | Mandatory     |
| HasProperty | Variable        | OutputArguments | Argument[] | PropertyType   | Mandatory     |

### 9.4.6 Transfer Method

Transfer is used to transfer data to and from the Device. The format of send or receive data is protocol-specific.

The signature of this Method is specified below. Table 34 and Table 35 specify the arguments and AddressSpace representation, respectively.

#### Signature

```

Transfer (
    [in] String      SendData,
    [out] String     ReceiveData,
    [out] Int32      TransferError);

```

**Table 34 – Transfer Method Arguments**

| Argument      | Description                                                                                                                                                                      |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SendData      | XML document based on the TransferSendDataType as specified in the communication profile-specific XML schema. See IEC 62769-4:2015, Annex F and IEC 62769-10 <sup>1</sup> 10x.   |
| ReceiveData   | XML document based on the TransferResultDataType as specified in the communication profile-specific XML schema. See IEC 62769-4:2015, Annex F and IEC 62769-10 <sup>1</sup> 10x. |
| TransferError | 0 – OK<br>-1 – E_InvalidState – the device is not in DirectAccess mode.                                                                                                          |

**Table 35 – Transfer Method AddressSpace Definition**

| Attribute   | Value     |                 |            |                |               |
|-------------|-----------|-----------------|------------|----------------|---------------|
| BrowseName  | Transfer  |                 |            |                |               |
| References  | NodeClass | BrowseName      | DataType   | TypeDefinition | ModellingRule |
| HasProperty | Variable  | InputArguments  | Argument[] | PropertyType   | Mandatory     |
| HasProperty | Variable  | OutputArguments | Argument[] | PropertyType   | Mandatory     |

## 10 Parameter Types

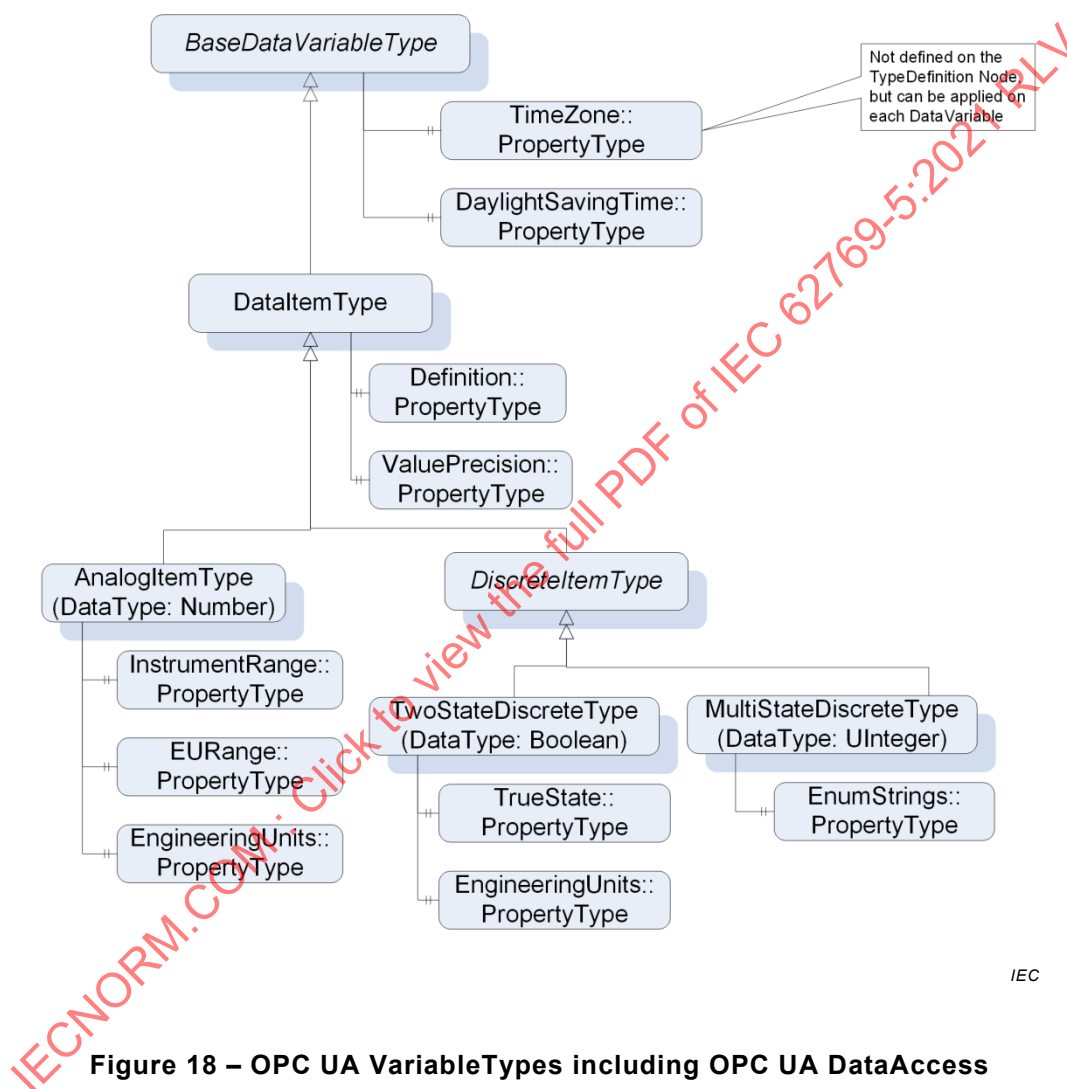
### 10.1 General

IEC 62541-100 defines a Parameter as "a variable of the Device that can be used for configuration, monitoring or control purposes. In the Information Model it is synonymous with an OPC UA DataVariable."

When discussing Parameter Types, we have to consider DataType and VariableType.

Each OPC UA DataVariable (Parameter) has a Value Attribute, which is of a certain DataType. OPC UA has already defined a set of built-in DataTypes, which are sufficient for the majority of types needed for FDI.

VariableTypes represent the type definition of (Data)Variables. Such a type definition typically defines certain behaviour as well as mandatory or optional Properties. The HasTypeDefinition Reference is used to define the VariableType for a Variable. OPC UA already defines a set of VariableTypes as illustrated in Figure 18. BaseDataVariableType is the base type and can be used if no more specialized type information is available (see IEC 62541-5). AnalogItemTypes and DiscreteItemTypes (see IEC 62541-8) are more concrete types.



IEC

Figure 18 – OPC UA VariableTypes including OPC UA DataAccess

The mapping of EDD Data Types to OPC UA DataTypes and VariableTypes is specified in 15.6.

## 10.2 ScalingFactor Property

The Value Attribute of Variables contains the raw value returned from the device. However, Servers can expose the Property ScalingFactor. It is suggested that the (raw) value is multiplied by this factor before being displayed.

The Property shall be aggregated by each Variable that it applies to. It is formally defined in Table 36.

**Table 36 – ScalingFactor Property Definition**

| Name          | DataType | Description                                                                               |
|---------------|----------|-------------------------------------------------------------------------------------------|
| ScalingFactor | Double   | This Property specifies the scaling factor to be used when displaying the Variable value. |

### 10.3 Min\_Max\_Values Property

This Property specifies one or more ranges to which a Variable value shall be set. If there are multiple ranges, they shall not overlap. A "Null" for the MIN\_Value or the MAX\_Value indicates that this boundary is not limited.

The Property shall be aggregated by each Variable that it applies to. It is formally defined in Table 37.

**Table 37 – Min\_Max\_Values Property Definition**

| Name           | DataType        | Description                                                                         |
|----------------|-----------------|-------------------------------------------------------------------------------------|
| Min_Max_Values | Variant_Range[] | This Property specifies the range or ranges to which a Variable Value shall be set. |

The Variant\_Range structure specifies a single range (a MIN\_Value and a MAX\_Value). The BaseDataType is used, because such a range can be applied to Variables of different DataTypes – in particular integer, floating point, date and duration. The actual datatype used has to match the DataType of the Variable value. It can also be Null, which means that this boundary is not defined.

Its elements are defined in Table 38.

**Table 38 – Variant\_Range DataType Structure**

| Name          | Type         | Description                                                                                                       |
|---------------|--------------|-------------------------------------------------------------------------------------------------------------------|
| Variant_Range | structure    |                                                                                                                   |
| MIN_Value     | BaseDataType | Specifies the upper bound of values to which a Variable shall be set. Null indicates that MIN_Value has no limit. |
| MAX_Value     | BaseDataType | Specifies the lower bound of values to which a Variable shall be set. Null indicates that MAX_Value has no limit. |

Its representation in the AddressSpace is defined in Table 39.

**Table 39 – Variant\_Range Definition**

| Attributes | Value         |
|------------|---------------|
| BrowseName | Variant_Range |

## 11 FDI StatusCodes

Clause 11 defines OPC UA StatusCodes that are specific to FDI Servers.

The general structure of the StatusCode is specified in IEC 62541-4. It includes a set of common operational result codes, which also apply to FDI.

Table 40 contains Good (success) codes that are specifically defined for FDI.

**Table 40 – Good operation level result codes**

| Symbolic ID                | Description                                                                                                                                                                                                                                                                                            |
|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Good_Edited                | This status applies to Variable values that are part of an EditContext (see 9.3). It is returned with values that are read or received in a DataChangeNotification from a Subscription.<br><br>It defines that it is an edited value that has not been transferred from the EditContext to the Device. |
| Good_PostActionFailed      | The value of a Variable was successfully read or written but one of the post actions failed.                                                                                                                                                                                                           |
| Good_DependentValueChanged | This status applies to Variable values that are part of an EditContext (see 9.3). It is delivered with a dominant Variable value when any of its dependent Variables was changed and not yet applied.                                                                                                  |

Table 41 contains Uncertain codes that are specifically defined for FDI.

**Table 41 – Uncertain operation level result codes**

| Symbolic ID                     | Description                                                                                                                                                                                                                                                                                           |
|---------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Uncertain_DominantValueChanged  | This status applies to Variable values that are part of an EditContext (see 9.3). It is delivered with a dependent Variable value when a dominant value – e.g. an engineering unit – was changed and the dependent Variable may have to be recalculated.                                              |
| Uncertain_DependentValueChanged | This status applies to Variable values that are part of an EditContext (see 9.3). It is delivered with a dominant Variable value when any of its dependent Variables was changed and not yet applied. The "uncertain" status indicates that the dominant variable value itself has uncertain quality. |

Table 42 contains Bad codes that are specifically defined for FDI.

**Table 42 – Bad operation level result codes**

| Symbolic ID               | Description                                                                                                                                                                                                                                                                                     |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Bad_DominantValueChanged  | This status applies to Variable values that are part of an EditContext (see 9.3). It is delivered with a dependent Variable value when a dominant value – e.g. an engineering unit – was changed and the dependent Variable cannot be accessed.                                                 |
| Bad_DependentValueChanged | This status applies to Variable values that are part of an EditContext (see 9.3). It is delivered with a dominant Variable value when any of its dependent Variables was changed and not yet applied. The "uncertain" status indicates that the dominant variable value itself has bad quality. |

## 12 Specialized topology elements

Devices and other topology elements can be specialized using the modelling elements defined in this document or in IEC 62541-100. No specific ObjectType is needed. A Communication Device for instance will have the CommunicationServices capability (Communication Devices and CommunicationServices are specified in IEC 62769-7).

Other specializations are possible applying the same techniques, for example, a Modular Communication Device.

See IEC 62541-100 for the definition of Block Device and Modular Device.

## 13 Auditing

### 13.1 General

Auditing is a requirement in many systems. It provides a means for tracking activities that occur as part of the normal operation of the system. It also provides a means for tracking abnormal behaviour. It is also a requirement from a security standpoint.

When an audit trail is maintained by the FDI Server, all audit trail records related to services invoked by FDI Clients will be implicitly created. In addition, FDI Clients have means for providing additional audit context information as specified in 13.2 and 13.3.

FDI Servers shall generate AuditEvents as specified in IEC 62541-4 and IEC 62541-5. These standards define AuditEvents for the following OPC UA Services:

- Secure Channel Services,
- Session Services,
- NodeManagement Service Set (AddNode, DeleteNode),
- Write Service,
- Method Service ("Call").

No AuditEvents are defined for reading and for subscriptions.

The FDI Server generates AuditEvents using the standard OPC UA event mechanism. This allows an external OPC UA Client to subscribe to and store the audit entries in a log file or other storage location.

### 13.2 FDI Client-provided context information

FDI Clients have various means for providing context information for the purpose of auditing:

- the ClientDescription and SessionName passed by the FDI Client when creating the Session,
- the context text from the Methods to initialise Lock or Direct Device Access.

When an AuditUpdateMethodEvent is generated for the EnterLock and InitDirectAccess Methods, the audit context information will be used for the Message field of this event.

### 13.3 LogAuditTrailMessage Method

LogAuditTrailMessage is used by the FDI Client to insert information about the current activity going on in the FDI Client into the audit trail of the FDI Server. Since it is a Method, it will be also inserted into the stream of AuditEvents. The message will be timestamped in the FDI Server.

This Method shall be a component of the Server Object. The ObjectId parameter of the Call Service shall be the NodeId of the Server Object.

FDI Clients do not have to browse for the LogAuditTrailMessage Method. Rather, they can use the well known NodeId of the Method declaration as the MethodId of the Call Service.

The signature of this Method is specified below. Table 43 and Table 44 specify the arguments and AddressSpace representation, respectively.

## Signature

```
LogAuditTrailMessage (
    [in] String Message);
```

**Table 43 – LogAuditTrailMessage Method Arguments**

| Argument | Description                       |
|----------|-----------------------------------|
| Message  | Free text describing the context. |

**Table 44 – LogAuditTrailMessage Method AddressSpace Definition**

| Attribute   | Value                |                |            |                |               |
|-------------|----------------------|----------------|------------|----------------|---------------|
| BrowseName  | LogAuditTrailMessage |                |            |                |               |
| References  | NodeClass            | BrowseName     | DataType   | TypeDefinition | ModellingRule |
| HasProperty | Variable             | InputArguments | Argument[] | PropertyType   | Mandatory     |

When an AuditUpdateMethodEvent is generated for the LogAuditTrailMessage Method, the Message argument will be used for the Message field of this event.

## 14 FDI Server Version

The FDI Technology Version supported by an FDI Server is exposed via an FDI-specific Property. The version exposed with this Property applies to

- the Information Model, and
- the XML Schema as used for UIDs and Actions.

The Property shall be aggregated by the OPC UA Server Object. It is formally defined in Table 45.

**Table 45 – FDI Server Version Property Definition**

| Name             | DataType | Description                                                                                                                              |
|------------------|----------|------------------------------------------------------------------------------------------------------------------------------------------|
| FDIServerVersion | String   | This Property specifies the FDI Technology Version that this FDI Server supports. The syntax of the string is as defined in IEC 62769-4. |

## 15 Mapping FDI Package information to the FDI Information Model

### 15.1 General

Clause 15 defines the mapping of EDDL and other FDI Package Information to the FDI Information Model and the underlying OPC UA and OPC UA Devices information models, respectively.

The OPC UA Object Model provides a standard way for Servers to represent Objects to Clients. In order to meet this objective, the OPC UA Object Model allows the definition of Objects in terms of Variables and Methods. It also allows relationships to other Objects to be expressed.

On the other hand, EDDL defines a set of language constructs that are used to describe industrial field devices. Each construct supports its own set of attributes and references. EDD information adds semantic contents to the raw data values read from and written to the field devices.

The primary objective of the EDDL-OPC UA information model is to describe the correspondence between the OPC UA Object Model elements and the EDDL elements when an EDD is used to populate the FDI Server with Objects.

Completely meeting this objective means dealing both with enhanced data access through OPC UA and with UI interactions between OPC UA clients and servers.

## **15.2 Localization**

### **15.2.1 Localized text**

In various definitions, EDDs may contain information in multiple language variants. Examples are the LABEL and HELP attributes. The server has to select the proper language for each client as follows: when creating an OPC UA Session, the OPC UA Client passes the locale(s) that it requests to be used for all services within this Session. If the Server does not support any of the requested locales, it chooses an appropriate default locale.

### **15.2.2 Engineering units**

Variables with a UNIT CODE are represented in OPC UA as AnalogItem Variables. The UNIT CODE is exposed via the EngineeringUnit Property. Changing the EngineeringUnit will cause all EDD Variables that depend on the associated UNIT CODE to be recalculated. As a result, the OPC UA Variable values will be set as well.

Changing the EngineeringUnit will affect all Clients.

## **15.3 Device**

### **15.3.1 General**

Subclause 15.3 specifies the mapping of FDI Package elements to Device Types and Device Instances.

Devices may also have Blocks (see 15.4).

### **15.3.2 Mapping to Attributes to a specific DeviceType Node**

The BrowseName and NodeId Attributes are vendor-specific.

The DisplayName Attribute is created from the Package Catalog: DeviceType.Name.

The Description Attribute of a Device is the information that serves to further identify, manage, locate, and/or explain the device whose contents are defined by the user. For purely block-oriented devices, this will appear only on blocks. For example, in HART, the MESSAGE variable can be used here.

### **15.3.3 Mapping to Properties**

Type and instances share the same Properties.

Some of the Properties are created from information in the Package Catalog. Table 46 specifies the mapping of Properties to Package Catalog elements.

**Table 46 – DeviceType Property Mapping**

| Property             | Package Catalog element                               |
|----------------------|-------------------------------------------------------|
| Manufacturer         | ManufacturerName                                      |
| Model                | ListOfDeviceTypes[i].ListOfInterfaces[j].DeviceModel. |
| DeviceRevision       | ListOfDeviceTypes[i].ListOfInterfaces[j].Version.     |
| FDITechnologyVersion | FDITechnologyVersion.                                 |

The SerialNumber, RevisionCounter, SoftwareRevision, and HardwareRevision Properties correspond to the value of the protocol-specific "serial number", "revision counter", "software revision", and "hardware revision" Parameters, respectively.

The DeviceManual Property is an empty string. Documents can be found in the attachment set.

If a Picture element is available in the FDI Package, it can be mapped to the OPC UA Icon Property (see IEC 62541-3). If multiple resolutions are available, the host has to choose.

#### 15.3.4 Mapping to ParameterSet

Some devices are strictly block-oriented with no kinds of Variables on the device level. Mapping an EDD for these devices will result in an empty ParameterSet. When VARIABLE, VALUE\_ARRAY or LIST items exist on the device-level, the resulting Parameters are kept in the "ParameterSet" as a flat list of Parameters. FunctionalGroups reflect the structure of the device menus defined in the device's EDD.

A ParameterSet with all Parameters exists on the Type, the offline and the online instances.

See 15.6 on how EDDL attributes are used to create Parameter nodes.

#### 15.3.5 Mapping to Functional Groups

The top-level Functional Groups that are referenced directly from the Device Object correspond to the root MENU items, as defined in IEC 61804-4. Naming conventions are used to differentiate between Functional Groups for handheld and for PC-based applications.

There are no Functional Groups on the DeviceType.

#### 15.3.6 Mapping to DeviceTypeImage

The Variables in the DeviceTypeImage folder are created from the Package Catalog: DeviceTypes[i].ListOfDeviceImages. BrowseName and DisplayName represent the file name from the Relationship Type.

#### 15.3.7 Mapping to Documentation

The Variables in the Documentation folder are created from the Package Catalog: DeviceTypes[i].ListOfDocuments. BrowseName and DisplayName represent the file name from the Relationship Type.

#### 15.3.8 Mapping to ProtocolSupport

The Variables in the ProtocolSupport folder are created from the Package Catalog: DeviceTypes[i].ListOfInterfaces[j].ListOfCommunicationProfileSupportFiles. BrowseName and DisplayName represent the file name from the Relationship Type.

### 15.3.9 Mapping to ImageSet

The ImageSet contains Variable Nodes for all images from the EDD that are needed for UIDs.

### 15.3.10 Mapping to ActionSet

The ActionSet references OPC UA Objects that represent all EDD Methods except for the abort and the action methods as defined in IEC 61804-3. See 15.8 on how EDDL attributes are used to create Action Nodes

### 15.3.11 Mapping to MethodSet

The MethodSet (inherited from IEC 62541-100) is not used by the FDI.

## 15.4 Modular Device

Subclause 15.4 specifies the mapping of a modular device's package.

As described in IEC 62769-4, a package for a modular device contains a head station EDD and one or more module EDDs. The head station EDD contains COMPONENT constructs that identify the module EDDs.

The EDDs for head station Device and for each module shall be individually mapped in accordance with the mapping rules for single Devices.

The head station Device will show up as a modular Device as specified in IEC 62541-100.

- The SubDevices component in the instance of the head Device references instantiated modules.
- The SupportedTypes folder in the SubDevices component references all DeviceTypes for modules that may appear in the instance of the head Device.

## 15.5 Block

### 15.5.1 General

Subclause 15.5 specifies the mapping of EDDL elements to Block Types and instances.

EDDL supports the definition of devices that are block-oriented, and devices that are non-block oriented. When blocks (specifically, Block\_A) exist in an EDD, the resulting device shall be modelled as a block-oriented Device as specified in IEC 62541-100. The Block node instances are kept in the Blocks component. A Device that does not support EDDL-defined Blocks will not have the Blocks component.

The SupportedTypes folder in the Blocks component of a DeviceType references all BlockTypes that may appear in a Device Instance. The Blocks component in a Device Instance references instantiated Blocks.

### 15.5.2 Mapping to Attributes

The BrowseName and DisplayName correspond to the EDD Identifier and LABEL Attribute of the corresponding EDDL Block, respectively.

The NodeId is vendor-specific.

The Help attribute of the corresponding EDDL Block is mapped to the Description attribute of the Block instance node. Bad\_AttributeIdInvalid shall be used if EDD contains no Help.

### 15.5.3 Mapping to ParameterSet

All VARIABLE, VALUE\_ARRAY, LIST items specified for a Block are used as Parameters in the "ParameterSet". A ParameterSet with all Parameters exist on the Type, the offline and the online instances.

See 15.6 on how EDDL attributes are used to create Parameter nodes.

### 15.5.4 Mapping to Functional Groups

A Block may have FunctionalGroups that expose its Parameters in an organized fashion, reflecting the structure of the block menus defined in the device's EDD. The top-level Functional Groups that are referenced directly from the Block Object correspond to the root MENU items, as defined in IEC 61804-4. Naming conventions are used to differentiate between Functional Groups for handheld and for PC-based applications

The BrowseName of a FunctionalGroup is the EDD identifier of the corresponding EDDL MENU or COLLECTION.

There are no Functional Groups on the BlockType.

### 15.5.5 Mapping to ActionSet

The ActionSet references OPC UA Objects that represent all EDD Methods defined for a specific BLOCK, except for the abort and the action methods as defined in IEC 61804-3. See 15.8 on how EDDL attributes are used to create Action Nodes.

### 15.5.6 Mapping to MethodSet

The MethodSet (inherited from IEC 62541-100) is not used by the FDI.

### 15.5.7 Instantiation rules

The BrowseName of a Block is generated by the FDI Server from the EDD identifier of the corresponding EDDL BLOCK\_A by adding a numeric suffix that the OPC UA server generates in order to make the BrowseName unique. For example, \_\_analog\_input\_0, \_\_analog\_input\_1, \_\_pid\_control\_0.

The DisplayName of a BLOCK\_B Block is the LABEL attribute.

The DisplayName of a BLOCK\_A Block is defined in the protocol annex.

The Description of a Block is the HELP attribute of the corresponding EDDL BLOCK. Bad\_AttributeInvalid shall be used if the EDD contains no Help.

## 15.6 Parameter

### 15.6.1 General

EDDL Parameters (for devices or blocks) are mapped to OPC UA Variables. The VariableType used may be of any sub-type of the abstract BaseVariableType. In most cases, they will be mapped to the VariableTypes defined in IEC 62541-8, for example, DataItemType, AnalogItemType or DiscreteItemType. This document includes additional VariableTypes for more sophisticated EDDL types. See Table 48 for the mapping of EDDL types.

The BrowseName of a Parameter is the EDD identifier of the corresponding EDDL VARIABLE, RECORD or VALUE\_ARRAY.

The DisplayName of a Parameter is the LABEL attribute of the corresponding EDDL VARIABLE, RECORD or VALUE\_ARRAY.

The Description of a Parameter is the HELP attribute of the corresponding EDDL VARIABLE, RECORD or VALUE\_ARRAY. Bad\_AttributeIdInvalid shall be used if the EDD contains no Help.

Parameters have also a set of Attributes that are common to all VariableTypes. Table 47 summarizes the Variable Attributes and describes how they are set from the EDDL description information.

**Table 47 – Setting OPC UA Variable Attributes from EDDL variable attributes**

| Attributes              | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                     |     |             |             |   |                                                                    |              |   |                                                                     |
|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|-----|-------------|-------------|---|--------------------------------------------------------------------|--------------|---|---------------------------------------------------------------------|
| Value                   | The most recent value of the Variable that the FDI Server has read from the device.                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                     |     |             |             |   |                                                                    |              |   |                                                                     |
| DataType                | The EDDL data type is translated into an OPC UA standard data type in accordance with Table 48.                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                     |     |             |             |   |                                                                    |              |   |                                                                     |
| ValueRank               | Either set to "Scalar" or – when the Parameter is an array – the number <del>OF ELEMENTS specified for the EDDL VALUE_ARRAY item</del> of dimensions.                                                                                                                                                                                                                                                                                                                                                                                      |                                                                     |     |             |             |   |                                                                    |              |   |                                                                     |
| ArrayDimensions         | Specifies the length of each dimension if the Parameter is an array. This attribute is not exposed if the length is unknown or dynamic.                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                     |     |             |             |   |                                                                    |              |   |                                                                     |
| AccessLevel             | <p>The AccessLevel Attribute is set based on the EDDL variable HANDLING attribute according to the following table:</p> <table><tr><th>Field</th><th>Bit</th><th>Description</th></tr><tr><td>CurrentRead</td><td>0</td><td>Set if EDDL variable HANDLING is defined as READ. Reset otherwise.</td></tr><tr><td>CurrentWrite</td><td>1</td><td>Set if EDDL variable HANDLING is defined as WRITE. Reset otherwise.</td></tr></table> <p>If the HANDLING attribute is missing, the Parameter will be defined as readable and writeable.</p> | Field                                                               | Bit | Description | CurrentRead | 0 | Set if EDDL variable HANDLING is defined as READ. Reset otherwise. | CurrentWrite | 1 | Set if EDDL variable HANDLING is defined as WRITE. Reset otherwise. |
| Field                   | Bit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Description                                                         |     |             |             |   |                                                                    |              |   |                                                                     |
| CurrentRead             | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Set if EDDL variable HANDLING is defined as READ. Reset otherwise.  |     |             |             |   |                                                                    |              |   |                                                                     |
| CurrentWrite            | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Set if EDDL variable HANDLING is defined as WRITE. Reset otherwise. |     |             |             |   |                                                                    |              |   |                                                                     |
| UserAccessLevel         | The AccessLevel with possible restrictions based on client identity as defined by the FDI Server.                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                     |     |             |             |   |                                                                    |              |   |                                                                     |
| MinimumSamplingInterval | The MinimumSamplingInterval Attribute indicates how fast the FDI Server can reasonably sample the value for changes. It is suggested that the FDI Server checks the variable CLASS attribute to differentiate static variables from dynamic variables regarding the sampling interval. Static variables might be sampled only once and then only when the RevisionCounter changes. For static variables, the FDI Server can use the MinimumSamplingInterval -1 (indeterminate).                                                            |                                                                     |     |             |             |   |                                                                    |              |   |                                                                     |

The Value Attribute is the Parameter value, and – for the online representation – reflects the device data value.

The DataType Attribute is an OPC UA DataType chosen to match the EDDL type and size. Table 48 shows the correspondence between the EDDL types and sizes and the OPC UA VariableTypes and standard DataTypes.

**Table 48 – Correspondence between EDDL and OPC UA standard data types**

| EDDL Data Type   | OPC UA VariableType                  | OPC UA DataType                                                                                                       | Constraints                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|------------------|--------------------------------------|-----------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Arithmetic       |                                      |                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| INTEGER          | BaseDataVariableType, AnalogItemType | SByte                                                                                                                 | When the size specified in EDDL is 1 byte.                                                                                                                                                                                                                                                                                                                                                                                                                               |
|                  |                                      | Int16                                                                                                                 | When the size specified in EDDL is 2 bytes.                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                  |                                      | Int32                                                                                                                 | When the size specified in EDDL is 3 or 4 bytes.                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                  |                                      | Int64                                                                                                                 | When the size specified in EDDL is 5, 6, 7 or 8 bytes.                                                                                                                                                                                                                                                                                                                                                                                                                   |
| UNSIGNED_INTEGER | BaseDataVariableType, AnalogItemType | Byte                                                                                                                  | When the size specified in EDDL is 1 byte.                                                                                                                                                                                                                                                                                                                                                                                                                               |
|                  |                                      | UInt16                                                                                                                | When the size specified in EDDL is 2 bytes.                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                  |                                      | UInt32                                                                                                                | When the size specified in EDDL is 3 or 4 bytes.                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                  |                                      | UInt64                                                                                                                | When the size specified in EDDL is 5, 6, 7 or 8 bytes.                                                                                                                                                                                                                                                                                                                                                                                                                   |
| DOUBLE           | BaseDataVariableType, AnalogItemType | Double                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| FLOAT            | BaseDataVariableType, AnalogItemType | Float                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| ENUMERATED       | See 15.6.5                           | Byte                                                                                                                  | When the size specified in EDDL is 1 byte.                                                                                                                                                                                                                                                                                                                                                                                                                               |
|                  |                                      | UInt16                                                                                                                | When the size specified in EDDL is 2 bytes.                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                  |                                      | UInt32                                                                                                                | When the size specified in EDDL is 3 or 4 bytes.                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                  |                                      | UInt64                                                                                                                | When the size specified in EDDL is 5, 6, 7 or 8 bytes.                                                                                                                                                                                                                                                                                                                                                                                                                   |
| BIT_ENUMERATED   | See 15.6.6                           | Byte                                                                                                                  | When the size specified in EDDL is 1 byte.                                                                                                                                                                                                                                                                                                                                                                                                                               |
|                  |                                      | UInt16                                                                                                                | When the size specified in EDDL is 2 bytes.                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                  |                                      | UInt32                                                                                                                | When the size specified in EDDL is 3 or 4 bytes.                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                  |                                      | UInt64                                                                                                                | When the size specified in EDDL is 5, 6, 7 or 8 bytes.                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Date and Time    |                                      |                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| DATE             | BaseDataVariableType                 | UtcTime (a 64-bit signed integer which represents the number of 100 nanosecond intervals since January 1, 1601 (UTC)) | The data type DATE consists of a calendar date. This data type has special codification in the device. Conversion to UtcTime is necessary when reading it from the device. Conversion back to DATE is necessary when writing it to the device. On write, if invalid data is written, the service returns an appropriate error in the serviceResult and the diagnosticInfo data members of the ResponseHeader and does not accept the data.                               |
| DATE_AND_TIME    | BaseDataVariableType                 | UtcTime                                                                                                               | The data type DATE_AND_TIME consists of a calendar date and a time. This data type has special codification in the device. Conversion to UtcTime is necessary when reading it from the device. Conversion back to DATE_AND_TIME is necessary when writing it to the device. On writing, if invalid data is written the service returns an appropriate error in the serviceResult and the diagnosticInfo data members of the ResponseHeader and does not accept the data. |

| EDDL Data Type | OPC UA VariableType  | OPC UA DataType                                                                                                                         | Constraints                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|----------------|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DURATION       | BaseDataVariableType | Duration<br>(a <i>Double</i> that defines an interval of time in milliseconds (fractions can be used to define sub-millisecond values)) | The DURATION data type is a time difference that consists of a time in milliseconds and an optional day count. This data type has special codification in the device. Conversion to TIME is necessary when reading it from the device. Conversion back to DURATION is necessary when writing it to the device. On writing, if invalid data is written, the service returns an appropriate error in the serviceResult and the diagnosticInfo data members of the ResponseHeader and does not accept the data. The OPC Duration type is limited to approximately 49,7 days, which is less than the theoretical maximum of the EDDL DURATION type. If the DURATION exceeds the OPC maximum, the quality should be set to indicate this condition. |
| TIME           | BaseDataVariableType | UtcTime                                                                                                                                 | The TIME data type consists of a time and an optional date. This data type has special codification in the device. Conversion to UtcTime is necessary when reading it from the device. Conversion back to TIME is necessary when writing it to the device. On writing, if invalid data is written, the service returns an appropriate error in the serviceResult and the diagnosticInfo data members of the ResponseHeader and does not accept the data.                                                                                                                                                                                                                                                                                       |
| TIME_VALUE[4]  | BaseDataVariableType | Duration                                                                                                                                | Number of 1/32 ms.<br>TIME_VALUE is the "number of 1/32 ms". The "Duration" is calculated by multiplying the TIME_VALUE by 0,031 25 (which is the float equivalent for 1/32 ms).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| TIME_VALUE[8]  | BaseDataVariableType | UtcTime                                                                                                                                 | The data type TIME_VALUE is used to represent date and time in the required precision for application clock synchronization. This data type has special codification in the device. Conversion to UtcTime is necessary when reading it from the device. Conversion back to TIME_VALUE is necessary when writing it to the device. On writing, if invalid data is written, the service returns an appropriate error in the serviceResult and the diagnosticInfo data members of the ResponseHeader and does not accept the data.                                                                                                                                                                                                                |
| String         |                      |                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| ASCII          | BaseDataVariableType | String                                                                                                                                  | Conversion to String is necessary when reading it from the device. Conversion back to ASCII is necessary when writing it to the device. On writing, if invalid characters are written, the service returns an appropriate error in the serviceResult and the diagnosticInfo data members of the ResponseHeader and does not accept the string.                                                                                                                                                                                                                                                                                                                                                                                                 |
| BIT_STRING     | BaseDataVariableType | ByteString                                                                                                                              | Conversion to ByteString is necessary when reading it from the device. Conversion back to BIT_STRING is necessary when writing it to the device. On writing, if invalid characters are written, the service returns an appropriate error in the serviceResult and the diagnosticInfo data members of the ResponseHeader and does not accept the string.                                                                                                                                                                                                                                                                                                                                                                                        |

| EDDL Data Type | OPC UA VariableType  | OPC UA DataType | Constraints                                                                                                                                                                                                                                                                                                                                           |
|----------------|----------------------|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| EUC            | BaseDataVariableType | String          | Conversion to String is necessary when reading it from the device. Conversion back to EUC is necessary when writing it to the device. On writing, if invalid characters are written, the service returns an appropriate error in the serviceResult and the diagnosticInfo data members of the ResponseHeader and does not accept the string.          |
| PACKED_ASCII   | BaseDataVariableType | String          | Conversion to String is necessary when reading it from the device. Conversion back to PACKED_ASCII is necessary when writing it to the device. On writing, if invalid characters are written, the service returns an appropriate error in the serviceResult and the diagnosticInfo data members of the ResponseHeader and does not accept the string. |
| PASSWORD       | BaseDataVariableType | String          | Conversion to String is necessary when reading it from the device.<br><br>FDI Servers shall allow PASSWORD Variables to be read only when a secure OPC UA channel has been created, i.e. a channel with encryption.                                                                                                                                   |
| VISIBLE        | BaseDataVariableType | String          | Conversion to String is necessary when reading it from the device. Conversion back to VISIBLE is necessary when writing it to the device. On writing, if invalid characters are written, the service returns an appropriate error in the serviceResult and the diagnosticInfo data members of the ResponseHeader and does not accept the string.      |
| OCTET          | BaseDataVariableType | ByteString      |                                                                                                                                                                                                                                                                                                                                                       |
| INDEX          | see 15.6.5           | String          |                                                                                                                                                                                                                                                                                                                                                       |
| BOOLEAN        | BaseDataVariableType | Boolean         |                                                                                                                                                                                                                                                                                                                                                       |

As Table 48 shows, EDDL supports a variety of variable types. While that table shows the correspondence between the EDDL data types and the OPC UA VariableType, it does not provide any details on how other EDDL VARIABLE TYPE construct attributes are supported. It does not provide any details on how other OPC UA BaseDataVariableType attributes should be set either. Subclause 15.6 is intended to provide details for each EDDL data type.

### 15.6.2 Private Parameters

The Parameters specified in an FDI Package may be declared private using the PRIVATE Attribute specified in IEC 61804-3. The FDI Server shall create Nodes in the Information Model for the private Parameters but they shall not be browsable. The FDI Server shall return the NodeIds of private Parameters when the name of such a Parameter is passed to TranslateBrowsePathsToNodeIds (the startingNode argument shall be the "ParameterSet" Object). Once the FDI Client has obtained the NodeId, all Service requests for private Parameters will be processed in the same way as for public (browsable) Parameters.

An example of private parameters is parameters that should only be modified through an Action. These parameters should not be visible to FDI Clients to prevent direct access. FDI Clients invoke Actions to access these private parameters.

### 15.6.3 MIN\_Value and MAX\_Value

If one or more MIN\_VALUE and MAX\_VALUE attributes are specified for a variable in EDDL, they shall be mapped to the Min\_Max\_Values Properties defined in 10.3.

### 15.6.4 Engineering units

The EngineeringUnits Property defined in IEC 62541-3 and IEC 62541-8 shall be used:

- If the variable has the CONSTANT\_UNIT defined for itself in EDDL. In this case, the EngineeringUnits Property keeps the EDD CONSTANT\_UNIT variable attribute. The FDI Server shall deal with the fact that CONSTANT\_UNIT can be conditional.
- If the variable is involved in an EDD UNIT relation, it is the FDI Server's responsibility to implement the unit code update mechanism. An EDD UNIT relation specifies a reference to a variable holding a unit code and a list of dependent variables. When the variable holding the unit code is modified, the list of affected variables using that unit code shall be refreshed. When an affected variable is displayed, the value of its unit code shall also be displayed.

The standard OPC UA notifications can be used to report to the FDI Clients that the unit code has changed.

### 15.6.5 Enumerated Parameters

An OPC UA DataVariable with the ~~OPC UA DataType Enumeration~~ VariableType MultiStateValueDiscreteType (defined in IEC 62541-8) is used for each enumerator in the EDDL enumerated variable definition.

The Value Attribute of the DataVariable is the numeric value of the state, and corresponds to the value attribute of the EDDL ENUMERATED TYPE.

The ValueAsText Property of the DataVariable exposes the display value of the state, which corresponds to the description attribute of the EDDL ENUMERATED TYPE.

The EnumValues Property of the DataVariable contains the complete list of enumerations, i.e. a table where each element is a structure consisting of EDDL ENUMERATED TYPE attributes "value", "description", and "help". If no help attribute exists in the EDD, the value of the description attribute will also be used for this purpose.

### 15.6.6 Bit-enumerated Parameters

A DataVariable of OPC UA OptionSet VariableType is used for each EDDL BIT ENUMERATED VARIABLE definition. The OPC UA DataType is an array of Boolean where one Boolean is used per bit in the EDDL BIT\_ENUMERATED VARIABLE definition.

The Boolean array of the DataVariable reflects the status of all bits. TRUE is used when a bit is set and FALSE when a bit is reset.

The EnumValues Property of the DataVariable contains the complete list of bit enumerations, i.e. a table where each element is a structure consisting of EDDL BIT ENUMERATED TYPE attributes "bit position", "description", and "help". If no help attribute exists in the EDD, the value of the description attribute will also be used for this purpose.

### 15.6.7 Representation of records

A complex DataVariable is used to represent EDDL RECORD Parameters. The root DataVariable represents the record itself. It will have component DataVariables that represent the EDDL RECORD MEMBERS. (The MEMBERS of an EDDL RECORD are defined in EDDL by means of a reference to an EDDL VARIABLE.).

See Figure 19 for an example of how records are represented in the OPC UA AddressSpace.

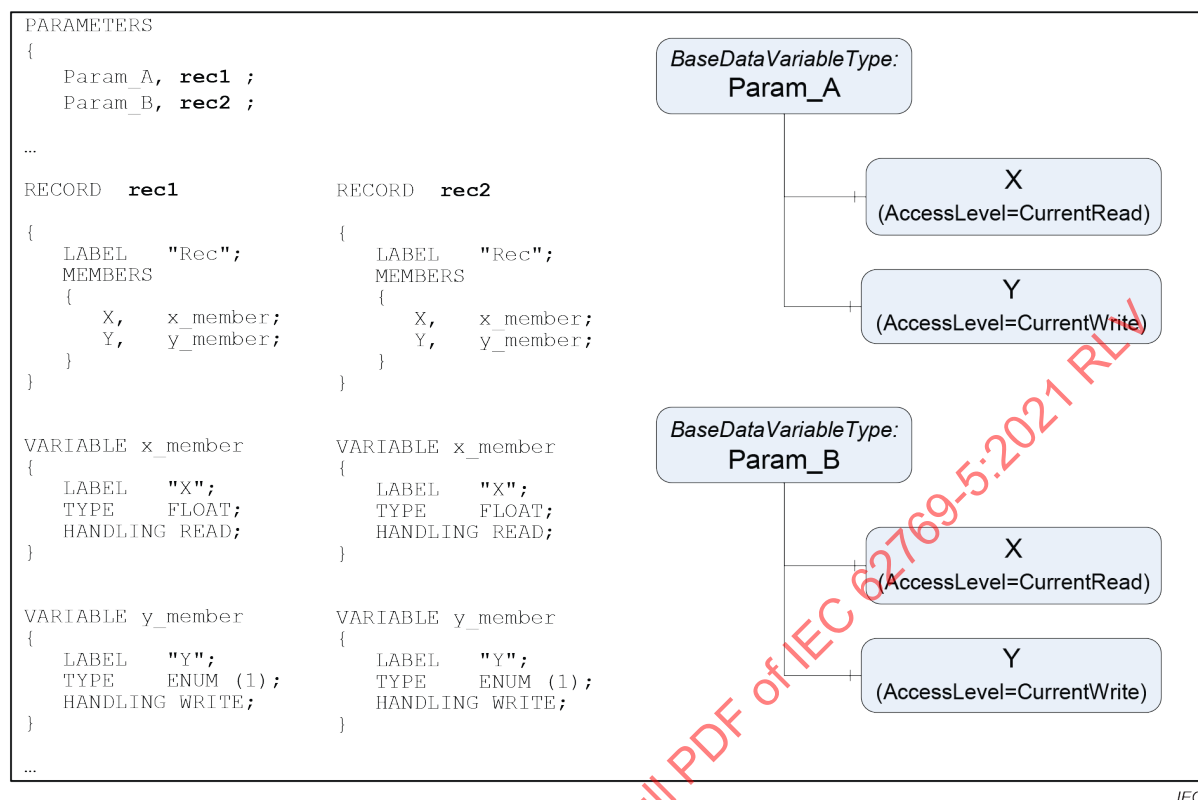


**Figure 19 – Example: Complex variable representing a RECORD**

BrowseName and DisplayName of the root DataVariable are set to the EDD identifier of the EDDL VARIABLE that implements this RECORD type. The DataType Attribute of the "root" DataVariable is BaseDataType. The ValueRank Attribute is used to specify that the value contains an array. The Value Attribute represents the values of all members in the order as defined for the RECORD. According to the example in Figure 19, the first variant will contain a floating-point value and the second will be a numeric value representing the Enumeration.

For each component DataVariable that represents an EDDL RECORD MEMBER:

- The BrowseName is the identifier of the corresponding EDDL VARIABLE.
- The DisplayName is the LABEL attribute of the corresponding EDDL VARIABLE.
- The Description is the HELP attribute of the corresponding EDDL VARIABLE. Bad\_AttributeIdInvalid shall be used if the EDD contains no Help.
- The AccessLevel is derived from the HANDLING attribute. Readable and Writeable shall be used if the EDD contains no HANDLING attribute.

#### 15.6.8 Representation of arrays, and lists of Parameters with simple data types

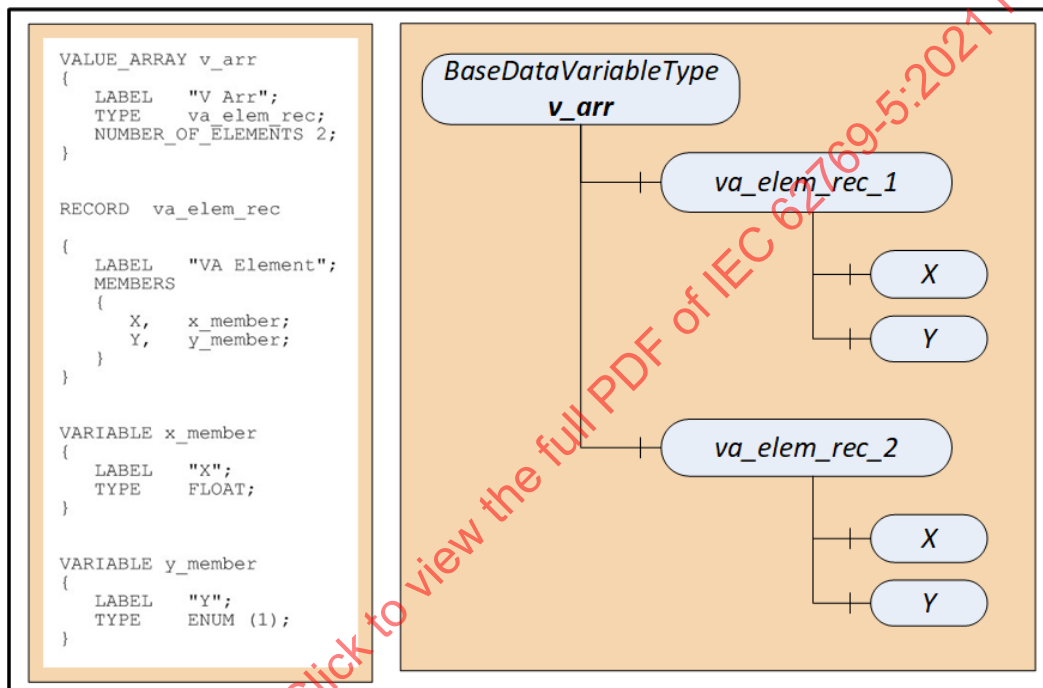
A single DataVariable will represent an EDDL VALUE\_ARRAY or LIST item when the data type of the referenced array element has a simple data type.

The OPC UA DataVariable Attributes are set as follows:

- DataType is set to the type of the array element (see Table 48 for the data type mapping).
- The ValueRank Attribute is used to specify that the value contains an array. In case of an EDDL VALUE\_ARRAY the number of elements is exposed in the *ArrayDimensions Attribute*. In the case of an EDDL LIST, the *ArrayDimensions Attribute* is not exposed. The number of elements is unspecific since the size can change dynamically.

### 15.6.9 Representation of values arrays, and lists of RECORD Parameters

Value arrays or lists of non-simple data types will be represented as OPC UA array of complex variables. Figure 20 shows the EDDL sample code of a VALUE\_ARRAY of RECORDs and the corresponding complex variable in the OPC UA AddressSpace.



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**Figure 20 – Complex variable representing a VALUE\_ARRAY of RECORDs**

In the FDI Server AddressSpace, a complex DataVariable is used to represent the entire VALUE\_ARRAY. Each VALUE\_ARRAY element, which is in fact a RECORD, is represented as a component complex DataVariable. The RECORD MEMBERS are also represented as component DataVariables. The FDI Client refers to the X member of the first record in the array through the BrowseName `v_arr.va_elem_1.x_member`. Note that the index always begins with '1'.

The DataType Attribute of all complex root DataVariables is BaseDataType. The ValueRank Attribute is used to specify that the value contains an array. The Value Attribute represents all VALUE\_ARRAY entries. The first element corresponds to the first array entry and so on. Each element in turn contains an array. This may either be an array of simple types or an array of BaseDataType. A RECORD is always represented as an array of BaseDataType.

### 15.6.10 Representation of COLLECTION and REFERENCE ARRAY

The EDDL constructs COLLECTION and REFERENCE ARRAY are mapped to Functional Group Objects (see 15.7) when used for grouping only.

### 15.6.11 SCALING\_FACTOR

If the EDD includes a SCALING\_FACTOR attribute for an EDD VARIABLE, it shall be mapped as follows.

- The Parameter value and associated Properties (like Ranges) shall be exposed in raw format (not scaled by the FDI Server). Any scaling is responsibility of the FDI Client (or UIP, respectively).
- The SCALING\_FACTOR shall be provided in a Property with the BrowseName "ScalingFactor". The DataType shall be "Double". If the SCALING\_FACTOR in the EDD is an expression, this expression will be computed by the EDD Interpreter.
- The SCALING\_FACTOR is also included in UID documents.

## 15.7 Functional Groups

FunctionalGroups are used to group Variables (EDDL parameters) or Actions (EDDL methods). They have a recursive definition, that is, FunctionalGroups may reference other FunctionalGroups.

Both Devices and Blocks may have FunctionalGroups. EDDL MENUs, EDDL BLOCK\_A PARAMETERS, COLLECTIONs, and REFERENCE ARRAYS are the building blocks for FunctionalGroups. The proper attributes of these EDDL constructs control which elements are referenced by the Functional Group.

- VARIABLE, RECORD, or VALUE\_ARRAY will cause a reference to the corresponding FDI Parameter.
- METHODS will be used to organise FDI Action Objects.
- Elements that represent one of the building blocks again will cause a reference to a subordinate Functional Group.

Root MENUs as defined in IEC 61804-4 will be top-level Functional Groups. The FDI Server generates the whole hierarchy of FunctionalGroups by browsing the EDDL MENU and their ITEMS attribute definitions. The FunctionalGroups reproduce the same structure of the MENUs as they are defined in EDD for the Device or Block.

All FunctionalGroups are instantiated in both the offline and the online representation of a Device. Naming conventions defined in IEC 61804-4 can be used to determine if a FunctionalGroup is relevant for offline or online.

The BrowseName Attribute of a FunctionalGroup is the EDD identifier of the menu or the instance identifier of the block. The naming conventions defined in IEC 61804-4 can be used to determine if a FunctionalGroup is relevant for PC or handheld.

The DisplayName Attribute of a FunctionalGroup is the LABEL attribute of the corresponding building block.

The Description Attribute of a FunctionalGroup is the value of the HELP attribute of the corresponding building block. Bad\_AttributeIdInvalid shall be used if the EDD contains no Help.

FunctionalGroups exposing standard sets of Parameters such as diagnostic information will be created for an EDD, which comply with the menu conventions for PC-based application as defined in IEC 61804-4.

### 15.8 AXIS elements in UIDs

AXIS elements are not represented as instances in the FDI information model. However, an EDDL AXIS has writable VIEW\_MIN/VIEW\_MAX attributes. They shall be modified by the FDI Client to inform the server about the zooming, scrolling or positioning.

To enable this modification, the FDI Server shall create variable nodes for each of these attributes in the Information Model. They need not be browsable. The NodeIds of these nodes are included into the UID document as described in the UID schema.

### 15.9 Actions

FDI Actions are used to represent EDD METHODS. Only EDD METHODS that are to be called by the FDI Client as part of a UID or a UIP shall be exposed as FDI Actions. If METHODS defined in IEC 61804-3, which include the pre or post read, edit and write actions, are exposed as Actions, they shall not be browsable. The names of these actions will be communicated to the Client as part of a UID document. These names can be passed to TranslateBrowsePathsToNodeIds to get the matching NodeId.

All Actions are instantiated in both the offline and the online representation of a Device.

The BrowseName Attribute of an Action is the EDD identifier of the METHOD.

The DisplayName Attribute of an Action is the LABEL attribute of the EDDL METHOD.

The Description Attribute of an Action is the HELP attribute of the EDDL METHOD. Bad\_AttributeIdInvalid shall be used if the EDD contains no Help.

The execution of an Action causes the execution of the EDD Method implementation. This is specified in detail in IEC 62769-2.

The METHODS specified in an FDI Package may be declared private using the PRIVATE Attribute specified in IEC 61804-3. The FDI Server shall create Action Objects in the Information Model for the private METHODS but they shall not be browsable. The FDI Server shall return the NodeIds of private Actions when the name of such an Action is passed to TranslateBrowsePathsToNodeIds (the startingNode argument shall be the "ActionSet" Object). Once the FDI Client has obtained the NodeId, private Actions can be invoked and processed in the same way as public (browsable) Actions.

### 15.10 UIPs

UIPs are specified in the FDI Package via the SupportedUIPs element. Each UIP is uniquely identified by a UUID.

UIPs are not exposed in the FDI AddressSpace but they can be referenced and accessed using the UUID. This is specified in IEC 62769-2.

### 15.11 Protocols, Networks and Connection Points

The FDI Server will create specific Protocol Types (sub-type of the ProtocolType defined in IEC 62541-100) for natively supported Protocols. Additional Protocol Types might be created for Communication Servers based on the Protocols they support.

Specific ConnectionPoint Types (sub-types of the ConnectionPointType defined in IEC 62541-100) will be created for natively supported Protocols. Additional Types might be created for Communication Servers based on the Protocols they support.

The types are created as specified in the protocol-specific series of standards IEC 62769-1xx.

## 16 Profiles

This clause defines the profiles and conformance units for the OPC UA Information Model for FDI Clients and FDI Servers. Profiles are named groupings of conformance units. Facets are profiles that will be combined with other Profiles to define the complete functionality of an OPC UA Server or Client.

FDI Servers (FDI Hosts) that implement a subset of the FDI Information Model that is relevant for generic OPC UA Clients shall implement as a minimum the BaseDevice\_Server\_Facet specified in IEC 62541-100 (OPC UA for Devices).

Table 49 specifies the facet for FDI Servers (FDI Hosts) that support FDI Clients.

**Table 49 – FDI Server Facet Definition**

| Conformance Unit      | Description                                                                                | Optional/<br>Mandatory |
|-----------------------|--------------------------------------------------------------------------------------------|------------------------|
| FDI Information Model | Support Objects that conform to the Types specified in this document and in IEC 62541-100. | M                      |

Table 50 defines the facet for FDI Clients that use the FDI Information Model.

**Table 50 – FDI Client Facet Definition**

| Conformance Unit             | Description                                                                                | Optional/<br>Mandatory |
|------------------------------|--------------------------------------------------------------------------------------------|------------------------|
| FDI Client Information Model | Consume Objects that conform to the Types specified in this document and in IEC 62541-100. | M                      |

## Annex A (normative)

### Namespace and Mappings

This annex defines the numeric identifiers for all of the numeric NodeIds defined in this document. The identifiers are specified in a CSV file with the following syntax:

`<SymbolName>, <Identifier>, <NodeClass>`

where the SymbolName is either the BrowseName of a Type Node or the BrowsePath for an Instance Node that appears in the specification and the Identifier is the numeric value for the NodeId.

The BrowsePath for an Instance Node is constructed by appending the BrowseName of the instance Node to the BrowseName for the containing instance or type. An underscore character is used to separate each BrowseName in the path.

The NamespaceUri `http://fdi-cooperation.com/OpcUa/Fdi5/` is applied to NodeIds defined here.

~~The CSV released with this version of the standard can be found here:~~

~~[http://www.fdi-cooperation.com/tl\\_files/Specification/1.0/Schemas/Opc.Ua.Fdi5.NodeIds.csv](http://www.fdi-cooperation.com/tl_files/Specification/1.0/Schemas/Opc.Ua.Fdi5.NodeIds.csv)~~

An electronic version of the complete Information Model defined in this document is also provided. It follows the XML Information Model Schema syntax defined in IEC 62541-6.

~~The Information Model Schema released with this version of the standard can be found here:~~

~~[http://www.fdi-cooperation.com/tl\\_files/Specification/1.0/Schemas/Opc.Ua.Fdi5.NodeSet2](http://www.fdi-cooperation.com/tl_files/Specification/1.0/Schemas/Opc.Ua.Fdi5.NodeSet2)~~

The Information Model Schema released with this version of the document is in a separate file named:

`OPCUA_Part5_Model_V1.1\Opc.Ua.Fdi5.NodeSet2.xml`

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# INTERNATIONAL STANDARD

## NORME INTERNATIONALE



**Field device integration (FDI) –  
Part 5: Information Model**

**Intégration des appareils de terrain (FDI) –  
Partie 5: Modèle d'Information**

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**FIELD DEVICE INTEGRATION (FDI) –****Part 5: Information Model****FOREWORD**

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International Standard IEC 62769-5 has been prepared by subcommittee 65E: Devices and integration in enterprise systems, of IEC technical committee 65: Industrial-process measurement, control and automation.

This second edition cancels and replaces the first edition published in 2015. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) support for generic protocol extension for faster adoption of other technologies;
- b) support of new protocols;
- c) generic protocol extension to allow adoption of other communication protocols;
- d) based on generic protocol extension: Modbus RTU.

The text of this International Standard is based on the following documents:

| FDIS         | Report on voting |
|--------------|------------------|
| 65E/762/FDIS | 65E/772/RVD      |

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62769 series, published under the general title *Field Device Integration (FDI)*, can be found on the IEC website.

This standard contains attached files in the form of XML schema. These files are intended to be used as a complement and do not form an integral part of the standard.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

**IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.**

## INTRODUCTION

The IEC 62769 series has the general title *Field Device Integration (FDI)* and the following parts:

- Part 1: Overview
- Part 2: FDI Client
- Part 3: FDI Server
- Part 4: FDI Packages
- Part 5: FDI Information Model
- Part 6: FDI Technology Mapping
- Part 7: FDI Communication Devices
- Part 100: Profiles – Generic Protocol Extensions
- Part 101-1: Profiles – Foundation Fieldbus H1
- Part 101-2: Profiles – Foundation Fieldbus HSE
- Part 103-1: Profiles – PROFIBUS
- Part 103-4: Profiles – PROFINET
- Part 109-1: Profiles – HART and WirelessHART
- Part 115-2: Profiles – Protocol-specific Definitions for Modbus RTU
- Part 150-1: Profiles – ISA 100.11a

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## FIELD DEVICE INTEGRATION (FDI) –

### Part 5: Information Model

#### 1 Scope

This part of IEC 62769 defines the FDI Information Model. One of the main tasks of the Information Model is to reflect the topology of the automation system. Therefore, it represents the devices of the automation system as well as the connecting communication networks including their properties, relationships, and the operations that can be performed on them. The types in the AddressSpace of the FDI Server constitute a catalogue, which is built from *FDI Packages*.

The fundamental types for the FDI Information Model are well defined in OPC UA for Devices (IEC 62541-100). The FDI Information Model specifies extensions for a few special cases and otherwise explains how these types are used and how the contents are built from elements of DevicePackages.

The overall FDI architecture is illustrated in Figure 1. The architectural components that are within the scope of this document have been highlighted in this illustration.

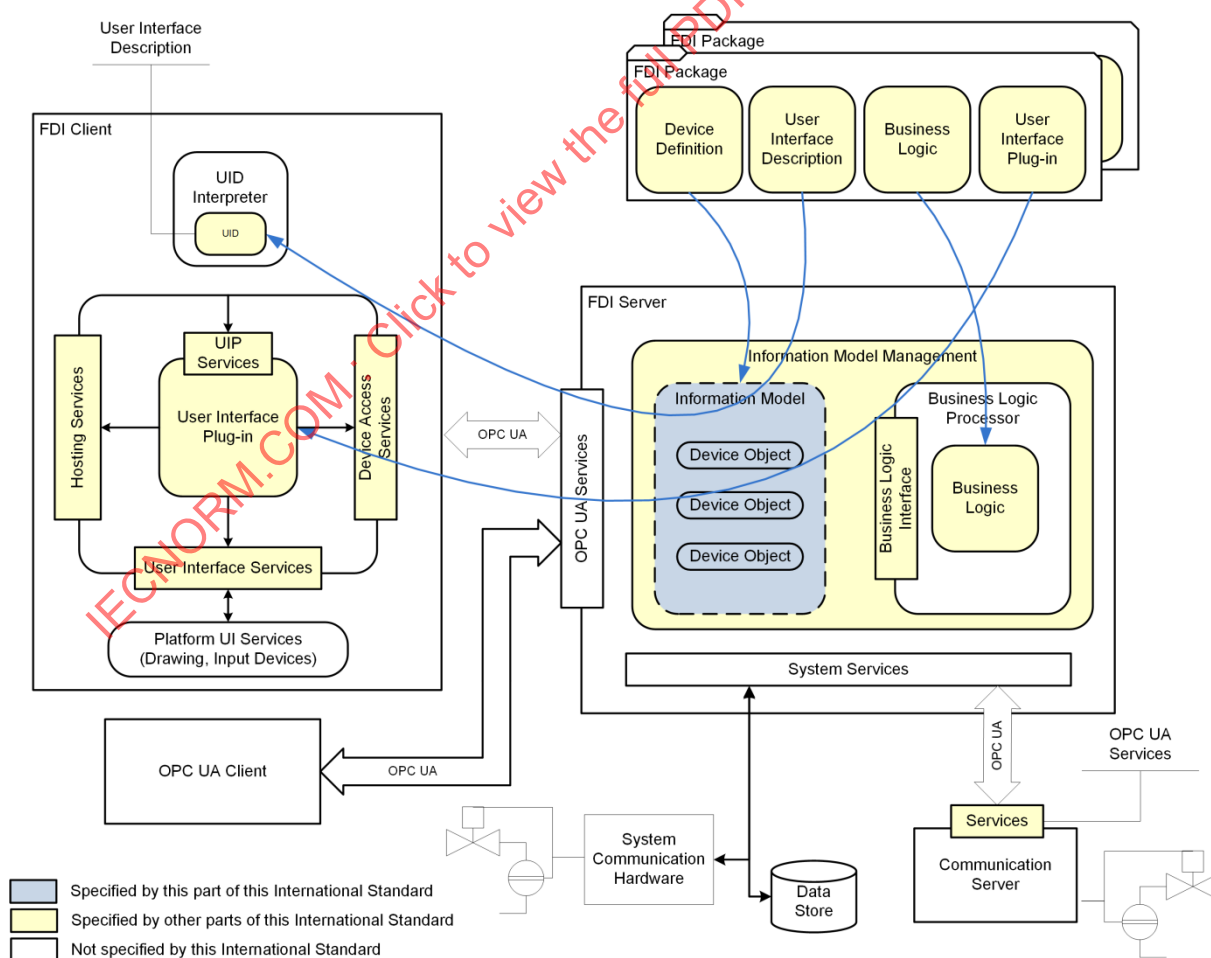


Figure 1 – FDI architecture diagram

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61784-1, *Industrial communication networks – Profiles – Part 1: Fieldbus profiles*

IEC 61804-3, *Function blocks (FB) for process control and Electronic Device Description Language (EDDL) – Part 3: EDDL syntax and semantics*

IEC 61804-4, *Function blocks (FB) for process control and electronic device description language (EDDL) – Part 4: EDD interpretation*

IEC 62541-3, *OPC unified architecture – Part 3: Address Space Model*

IEC 62541-4, *OPC unified architecture – Part 4: Services*

IEC 62541-5, *OPC unified architecture – Part 5: Information Model*

IEC 62541-6, *OPC unified architecture – Part 6: Mappings*

IEC 62541-8, *OPC unified architecture – Part 8: Data Access*

IEC 62541-100, *OPC unified architecture – Part 100: OPC UA for Devices*

IEC 62769-1, *Field Device Integration (FDI) – Part 1: Overview*

IEC 62769-2, *Field Device Integration (FDI) – Part 2: FDI Client*

IEC 62769-4, *Field Device Integration (FDI) – Part 4: FDI Packages*

IEC 62769-7, *Field Device Integration (FDI) – Part 7: FDI Communication Devices*

## 3 Terms, definitions, abbreviated terms and conventions

### 3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62769-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

### 3.2 Abbreviated terms

For the purposes of this document, the abbreviated terms given in IEC 62769-1 as well as the following apply.

|       |                                          |
|-------|------------------------------------------|
| HMI   | Human Machine Interface                  |
| SCADA | Supervisory Control and Data Acquisition |
| TCP   | Transmission Control Protocol            |

### 3.3 Conventions

For the purposes of this document, the conventions given in IEC 62769-1 apply.

### 3.4 Conventions for graphical notation

OPC UA defines a graphical notation for an OPC UA AddressSpace. It defines graphical symbols for all NodeClasses and how different types of References between Nodes can be visualized. Figure 2 shows the symbols for the NodeClasses used in this document. NodeClasses representing types always have a shadow.

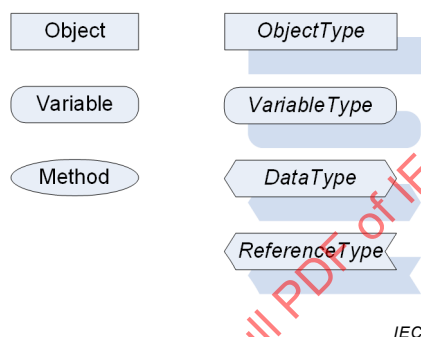
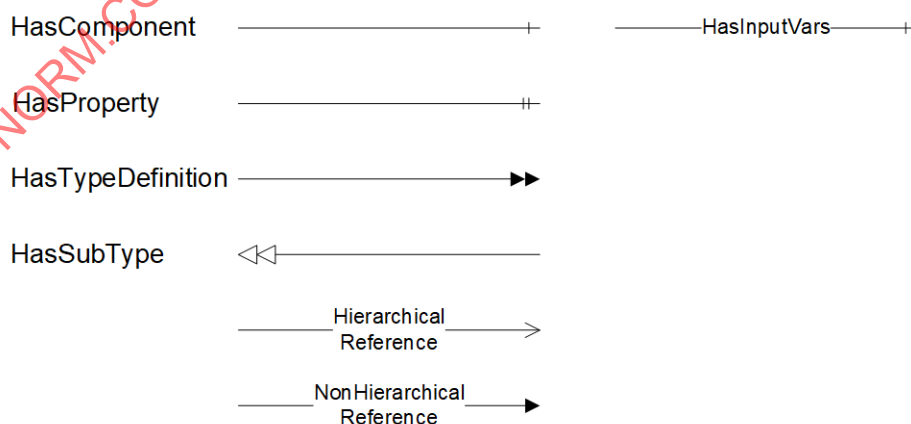


**Figure 2 – OPC UA Graphical Notation for NodeClasses**

Figure 3 shows the symbols for the ReferenceTypes used in this document. The Reference symbol is normally pointing from the source Node to the target Node. The only exception is the HasSubType Reference. The most important References such as HasComponent, HasProperty, HasTypeDefinition and HasSubType have special symbols avoiding the name of the Reference. For other ReferenceTypes or derived ReferenceTypes, the name of the ReferenceType is used together with the symbol.



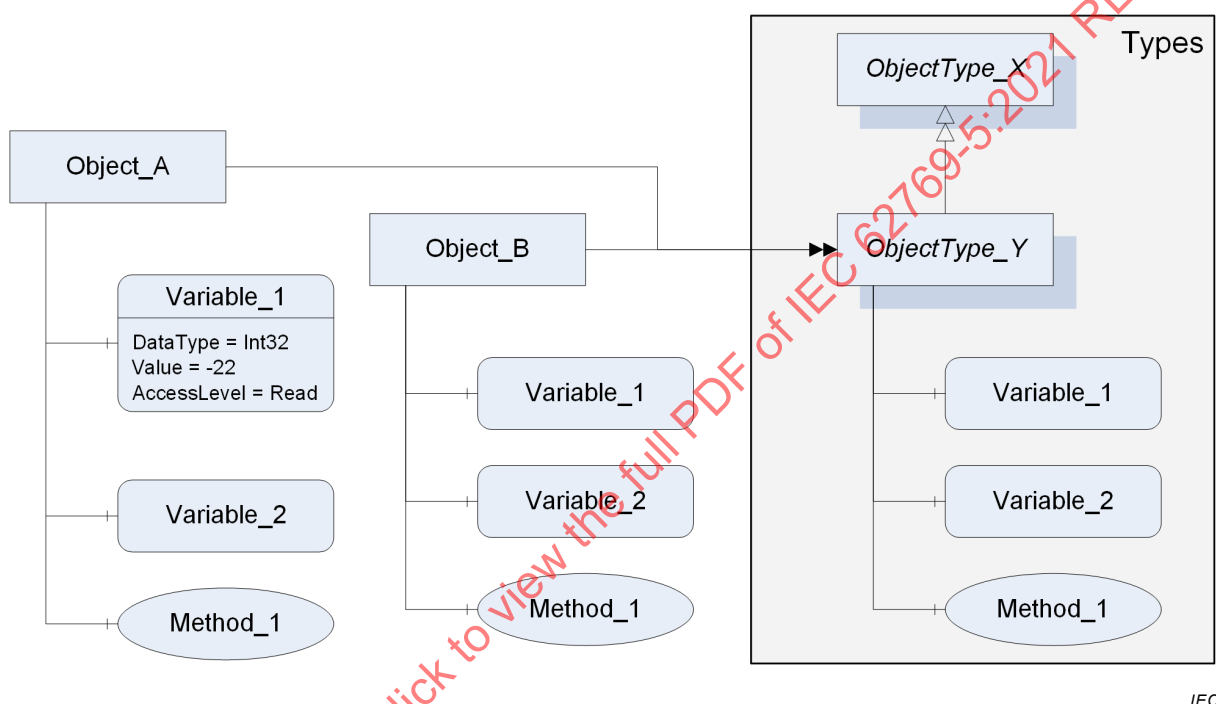
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**Figure 3 – OPC UA Graphical Notation for References**

Figure 4 shows a typical example for the use of the graphical notation. Object\_A and Object\_B are instances of the ObjectType\_Y indicated by the HasTypeDefinition References. The ObjectType\_Y is derived from ObjectType\_X indicated by the HasSubType Reference. The Object\_A has the components Variable\_1, Variable\_2 and Method\_1.

To describe the components of an Object on the ObjectType the same NodeClasses and References are used on the Object and on the ObjectType such as for ObjectType\_Y in the example. The Nodes used to describe an ObjectType are instance declaration Nodes.

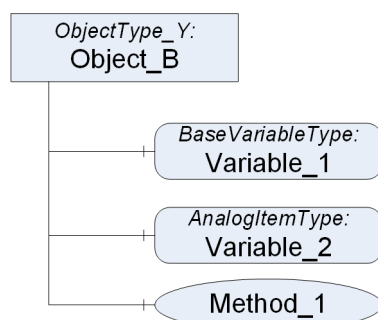
To provide more detailed information for a Node, a subset or all Attributes and their values can be added to a graphical symbol (see for example Variable\_1, the component of Object\_A in Figure 4).



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**Figure 4 – OPC UA Graphical Notation Example**

To improve readability, this document frequently includes the type name inside the instance box rather than displaying both boxes and a reference between them. This optimization is shown in Figure 5.



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**Figure 5 – Optimized Type Reference**

## 4 Overview of OPC Unified Architecture

### 4.1 General

The main use case for OPC standards is the online data exchange between devices and HMI or SCADA systems. In this use case, the device data is provided by an OPC server and is consumed by an OPC client integrated in the HMI or SCADA system. OPC provides functionality to browse through a hierarchical namespace containing data items and to read, write and monitor these items for data changes. Numeric identifiers for NodeIds are defined in Annex A.

OPC UA incorporates features like Data Access, Alarms and Historical Data via platform independent communication mechanisms and generic, extensible and object-oriented modelling capabilities for the information a system wants to expose.

The current version of OPC UA defines an optimized binary TCP protocol for high-performance intranet communication as well as a mapping to Web Services. The abstract service model does not depend on a specific protocol mapping and allows adding new protocols in the future. Features like security, access control and reliability are directly built into the transport mechanisms. Based on the platform independence of the protocols, OPC UA servers and clients can be directly integrated into devices and controllers.

The OPC UA information model provides a standard way for Servers to expose Objects to Clients. Objects in OPC UA terms are composed of other Objects, Variables and Methods. OPC UA also allows relationships to other Objects to be expressed.

The set of Objects and related information that an OPC UA Server makes available to Clients is referred to as its AddressSpace. The elements of the OPC UA Object Model are represented in the AddressSpace as a set of Nodes described by Attributes and interconnected by References. OPC UA defines various classes of Nodes to represent AddressSpace components, most importantly Objects, Variables, Methods, ObjectTypes, DataTypes and ReferenceTypes. Each NodeClass has a defined set of Attributes.

Objects are used to represent components like folders, Devices or Networks. An Object is associated to a corresponding ObjectType that provides definitions for that Object.

Variables are used to represent values. Two categories of Variables are defined: Properties and DataVariables.

Properties are Server-defined characteristics of Objects, DataVariables and other Nodes. Properties are not allowed to have Properties defined for them. An example for Properties of Objects is the Manufacturer Property of a Device.

DataVariables represent the contents of an Object. DataVariables may have component DataVariables. This is typically used by Servers to expose individual elements of arrays and structures. This document uses DataVariables mainly to represent the Parameters of Devices.

### 4.2 Overview of OPC UA Devices

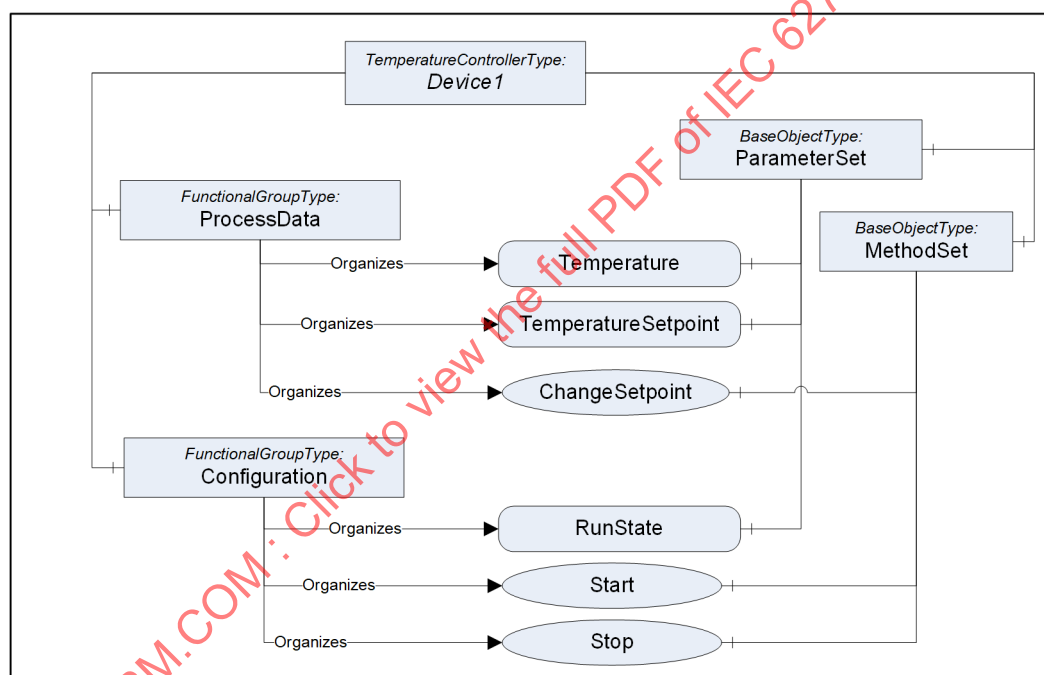
The OPC Unified Architecture for Devices (DI) (IEC 62541-100) standard is an extension of the overall OPC Unified Architecture standard series and defines information models associated with Devices. IEC 62541-100 describes three models that build upon each other as follows:

- The (base) Device Model is intended to provide a unified view of devices irrespective of the underlying device protocols.
- The Device Communication Model adds Network and Connection information elements so that communication topologies can be created.

- The Device Integration Host Model finally adds additional elements and rules required for host systems to manage integration for a complete system. It allows reflecting the topology of the automation system with the devices as well as the connecting communication networks.

The Devices information model specifies different ObjectTypes and other AddressSpace elements used to represent Devices and related components such as the communication infrastructure in an OPC UA AddressSpace. The main use cases are Device configuration and diagnostic, but it allows a general and standardized way for any kind of application to access Device-related information.

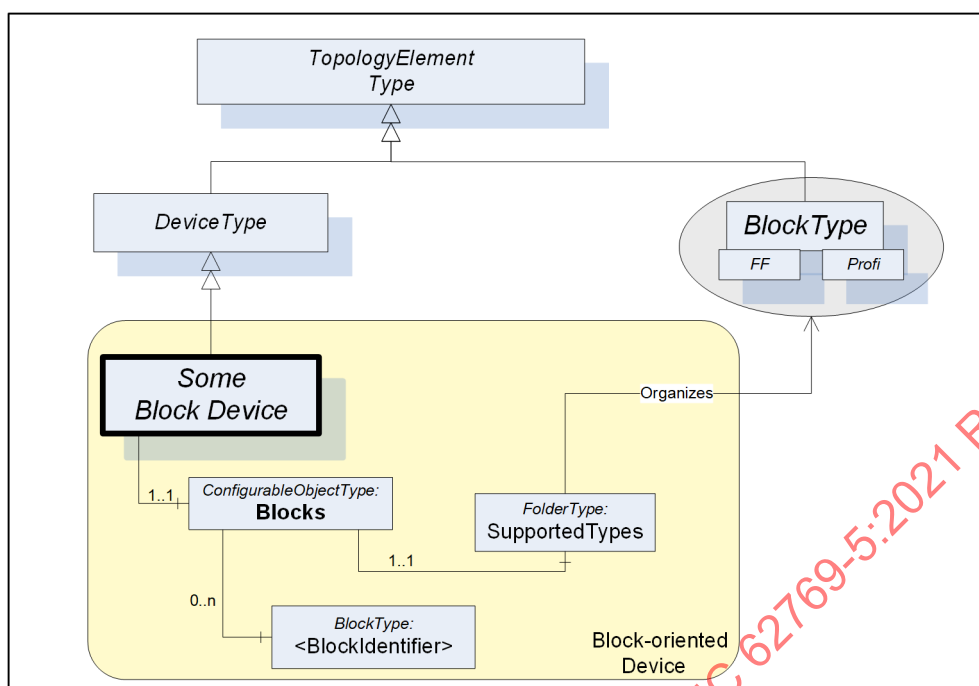
Figure 6 shows an example for a temperature controller represented as Device Object. It is a DeviceType Object that is a subtype of TopologyElementType and inherits all components of this type. The component ParameterSet contains all Variables describing the Device. The component MethodSet contains all Methods provided by the Device. Components of the FunctionalGroupType are used to collect the Parameters and Methods of the Device into logical groups. The FunctionalGroupType and the grouping concept are defined in IEC 62541-100, but the groups are DeviceType-specific, i.e. the groups ProcessData and Configuration are defined by the TemperatureControllerType in this example.



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**Figure 6 – OPC UA Devices Example: Functional Groups**

Another IEC 62541-100 concept is illustrated in Figure 7. The ConfigurableObjectType is used to provide a way to group sub-components of a Device and to indicate which types of sub-components can be instantiated. The allowed types are referenced from the SupportedTypes folder. This information can be used by configuration clients to allow a user to select the type to instantiate as sub-component of the Device.



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**Figure 7 – OPC UA Devices example: Configurable components**

The SupportedTypes folder can contain different subsets of ObjectTypes for different instances of the Block-oriented Device depending on their current configuration, since the list contains only types that can be instantiated for the current configuration.

## 5 Concepts

### 5.1 General

The FDI Server provides FDI Clients access to information about Device instances and Device types regardless of where the information is stored, for example, in the Device itself or in a data store. This information is provided via OPC UA Services and is called the FDI Information Model.

The FDI Information Model specifies the entities that may be accessed in the FDI Server, including their properties, relationships, and the operations that can be performed on them. Which types of Devices or other topological elements are available in a given FDI Server is driven largely by the information in the FDI Packages.

### 5.2 Device topology

One of the main tasks of the Information Model is to reflect the topology of the automation system. Therefore, the Information Model represents the devices of the automation system as well as the connecting communication networks. The entry point Device Topology is the starting point within the Information Model for the topology of the automation system. The entry point Communication Devices contains the communication devices that are used by the FDI Server to access the elements of the topology. Figure 8 and Figure 9 illustrate an example configuration and the configured topology as it will appear in the FDI Server AddressSpace (details left out).

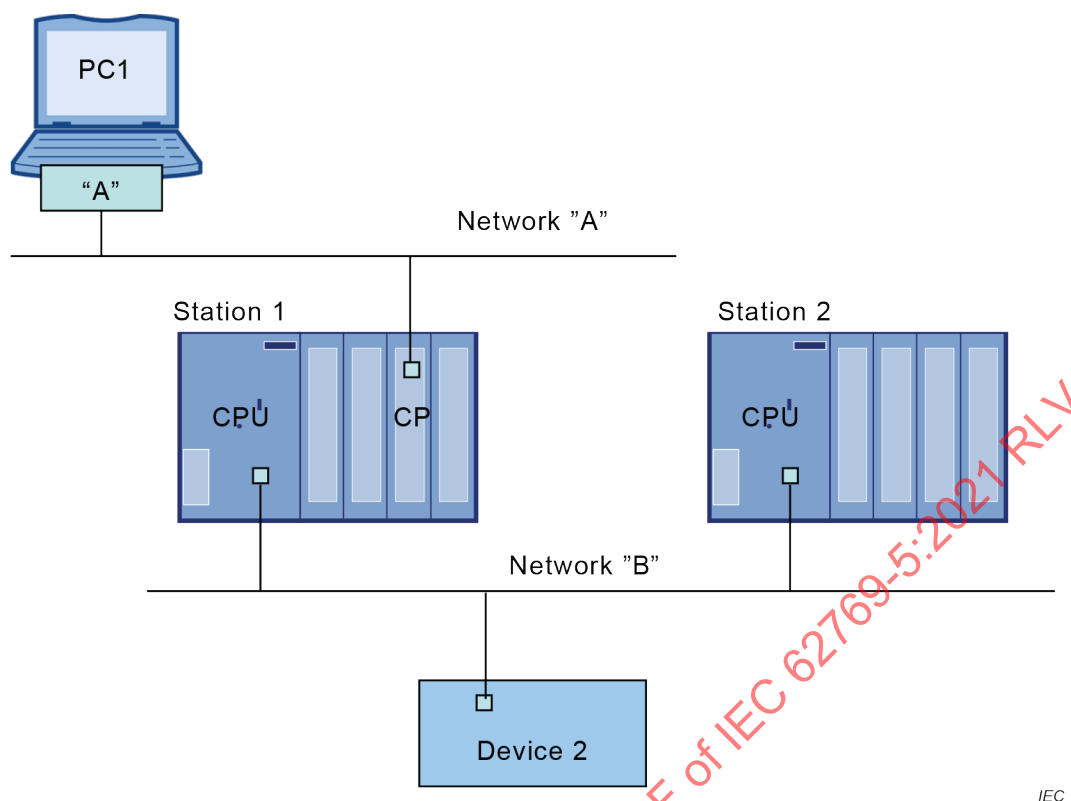


**Figure 8 – Example of an automation system**

The PC in Figure 8 represents the FDI Server box. The FDI Server communicates with devices connected to Network "A" via a Native Communication, and it communicates with devices connected to Network "B" via a Nested Communication.

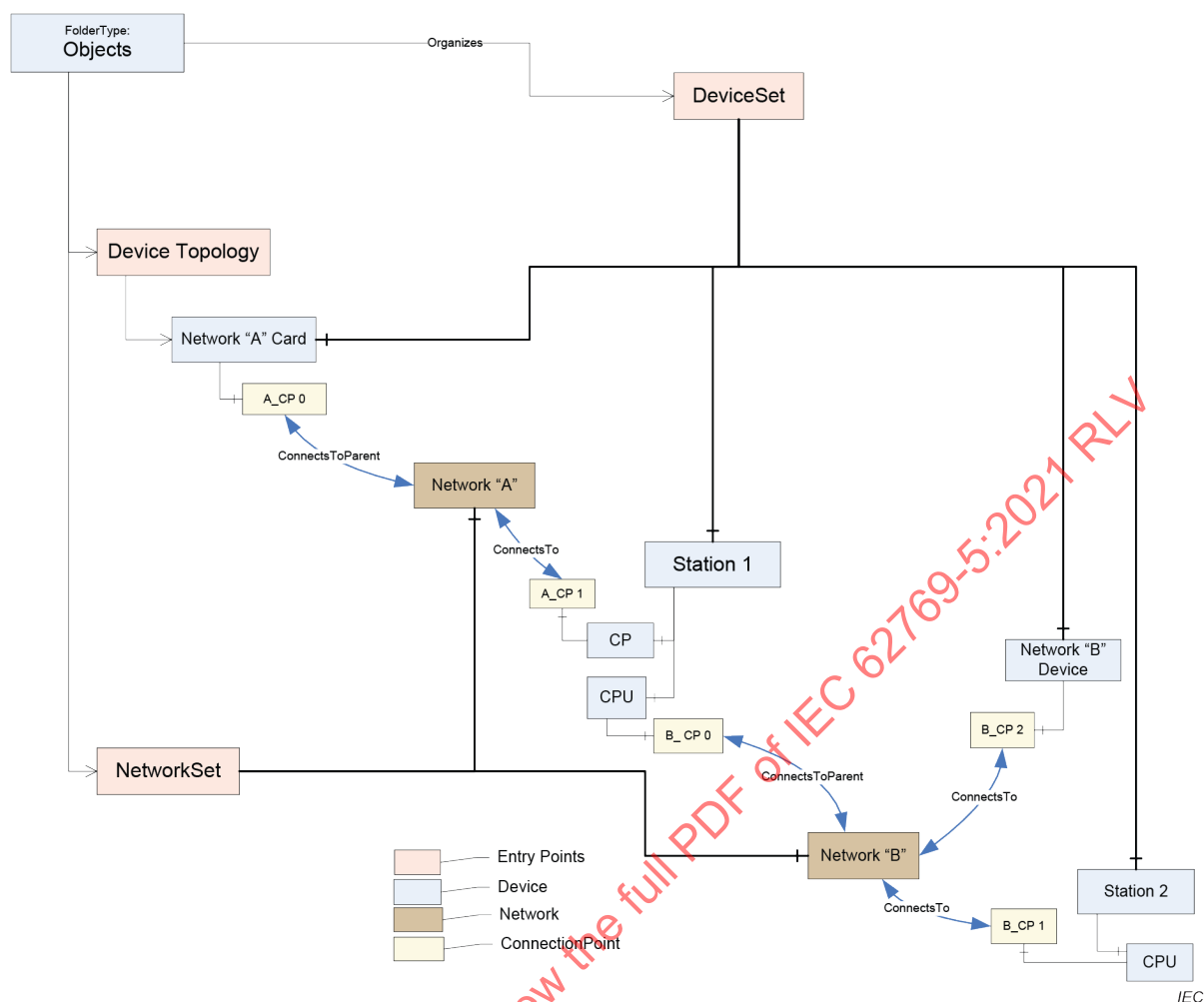


**Figure 9 – Example of a Device topology**

Coloured boxes are used to easily recognize the various types of information.

Brown boxes represent the networks. Light blue boxes represent the Devices and light yellow is used for Connection Points.

Light pink boxes represent the entry points that assure common behaviour across different implementations:

- DeviceTopology: Starting node for the topology configuration.
- DeviceSet: All instantiated Devices are components of this Object, i.e. they exist in the AddressSpace independently of the Device Topology.
- NetworkSet: All Networks are components of this Object.

### 5.3 Online/offline

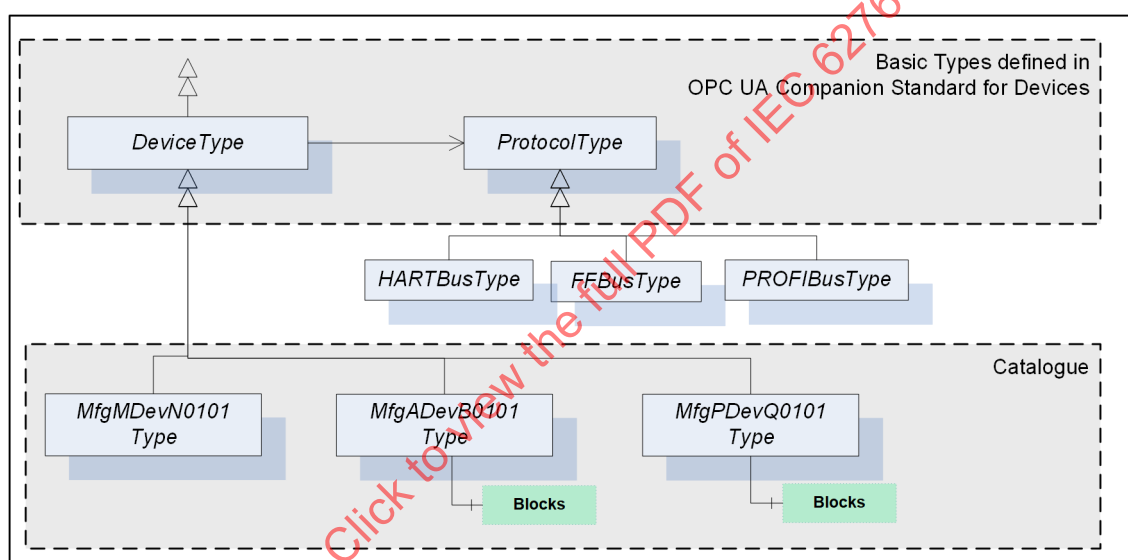
Management of the Device Topology is a configuration task, i.e. the elements in the topology (Devices, Networks, and Connection Points) are usually configured "offline" and – at a later time – will be validated against their physical representative in a real network.

To support explicit access to either the online or the offline information, each element is represented by two instances that are schematically identical, i.e., there exists a ParameterSet, FunctionalGroups, and so on. A Reference connects the online and offline representation and allows navigating between them.

#### 5.4 Catalogue (Type Definitions)

The supported (sub-types of) TopologyElements are organised as Type definitions in the OPC UA AddressSpace, forming a kind of catalogue. These definitions typically are generated based on descriptive information from FDI Packages. The Type definitions contain the Parameters, and default values for Parameters, Methods, Actions and Functional Groups including user interface elements. The FDI Server can include folders in the type model to organise the types according to the manufacturer or other criteria.

Type definitions can then be used to create instances of Devices in the OPC UA AddressSpace. Instances can be created either offline or based on data determined by Scanning. Figure 10 illustrates an example of some Type definitions (details left out) as they can exist in the AddressSpace.



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Figure 10 – Example Device Types representing a catalogue

#### 5.5 Communication

In order to integrate Devices, the FDI Server needs to be able to communicate to them. This can be done using Native Communication or Nested Communication.

The example in Figure 9 above for instance specifies that the FDI Server has direct access to the PROFINET Network using its PROFINET network card. In order to access "Station 2", the FDI Server has to go through Station 1, which provides the communication services for the PROFIBUS DP Network (see IEC 61784-1, CPF 3). This can be achieved through Nested Communication, which is specified in IEC 62769-4. Communication Devices and Communication Servers are specified in IEC 62769-7.

### 6 AddressSpace organization

To promote interoperability of FDI Clients and FDI Servers, a set of Objects and relationships are defined in Clauses 7, 8, 9, and 10. FDI Servers can implement a subset of these standard Nodes, depending on their capabilities.

Based on OPC UA rules, an OPC UA Server separates the AddressSpace into two parts:

- The Types-part contains information about all components that have been generated based on descriptive information from FDI Packages (see 5.4).
- The Objects-part contains the Device Topology with all instantiated components. All instances of the AddressSpace are related to a type of the Types folder
  - The entry points DeviceSet, NetworkSet, and DeviceTopology are formally defined in IEC 62541-100.
    - DeviceTopology is used to aggregate the top level Networks that provide access to all instances that constitute the Device Topology ((sub-)networks, devices and communication elements). Some example elements are shown in Clause 7 and highlighted using the green colour.
    - All instantiated Devices are components of the DeviceSet Object, i.e. they exist in the AddressSpace independently of the Device Topology. All Networks are components of the NetworkSet Object.

FDI Servers can either automatically create Device Objects or they may only show the available types (SupportedTypes folder) and leave it to the user to create proper instances. When using native communication, the system will typically provide the Device Topology without having to have it configured by the FDI Client.

## 7 Device Model for FDI

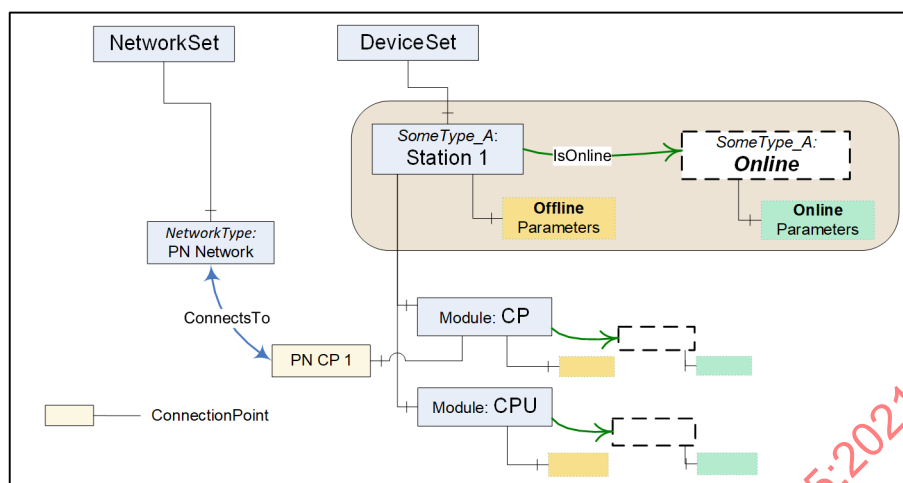
### 7.1 General

As mentioned in Clause 6, IEC 62541-100 specifies the fundamental types needed for FDI, like the TopologyElementType, the DeviceType and the ProtocolType (the fieldbus protocol). Clause 7 briefly repeats important design elements specified in IEC 62541-100 and specifies additional types that are not in IEC 62541-100.

### 7.2 Online/offline

All elements that appear in the Device Topology (Devices, Networks, and Connection Points) including their relationship correspond to information stored in the FDI Server's configuration database. Management of these elements most commonly requires access to the physical component/device (called online data in this standard) and also the storage and administration of related data in a configuration database (called offline data).

To support explicit access to either the online or the offline information, each element is represented by two instances that are schematically identical, i.e. there exists a ParameterSet, FunctionalGroups, and so on. A Reference connects online and offline representation and allows navigation between them. This is illustrated in Figure 11.



IEC

**Figure 11 – Online component for access to device data**

Support of online/offline is mandatory for FDI Servers. Detailed information of the model and the formal definitions are specified in IEC 62541-100.

### 7.3 Device health

#### 7.3.1 DeviceHealth Mapping

The DeviceHealth Property indicates the status of a device as defined by NAMUR NE107. FDI Clients can read or monitor this Property to determine the device condition.

Servers determine the health status using the EDD METHOD GetHealthStatus defined in IEC 62769-4. The frequency at which Servers actually examine the health status may vary from several seconds up to minutes.

The mapping of the GetHealthStatus return values to OPC UA is specified in Table 1.

**Table 1 – DeviceHealth Mapping**

| GetHealthStatus                                                                                                     | OPC UA                                                                                                                                                                                                                                                                                                                                                          |
|---------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0 – Indeterminate                                                                                                   | Indeterminate is not defined in the the DeviceHealth data type in IEC 62541-100. Servers that cannot determine the health status of the device shall return the OPC UA Read operation for this Property with an appropriate OPC UA status code, for example:<br><br>Bad_NotConnected<br><br>Bad_OutOfService<br><br>Bad_NoCommunication<br><br>Bad_NotSupported |
| The following values can be mapped to corresponding values defined for the DeviceHealth data type in IEC 62541-100. |                                                                                                                                                                                                                                                                                                                                                                 |
| GetHealthStatus                                                                                                     | DeviceHealth data type values                                                                                                                                                                                                                                                                                                                                   |
| 1 – Failure                                                                                                         | FAILURE_1                                                                                                                                                                                                                                                                                                                                                       |
| 2 – Function Check                                                                                                  | CHECK_FUNCTION_2                                                                                                                                                                                                                                                                                                                                                |
| 3 – Out of Specifications                                                                                           | OFF_SPEC_3                                                                                                                                                                                                                                                                                                                                                      |
| 4 – Maintenance Required                                                                                            | MAINTENANCE_REQUIRED_4                                                                                                                                                                                                                                                                                                                                          |
| 5 – Good                                                                                                            | GOOD_0                                                                                                                                                                                                                                                                                                                                                          |

Different to OPC UA for Devices (IEC 62541-100), support of the DeviceHealth Property is mandatory for Device Objects in FDI. This is illustrated in Table 2. The complete DeviceType model and its formal definition are in IEC 62541-100.

**Table 2 – DeviceType definition (excerpt applicable to this clause)**

| Attribute                                                   | Value      |              |              |                      |               |
|-------------------------------------------------------------|------------|--------------|--------------|----------------------|---------------|
| BrowseName                                                  | DeviceType |              |              |                      |               |
| IsAbstract                                                  | True       |              |              |                      |               |
| References                                                  | NodeClass  | BrowseName   | DataType     | TypeDefinition       | ModellingRule |
| Subtype of the TopologyElementType defined in IEC 62541-100 |            |              |              |                      |               |
| .....                                                       |            |              |              |                      |               |
| HasComponent                                                | Variable   | DeviceHealth | DeviceHealth | BaseDataVariableType | Mandatory     |
| .....                                                       |            |              |              |                      |               |

### 7.3.2 DeviceHealth Diagnostics

In certain cases, a Device may have additional information associated with the health status, e.g. the possible cause of an abnormal DeviceHealth status and suggested actions to return to normal.

This additional information is available with the DeviceHealthDiagnostics Variable. It is formally defined in Table 3.

**Table 3 – DeviceType definition with DeviceHealth and DeviceHealthDiagnostics**

| Attribute                                                   | Value      |                           |               |                      |               |
|-------------------------------------------------------------|------------|---------------------------|---------------|----------------------|---------------|
| BrowseName                                                  | DeviceType |                           |               |                      |               |
| IsAbstract                                                  | True       |                           |               |                      |               |
| References                                                  | NodeClass  | BrowseName                | DataType      | TypeDefinition       | ModellingRule |
| Subtype of the TopologyElementType defined in IEC 62541-100 |            |                           |               |                      |               |
| .....                                                       |            |                           |               |                      |               |
| HasComponent                                                | Variable   | DeviceHealth              | DeviceHealth  | BaseDataVariableType | Mandatory     |
| HasComponent                                                | Variable   | DeviceHealthDiagnostics[] | LocalizedText | BaseDataVariableType | Mandatory     |
| .....                                                       |            |                           |               |                      |               |

DeviceHealthDiagnostics is an array of LocalizedText. Each array element contains related diagnostic information. The language shall match the requested locale specified in the OPC UA Session. See 15.2.1 on how to select the proper language for the current OPC UA Session.

When DeviceHealth is requested, the Server shall always also fetch the matching DeviceHealthDiagnostics. The Server shall ensure that the values are synchronized by executing GetHealthStatus first and then reading the DeviceHealthDiagnostics. The Server will cache the DeviceHealthDiagnostics as part of the OPC UA Session until DeviceHealth is requested again.

If DeviceHealthDiagnostics is read with a separate service request, the Server shall return the diagnostic information associated with the most recently read DeviceHealth status. If the DeviceHealth status has not been read in the current OPC UA Session the Server shall return Bad\_NotReadable.

If no diagnostic information is available, the returned Value is Null.

See IEC 62769-4 on how DeviceHealthDiagnostics maps to the corresponding EDD information.

Example of a DeviceHealthInformation value with two array elements:

- [0]:  
"Critical Power Failure\n  
Possible cause: Critical Power failure has occurred\n  
Suggested action: Please check device/surroundings/process.\n"
- [1]:  
"Device Malfunction\n  
Possible Cause: The device has detected a serious hardware error or failure.\n  
Suggested action: Check detailed device diagnosis if possible and/or replace device hardware if necessary.\n"

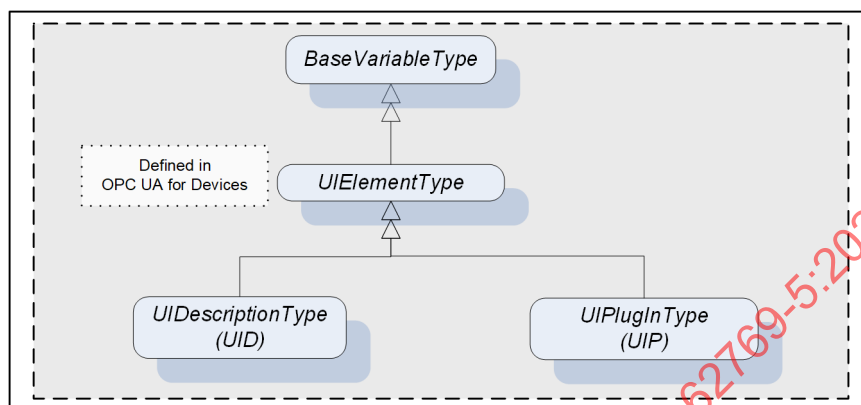
## 7.4 User interface elements

### 7.4.1 General

IEC 62541-100 defines, in an abstract way, how Servers can expose user interface elements for Clients to display a user interface specific to a FunctionalGroup of a TopologyElement.

Subclause 7.4 specifies two concrete user element types: descriptive user interface elements (UIDs) and programmed (executable) user interface elements (UIPs). UIPs are never referenced directly from a FunctionalGroup. They are always indirectly referenced from a UID by means of their UipId.

Figure 12 illustrates the type hierarchy of the user interface elements defined in IEC 62541-100 and in this document.



IEC

**Figure 12 – Hierarchy of user interface Types**

#### 7.4.2 UI Description Type

FDI Servers may provide a descriptive user interface element (a UID) for each FunctionalGroup. Such an element will be rendered by the FDI Client. The UIDescriptionType is formally specified in Table 4.

**Table 4 – UIDescriptionType Definition**

| Attribute                                                              | Value             |            |          |                |               |
|------------------------------------------------------------------------|-------------------|------------|----------|----------------|---------------|
| BrowseName                                                             | UIDescriptionType |            |          |                |               |
| DataType                                                               | String            |            |          |                |               |
| IsAbstract                                                             | False             |            |          |                |               |
| References                                                             | NodeClass         | BrowseName | DataType | TypeDefinition | ModellingRule |
| Inherits the Properties of the UIElementType defined in IEC 62541-100. |                   |            |          |                |               |

The Value Attribute provides the UID as a String containing an XML Element. See IEC 62769-2 for the syntax of UID elements. The XML Schema for the UID Value of all exposed devices adheres to the same FDI Technology Version as indicated by the FDIServerVersion Property (see Clause 14).

#### 7.4.3 UI Plug-in Type

A User Interface Plug-in (UIP) is a software module that is hosted and run by an FDI Client. In contrast to a User Interface Description (UID), it is an executable UI element.

Details on hosting and running Plug-ins are specified in IEC 62769-2. The UIPlugInType is formally specified in Table 5.

**Table 5 – UIPluginType Definition**

| Attribute                                                              | Value                                                 |                      |          |                |               |
|------------------------------------------------------------------------|-------------------------------------------------------|----------------------|----------|----------------|---------------|
| BrowseName                                                             | UIPluginType                                          |                      |          |                |               |
| DataType                                                               | Byte                                                  |                      |          |                |               |
| ValueRank                                                              | 1 – one dimensional array                             |                      |          |                |               |
| ArrayDimensions                                                        | UInt32[1] – the length (number of bytes) of the array |                      |          |                |               |
| IsAbstract                                                             | False                                                 |                      |          |                |               |
| References                                                             | NodeClass                                             | BrowseName           | DataType | TypeDefinition | ModellingRule |
| Inherits the Properties of the UIElementType defined in IEC 62541-100. |                                                       |                      |          |                |               |
| HasProperty                                                            | Variable                                              | UIPVariantVersion    | String   | PropertyType   | Mandatory     |
| HasProperty                                                            | Variable                                              | FDITechnologyVersion | String   | PropertyType   | Mandatory     |
| HasProperty                                                            | Variable                                              | RuntimeId            | String   | PropertyType   | Mandatory     |
| HasProperty                                                            | Variable                                              | CpuInformation       | String   | PropertyType   | Mandatory     |
| HasProperty                                                            | Variable                                              | PlatformId           | String   | PropertyType   | Mandatory     |
| HasProperty                                                            | Variable                                              | Style                | String   | PropertyType   | Mandatory     |
| HasProperty                                                            | Variable                                              | StartElementName     | String   | PropertyType   | Mandatory     |
| HasComponent                                                           | Object                                                | Documentation        |          | FolderType     | Optional      |

UIPs may exist in multiple variants for different platforms or supporting different versions. The UipId (a unique identifier defined in the FDI package) identifies the UIP, not a specific variant.

UIPs do not have to be exposed in the AddressSpace. With the UipId, the FDI Client can retrieve the NodeIds of UIP Variants and their Properties by calling the OPC UA TranslateBrowsePathToNodeIds Service with the Device NodeId as the startingNode and the following list of relative names:

- "UIPSet/<UipId>"
- "UIPSet/<UipId >/RuntimeId"
- "UIPSet/<UipId >/CpuInformation"
- "UIPSet/<UipId >/PlatformId"
- "UIPSet/<UipId >/FDITechnologyVersion"
- "UIPSet/<UipId >/Style"
- "UIPSet/<UipId >/StartElementName"
- "UIPSet/<UipId >/UIPVariantVersion"

NOTE "UIPSet" is an identifier for the Server and does not have to be a Node in the AddressSpace.

The FDI Server returns arrays of NodeIds for each relative name. The number of entries in each array matches the number of UIP Variants for the UipId. The FDI Client can read the property values using the received NodeIds and choose the appropriate UIP Variant based on FDITechnologyVersion, RuntimeId, CpuInformation, and PlatformId.

The Value Attribute provides the UIP executable. The exact representation is technology dependent (see IEC 62769-6). The ArrayDimensions Attribute shall specify the size (number of bytes) of the UIP.

FDI Clients need to be able to handle large UIPs. Reading large UIPs with a single Read operation may not be possible due to configured limits in either the FDI Client or the FDI Server stack. The default maximum size for an array of bytes is 1 MegaByte. FDI Clients can use the IndexRange in the OPC UA Read Service (see IEC 62541-4) to read a UIP in – for instance – one-megabyte chunks. It is up to the FDI Client whether it starts without index and repeats with an indexRange only after an error or whether it always uses an indexRange.

The following Properties help the FDI Client to identify which UIP fits best to its environment:

- **UIPVariantVersion:**  
The version of this UIP Variant.
- **FDITechnologyVersion:**  
FDI Technology Version according to which the UIP is developed. A UIP shall always be capable of running in a client/server system with the same major version and different minor/maintenance version.
- **RuntimeId:**  
Runtime environment of the UIP as specified in IEC 62769-6.
- **CpuInformation:**  
Provides additional information about the execution environment associated with the RuntimeId. The allowed values are specified in IEC 62769-6.
- **PlatformId** defines the type of platform on which this UIP Variant is supported. An FDI Client can choose a particular UIP Variant if it matches the FDI Client's platform (see IEC 62769-4 for the concrete definitions).
  - "Workstation"– with regular screen resolution capabilities, memory capabilities, input devices available (like mouse and keyboard)
  - "Mobile"– limited screen resolution, memory and input devices possible
- **Style:**  
Defines whether the UIP shall be run "modal" or "modeless" as defined in IEC 62541-4. Currently, the values "Dialog" and "Window" are defined. While "Dialog" requires a modal window, a UIP with style "Window" will be invoked either in a modal or a non-modal window as defined in IEC 62769-2.
- **StartElementName:**  
Element needed to start this UIP Variant. IEC 62769-6 specifies how this information is used when activating the UIP.

Documents provided for a UIP Variant are exposed as Variables organized in the Documentation folder. In most cases, they will represent a product manual, which can exist as a set of individual documents. The information can be retrieved by reading the Variable value which is represented as a ByteString. The complete ByteString shall be interpreted as a PDF file. FDI Clients need to be aware that the contents that these variables represent may be large. Reading large values with a single Read operation may not be possible due to configured limits in either the FDI Client or the FDI Server stack. The default maximum size for an array of bytes is 1 MegaByte. It is recommended that FDI Clients use the IndexRange in the OPC UA Read Service (see IEC 62541-4) to read these Variables in chunks, for example, one-megabyte chunks.

## 7.5 Type-specific support information

Each DeviceType may have a set of additional data. These are mainly images, documents, or protocol-specific data. The various types of information are organized into different folders.

See IEC 62541-100 for the formal definition of support information.

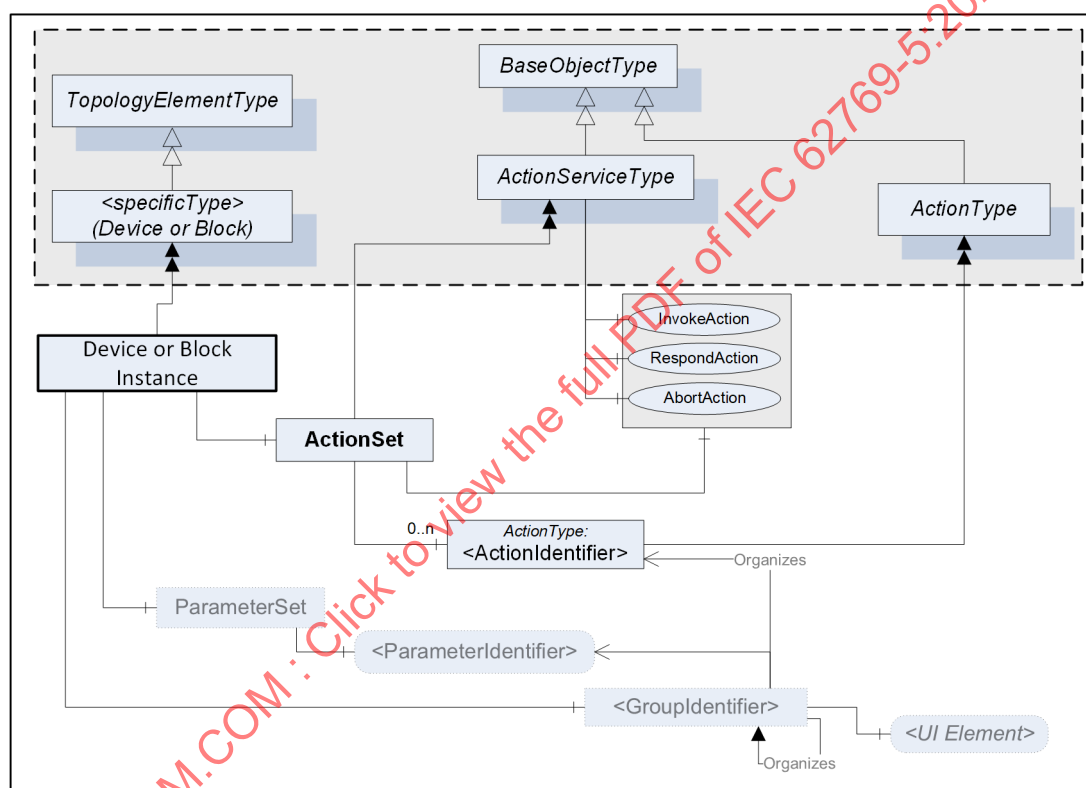
## 7.6 Actions

### 7.6.1 Overview

Actions are operations that are executed in the FDI Server on behalf of a topology element. Once invoked with the InvokeAction Method, Actions can make various state transitions until completed. The actual state is accessible via a transient, non-browsable Variable the NodeId of which is returned by the InvokeAction Method.

FDI Clients can subscribe to this Variable to receive updates concerning the Action execution (Action data). Action data may report a state transition or a request to the FDI Client that input is necessary for continuation. The FDI Client can resume the execution with the RespondAction Method and submit the requested data.

Figure 13 illustrates how Actions are integrated into a TopologyElement.



IEC

**Figure 13 – Integration of Actions within a TopologyElement**

ActionSet is used to aggregate the Actions for a specific TopologyElement. This Object is not available on the Type and is only available in an instance if Actions exist for this TopologyElement.

Actions can also be referenced from FunctionalGroup Objects.

### 7.6.2 Action Type

This ObjectType defines the structure of an Action. It is formally defined in Table 6.

**Table 6 – ActionType Definition**

| Attribute                                                | Value      |            |          |                |               |
|----------------------------------------------------------|------------|------------|----------|----------------|---------------|
| BrowseName                                               | ActionType |            |          |                |               |
| IsAbstract                                               | True       |            |          |                |               |
| References                                               | NodeClass  | BrowseName | DataType | TypeDefinition | ModellingRule |
| Subtype of the BaseObjectType is defined in IEC 62541-5. |            |            |          |                |               |

The FDI Client determines the required invocation arguments for an Action from the UID.

### 7.6.3 ActionService Type

The ActionServiceType defines the Methods to invoke and control Actions. Instances of this type aggregate the Actions for a specific topology element. The ActionServiceType is formally defined in Table 7. Its use is illustrated in Figure 13.

**Table 7 – ActionServiceType Definition**

| Attribute                                             | Value             |                    |          |                |               |
|-------------------------------------------------------|-------------------|--------------------|----------|----------------|---------------|
| BrowseName                                            | ActionServiceType |                    |          |                |               |
| IsAbstract                                            | False             |                    |          |                |               |
| References                                            | NodeClass         | BrowseName         | DataType | TypeDefinition | ModellingRule |
| Subtype of the BaseObjectType defined in IEC 62541-5. |                   |                    |          |                |               |
| HasComponent                                          | Method            | InvokeAction       |          |                | Mandatory     |
| HasComponent                                          | Method            | RespondAction      |          |                | Mandatory     |
| HasComponent                                          | Method            | AbortAction        |          |                | Mandatory     |
| HasComponent                                          | Object            | <ActionIdentifier> |          | ActionType     | Optional      |

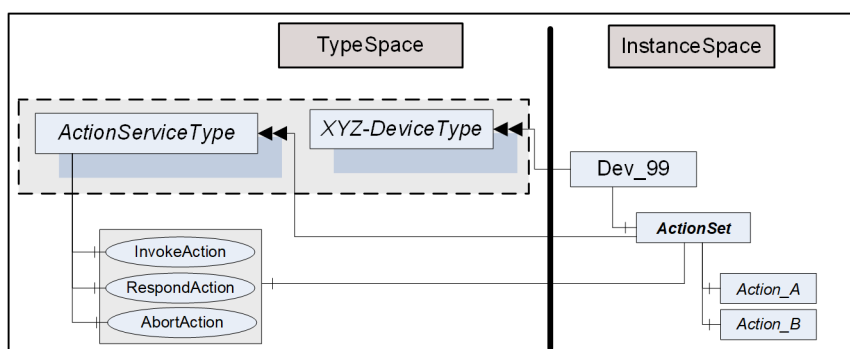
The ActionServiceType and each instance of this Type share the same Methods. The NodeId of these Methods will be fixed and defined in this document. FDI Clients therefore do not have to browse for these Methods. They can use the fixed NodeId as the MethodId of the Call Service.

The OPC UA StatusCode Bad\_MethodInvalid shall be returned from the Call Service for elements where the ActionService Methods are not supported.

<ActionIdentifier> stands for one or several Actions. Actions (Objects of ActionType) exist only in instances of the ActionServiceType, i.e. when an instance of this ObjectType is added to a TopologyElement. No Actions (Objects of ActionType) exist in the ActionServiceType itself.

### 7.6.4 ActionService Object

The support of the ActionService for an Object is declared by aggregating an instance of the ActionService Type as illustrated in Figure 14.



IEC

**Figure 14 – Action Service**

This Object is used as container for the ActionService Methods and shall have the BrowseName ActionSet. It is formally defined in Table 29. HasComponent is used to reference from a TopologyElement (for example, a Device) to its "ActionService" Object.

The ActionServiceType and each ActionSet Object share the same Methods. Actions will typically be shared by all instances of the same Device Type.

### 7.6.5 InvokeAction Method

InvokeAction is used to start an Action. It immediately returns after the state machine has been created. The "ActionSet" component of the TopologyElement (Device) on behalf of which the Action shall be invoked is specified via the ObjectId argument of the Call Service.

Explicit locking is required. If the Device has not been locked, the FDI Server will reject the request.

After InvokeAction returns, the FDI Client shall subscribe to the Value Attribute of the ActionNodeId. The Value Attribute contains an XML element (DataType = String)) that reflects the current state of the Action as well as additional data (depending on state). The FDI Client therefore will get a DataChange notification whenever the state of the Action changes.

See IEC 62769-2 for the Action state diagrams as well as the XML Schema of the ActionNodeId value.

FDI Servers shall cache Action state data for an appropriate period of time (a few seconds) so that no state information is lost until the FDI Client has had a chance to subscribe.

The signature of this Method is specified below. Table 8 and Table 9 specify the arguments and AddressSpace representation, respectively.

## Signature

```

InvokeAction (
    [in] String      ActionName,
    [in] String      MethodArguments,
    [out] NodeId     ActionNodeId,
    [out] Int32      InvokeActionError);

```

**Table 8 – InvokeAction Method Arguments**

| Argument          | Description                                                                                                                                                            |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ActionName        | String portion of the BrowseName of the Action as used in the ActionServiceType instance.                                                                              |
| MethodArguments   | XML document that contains the Action input arguments (if any). The ListOfActionArguments XML Schema defined in IEC 62769-2 is used for the MethodArguments parameter. |
| ActionNodeId      | Non-browsable node of type Variable. This node is used both to identify the instance of the Action state machine and for access to the Action state information.       |
| InvokeActionError | 0 – OK.<br>-1 – E_LockRequired – the element is not locked as required<br>-2 – E_UnknownAction – the passed name is not a valid action for this element.               |

**Table 9 – InvokeAction Method AddressSpace Definition**

| Attribute   | Value        |                 |            |                |               |
|-------------|--------------|-----------------|------------|----------------|---------------|
| BrowseName  | InvokeAction |                 |            |                |               |
| References  | NodeClass    | BrowseName      | DataType   | TypeDefinition | ModellingRule |
| HasProperty | Variable     | InputArguments  | Argument[] | PropertyType   | Mandatory     |
| HasProperty | Variable     | OutputArguments | Argument[] | PropertyType   | Mandatory     |

### 7.6.6 RespondAction Method

RespondAction is used by the FDI Client to provide the requested value or selection of a UI function request (if applicable). The "ActionSet" component of the TopologyElement on behalf of which the Action had been invoked is specified via the ObjectId argument of the Call Service.

The signature of this Method is specified below. Table 10 and Table 11 specify the arguments and AddressSpace representation, respectively.

**Signature**

```

RespondAction (
    [in]  NodeId      ActionNodeId,
    [in]  String      Response,
    [out] Int32       RespondActionError);

```

**Table 10 – RespondAction Method Arguments**

| Argument           | Description                                                                                                                                                    |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ActionNodeId       | NodeId of a transient Variable that represents and identifies the executing Action. This Id is returned by the InvokeAction Method.                            |
| Response           | XML document that contains the response (value or selection). See IEC 62769-2 for the XML Schema for the Response parameter.                                   |
| RespondActionError | 0 – OK<br>-1 – E_InvalidAction – the NodeId does not refer to an existing action<br>-2 – E_InvalidResponse – the passed response data could not be interpreted |

**Table 11 – RespondAction Method AddressSpace Definition**

| Attribute   | Value         |                 |            |                |               |
|-------------|---------------|-----------------|------------|----------------|---------------|
| BrowseName  | RespondAction |                 |            |                |               |
| References  | NodeClass     | BrowseName      | Data Type  | TypeDefinition | ModellingRule |
| HasProperty | Variable      | InputArguments  | Argument[] | PropertyType   | Mandatory     |
| HasProperty | Variable      | OutputArguments | Argument[] | PropertyType   | Mandatory     |

**7.6.7 AbortAction Method**

AbortAction is used by the FDI Client to abort an Action execution. This Method call immediately returns. The FDI Client is informed via a notification event on the ActionNodeId Variable when the Action enters the Aborting state.

The "ActionSet" component of the TopologyElement on behalf of which the Action had been invoked is specified via the ObjectId argument of the Call Service.

The signature of this Method is specified below. Table 12 and Table 13 specify the arguments and AddressSpace representation, respectively.

**Signature**

```

AbortAction (
    [in]  NodeId      ActionNodeId,
    [out] Int32       AbortActionError);

```

**Table 12 – AbortAction Method Arguments**

| Argument         | Description                                                                                                                         |
|------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| ActionNodeId     | NodeId of a transient Variable that represents and identifies the executing Action. This Id is returned by the InvokeAction Method. |
| AbortActionError | 0 – OK<br>-1 – E_InvalidAction – the NodeId does not refer to an existing action                                                    |

**Table 13 – AbortAction Method AddressSpace Definition**

| Attribute   | Value       |                 |            |                |               |
|-------------|-------------|-----------------|------------|----------------|---------------|
| BrowseName  | AbortAction |                 |            |                |               |
| References  | NodeClass   | BrowseName      | DataType   | TypeDefinition | ModellingRule |
| HasProperty | Variable    | InputArguments  | Argument[] | PropertyType   | Mandatory     |
| HasProperty | Variable    | OutputArguments | Argument[] | PropertyType   | Mandatory     |

## 8 Network and connectivity

Network and connection information elements are required to create communication topologies.

A Network represents the communication means for Devices that are connected to it. It includes wired and wireless technologies. ConnectionPoints represent the interface (interface card) of a Device to a Network. A specific sub-type shall be defined for each protocol.

These elements are described and formally defined in IEC 62541-100.

## 9 Utility functions

### 9.1 Overview

Clause 9 provides specific services for certain FDI information elements.

### 9.2 Locking

Locking is the means to avoid concurrent modifications to a Device or Network and their components. FDI Clients shall use the Locking Services for any changes (e.g. write operations and Action invocations).

The main purpose of locking a Device is to avoid concurrent device modifications. The main purpose of locking a Network is to avoid concurrent topology changes.

When locking a Device, the lock always applies to both the online and the offline versions.

When locking a Modular Device, the lock applies to the complete Device (including all modules). Equally, when locking a Block Device, the lock applies to the complete Device (including all blocks).

If no lock is applied to the top-level Device (for Modular Device or for Block Device), the sub-devices or blocks, respectively, can be locked independently.

When locking a Network, the lock applies to the Network and all connected Devices. If any of the connected Devices provides access to a sub-ordinate Network (such as a Gateway), the sub-ordinate Network and its connected Devices are locked as well.

The LockingService is fully described and formally defined in IEC 62541-100.

### 9.3 EditContext

#### 9.3.1 Overview

An EditContext can be used to make changes to Variable values visible to the Server without applying them to the Device. The FDI Server provides the EditContext concept to support Clients in their editing task.

The EditContext is specified in IEC 62541-3. Following is the OPC UA Information Model including the Methods to maintain EditContext instances.

EditContext is exposed as an AddIn capability, which is comparable to the interface technology found in some programming languages. The EditContext service is modelled as an ObjectType and instances of this type are added to the Device with a pre-defined BrowseName. Additional AddIn examples are defined in IEC 62541-100.

When reading or subscribing to Variable values registered in an EditContext, the following FDI-specific StatusCodes may occur (see Clause 11):

- Good\_Edited distinguishes values that have been edited but have not been written to the Device.
- Uncertain\_DominantValueChanged indicates that dependent values are invalid and will be recalculated after the dominant value has been applied to the device. In the offline case, the dependent value has to be written by the Client as well.
- Good\_DependentValueChanged indicates that a dependent value has been changed but the change has not been applied to the device.

#### 9.3.2 EditContext Type

The EditContextType comprises the EditContext Methods. It is formally defined in Table 14.

**Table 14 – EditContextType Definition**

| Attribute                                             | Value           |                             |          |                |               |
|-------------------------------------------------------|-----------------|-----------------------------|----------|----------------|---------------|
| BrowseName                                            | EditContextType |                             |          |                |               |
| IsAbstract                                            | False           |                             |          |                |               |
| References                                            | NodeClass       | BrowseName                  | DataType | TypeDefinition | ModellingRule |
| Subtype of the BaseObjectType defined in IEC 62541-5. |                 |                             |          |                |               |
| HasComponent                                          | Method          | GetEditContext              |          |                | Mandatory     |
| HasComponent                                          | Method          | RegisterNodesById           |          |                | Mandatory     |
| HasComponent                                          | Method          | RegisterNodesByRelativePath |          |                | Mandatory     |
| HasComponent                                          | Method          | Apply                       |          |                | Mandatory     |
| HasComponent                                          | Method          | Reset                       |          |                | Mandatory     |
| HasComponent                                          | Method          | Discard                     |          |                | Mandatory     |

The StatusCode Bad\_MethodInvalid shall be returned from the Call Service for elements where the EditContext Methods are not supported. Bad\_UserAccessDenied shall be returned if the Client User does not have the permission to call the Methods.

#### 9.3.3 EditContext Object

The support of EditContext for an Object is declared by aggregating an instance of the EditContextType as illustrated in Figure 15.

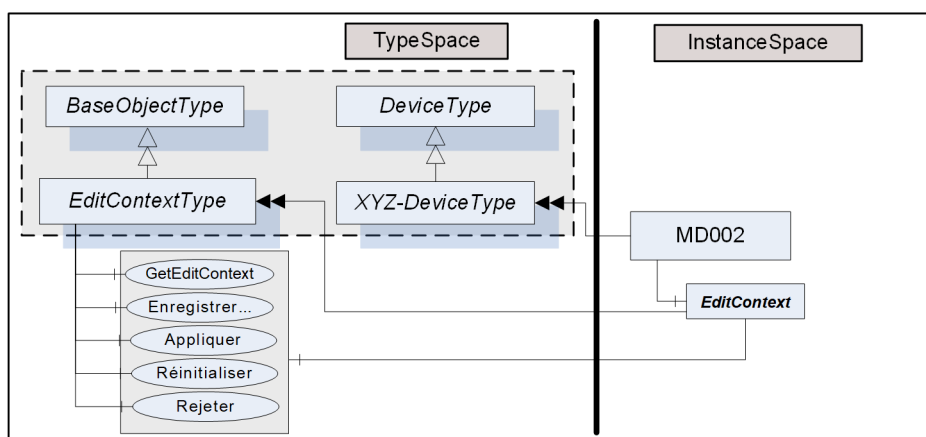


**Figure 15 – EditContext type and instance**

This Object is used as container for the EditContext Methods and shall have the BrowseName EditContext. HasComponent is used to reference from a Device to its "EditContext" Object.

The EditContextType and each instance may share the same Methods.

#### 9.3.4 GetEditContext Method

Returns an EditContext as specified in IEC 62541-3.

The signature of this Method is specified below. Table 15 and Table 16 specify the arguments and AddressSpace representation, respectively.

#### Signature

```
GetEditContext (
    [in] String      ParentId,
    [in] WindowMode TargetWindowMode,
    [out] String     EditContextId,
    [out] Int32      GetEditContextStatus);
```

**Table 15 – GetEditContext Method Arguments**

| Argument             | Description                                                                                                                                                              |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ParentId             | If Null, a root instance is requested.<br>Otherwise, the Client passes the identifier of a previously acquired EditContext, indicating that it will create a sub-window. |
| TargetWindowMode     | An enumeration that indicates the User Interface element used for this context.<br>1 – Modal Window<br>2 – NonModal Window<br>3 – UIP                                    |
| EditContextId        | A string identifier created by the Server.                                                                                                                               |
| GetEditContextStatus | 0 – OK<br>-1 – E_NotSupported – the element does not support the EditContext Service                                                                                     |

**Table 16 – GetEditContext Method AddressSpace Definition**

| Attribute   | Value          |                 |            |                |               |
|-------------|----------------|-----------------|------------|----------------|---------------|
| BrowseName  | GetEditContext |                 |            |                |               |
| References  | NodeClass      | BrowseName      | DataType   | TypeDefinition | ModellingRule |
| HasProperty | Variable       | InputArguments  | Argument[] | PropertyType   | Mandatory     |
| HasProperty | Variable       | OutputArguments | Argument[] | PropertyType   | Mandatory     |

### 9.3.5 RegisterNodes Method

This Method is used to register Nodes with an EditContext. It returns new NodeIds that have to be used to address this Node within the EditContext.

The signature of this Method is specified below. Table 17 and Table 18 specify the arguments and AddressSpace representation, respectively.

#### Signatures

```

RegisterNodes (
    [in] String EditContextId,
    [in] RegistrationParameters[] NodesToRegister,
    [out] RegisterNodesResult RegisterNodesStatus);

```

**Table 17 – RegisterNodes Method Arguments**

| Argument            | Description                                                                           |
|---------------------|---------------------------------------------------------------------------------------|
| EditContextId       | Identifier of an EditContext that was previously acquired with a GetEditContext call. |
| NodesToRegister     | An array of structures for each node to register.                                     |
| RegisterNodesStatus | A structure with overall execution status and result data for each Node to register.  |

**Table 18 – RegisterNodes Method AddressSpace Definition**

| Attribute   | Value         |                 |            |                |               |
|-------------|---------------|-----------------|------------|----------------|---------------|
| BrowseName  | RegisterNodes |                 |            |                |               |
| References  | NodeClass     | BrowseName      | DataType   | TypeDefinition | ModellingRule |
| HasProperty | Variable      | InputArguments  | Argument[] | PropertyType   | Mandatory     |
| HasProperty | Variable      | OutputArguments | Argument[] | PropertyType   | Mandatory     |

The RegistrationParameters DataType defines a single Node to be registered. Its elements are defined in Table 19.

**Table 19 – RegistrationParameters DataType Structure**

| Name                   | Type                    | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           |                  |             |                        |             |                       |             |                         |             |                        |
|------------------------|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|------------------|-------------|------------------------|-------------|-----------------------|-------------|-------------------------|-------------|------------------------|
| RegistrationParameters | structure               | This structure specifies one of the nodes to register.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |                  |             |                        |             |                       |             |                         |             |                        |
| path                   | RelativePath            | RelativePath for this Node to register.<br>The RelativePath type is defined in IEC 62541-4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           |                  |             |                        |             |                       |             |                         |             |                        |
| selectionFlags         | UInt32                  | <p>A bit mask that identifies the EditContext-specific NodeIds to be returned in the RegisterNodesResult structure.</p> <p>The value of this parameter shall contain at least one of the following values. No value will be rejected with E_InvalidSelectionFlags.</p> <table><thead><tr><th>Bit Value</th><th>NodeId to return</th></tr></thead><tbody><tr><td>0x0000 0001</td><td>Online / ContextNodeId</td></tr><tr><td>0x0000 0002</td><td>Online / DeviceNodeId</td></tr><tr><td>0x0000 0004</td><td>Offline / ContextNodeId</td></tr><tr><td>0x0000 0008</td><td>Offline / DeviceNodeId</td></tr></tbody></table> | Bit Value | NodeId to return | 0x0000 0001 | Online / ContextNodeId | 0x0000 0002 | Online / DeviceNodeId | 0x0000 0004 | Offline / ContextNodeId | 0x0000 0008 | Offline / DeviceNodeId |
| Bit Value              | NodeId to return        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |                  |             |                        |             |                       |             |                         |             |                        |
| 0x0000 0001            | Online / ContextNodeId  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |                  |             |                        |             |                       |             |                         |             |                        |
| 0x0000 0002            | Online / DeviceNodeId   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |                  |             |                        |             |                       |             |                         |             |                        |
| 0x0000 0004            | Offline / ContextNodeId |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |                  |             |                        |             |                       |             |                         |             |                        |
| 0x0000 0008            | Offline / DeviceNodeId  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |                  |             |                        |             |                       |             |                         |             |                        |

The RegisterNodesResult DataType includes overall status information and result data for each Node to be registered. Its elements are defined in Table 20.

**Table 20 – RegisterNodesResult DataType Structure**

| Name                 | Type             | Description                                                                                                                                                                                    |
|----------------------|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| RegisterNodesResult  | structure        | This structure specifies the registration result.                                                                                                                                              |
| status               | Int32            | 0 – OK – the field registeredNodes contains a result for each Node to register<br>-1 – E_InvalidId – the specified EditContext is unknown<br>the registeredNodes field is empty                |
| registeredNodes      | RegisteredNode[] | The list contains EditContext-specific NodeIds for the registered Node. The Client has to use these NodeIds for all subsequent OPC UA Service calls                                            |
| nodeStatus           | Int32            | 0 – OK<br>-1 – E_InvalidNode – an invalid Node has been registered. See IEC 62541-3 for details.<br>-2 – E_InvalidSelectionFlags – the RegistrationParameters for this Node contained no value |
| onlineContextNodeId  | NodeId           | This NodeId shall be used to address the online representation of the Node in the EditContext. See IEC 62541-3 for details.                                                                    |
| onlineDeviceNodeId   | NodeId           | This NodeId shall be used to address the online representation of the Node in the Device. See IEC 62541-3 for details.                                                                         |
| offlineContextNodeId | NodeId           | This NodeId shall be used to address the offline representation of the Node in the EditContext. See IEC 62541-3 for details.                                                                   |
| offlineDeviceNodeId  | NodeId           | This NodeId shall be used to address the offline representation of the Node in the Device. See IEC 62541-3 for details.                                                                        |

### 9.3.6 Apply Method

This Method is used to apply values that have been modified in the EditContext.

The signature of this Method is specified below. Table 21 and Table 22 specify the arguments and AddressSpace representation, respectively.

## Signature

```
Apply (
    [in] String      EditContextId,
    [out] ApplyResult ApplyStatus);
```

**Table 21 – Apply Method Arguments**

| Argument      | Description                                                                                     |
|---------------|-------------------------------------------------------------------------------------------------|
| EditContextId | Identifier of an EditContext that was previously acquired with a GetEditContext call.           |
| ApplyStatus   | A structure with overall execution status and status information for each transferred Variable. |

**Table 22 – Apply Method AddressSpace Definition**

| Attribute   | Value     |                 |            |                |               |
|-------------|-----------|-----------------|------------|----------------|---------------|
| BrowseName  | Apply     |                 |            |                |               |
| References  | NodeClass | BrowseName      | DataType   | TypeDefinition | ModellingRule |
| HasProperty | Variable  | InputArguments  | Argument[] | PropertyType   | Mandatory     |
| HasProperty | Variable  | OutputArguments | Argument[] | PropertyType   | Mandatory     |

The ApplyResult DataType includes overall Apply status information and status information for each Variable that could not be transmitted. Its elements are defined in Table 23.

**Table 23 – ApplyResult DataType Structure**

| Name              | Type               | Description                                                                                                                                                                                                                                                      |
|-------------------|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ApplyResult       | structure          | This structure is returned in case of errors. No result data are returned. Further calls with the same TransferId are not possible.                                                                                                                              |
| status            | Int32              | 0 – OK – the transferIncidents field may include individual Variables that failed<br>-1 – E_InvalidId – the specified EditContext is unknown                                                                                                                     |
| transferIncidents | TransferIncident[] | If the service returns normally and the TransferIncidents list is empty, all changes have been applied and the edited values are cleared.<br>Otherwise, the list contains Variables that could not be transferred successfully. The edited Values are preserved. |
| contextNodeId     | NodeId             | The NodeId returned from RegisterNodesById or RegisterNodesByRelativePath.                                                                                                                                                                                       |
| statusCode        | StatusCode         | OPC UA StatusCode as defined in IEC 62541-4 and in IEC 62541-8.                                                                                                                                                                                                  |
| diagnostics       | DiagnosticInfo     | Diagnostic information. This parameter is empty if diagnostics information was not requested in the request header or if no diagnostic information was encountered in the processing of the request. The DiagnosticInfo type is defined in IEC 62541-4.          |

### 9.3.7 Reset Method

Clears all modified values in the EditContext.

The signature of this Method is specified below. Table 24 and Table 25 specify the arguments and AddressSpace representation, respectively.

## Signature

```
Reset (
    [in] String      EditContextId,
    [out] Int32      ResetStatus);
```

**Table 24 – Reset Method Arguments**

| Argument      | Description                                                                           |
|---------------|---------------------------------------------------------------------------------------|
| EditContextId | Identifier of an EditContext that was previously acquired with a GetEditContext call. |
| ResetStatus   | 0 – OK<br>-1 – E_InvalidId – the specified EditContext is unknown                     |

**Table 25 – Reset Method AddressSpace Definition**

| Attribute   | Value     |                 |            |                |               |
|-------------|-----------|-----------------|------------|----------------|---------------|
| BrowseName  | Reset     |                 |            |                |               |
| References  | NodeClass | BrowseName      | DataType   | TypeDefinition | ModellingRule |
| HasProperty | Variable  | InputArguments  | Argument[] | PropertyType   | Mandatory     |
| HasProperty | Variable  | OutputArguments | Argument[] | PropertyType   | Mandatory     |

### 9.3.8 Discard Method

This Method releases the EditContext. Any modified values that have not been applied are lost.

The signature of this Method is specified below. Table 26 and Table 27 specify the arguments and AddressSpace representation, respectively.

## Signature

```
Discard(
    [in] String      EditContextId,
    [out] Int32      DiscardStatus);
```

**Table 26 – Discard Method Arguments**

| Argument      | Description                                                                                                                                                               |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| EditContextId | Identifier of an EditContext that was previously acquired with a GetEditContext call.                                                                                     |
| DiscardStatus | 0 – OK<br>-1 – E_InvalidId – the specified EditContext is unknown<br>-2 – E_ChildExists – the specified EditContext cannot be discarded, because a child instance exists. |

**Table 27 – Discard Method AddressSpace Definition**

| Attribute   | Value     |                 |            |                |               |
|-------------|-----------|-----------------|------------|----------------|---------------|
| BrowseName  | Discard   |                 |            |                |               |
| References  | NodeClass | BrowseName      | Data Type  | TypeDefinition | ModellingRule |
| HasProperty | Variable  | InputArguments  | Argument[] | PropertyType   | Mandatory     |
| HasProperty | Variable  | OutputArguments | Argument[] | PropertyType   | Mandatory     |

## 9.4 Direct Device Access

### 9.4.1 General

DirectDeviceAccess provides the means to communicate with a device in the Device Topology. It will be used by UIPs for operations that cannot, or at least not easily, be performed through Information Model access. Use cases include the transmission of large data buckets from or to the device, for example, historical data or firmware. It is generally assumed that directly accessed data will not be reflected in the Information Model as well. DirectDeviceAccess shall not influence the structure and the data integrity of the Information Model. FDI Servers may be restrictive about when they enable the use of these Methods.

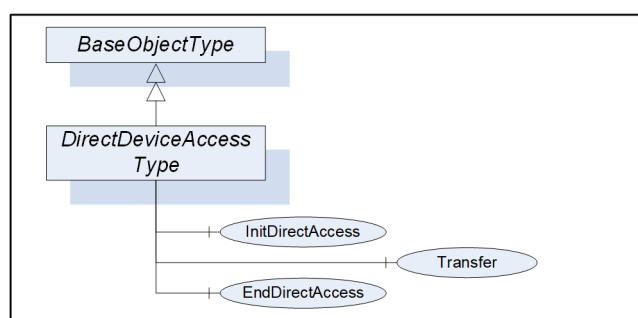
A DirectDeviceAccess Object shall exist for every Device where the FDI Server allows direct access via a UIP.

The following behaviour applies when using DirectDeviceAccess:

- Only one FDI Client can use DirectDeviceAccess at a given time.
- DirectDeviceAccess requires a lock. If the Device has not been locked, the request will be rejected.
- Due to the lock, no write operations and no Method invocations from other FDI Clients are permitted during DirectDeviceAccess. This includes the execution of Actions.
- If Attribute values of Parameters might have changed due to DirectDeviceAccess, the UIP shall set the InvalidateCache in the EndDirectAccess argument to True.

### 9.4.2 DirectDeviceAccessType

The DirectDeviceAccessType provides the Methods needed to open and close a connection and to transfer data. Figure 16 shows the DirectDeviceAccessType definition. It is formally defined in Table 28.



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**Figure 16 – DirectDeviceAccessType**

**Table 28 – DirectDeviceAccessType Definition**

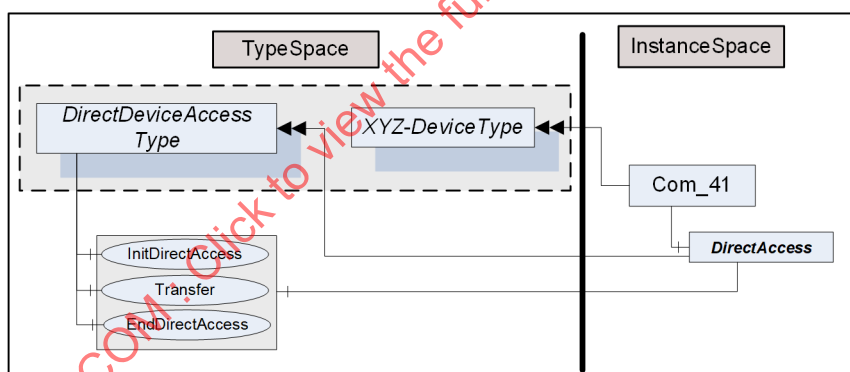
| Attribute                                             | Value                  |                  |          |                |               |
|-------------------------------------------------------|------------------------|------------------|----------|----------------|---------------|
| BrowseName                                            | DirectDeviceAccessType |                  |          |                |               |
| IsAbstract                                            | False                  |                  |          |                |               |
| References                                            | NodeClass              | BrowseName       | DataType | TypeDefinition | ModellingRule |
| Subtype of the BaseObjectType defined in IEC 62541-5. |                        |                  |          |                |               |
| HasComponent                                          | Method                 | InitDirectAccess |          |                | Mandatory     |
| HasComponent                                          | Method                 | Transfer         |          |                | Mandatory     |
| HasComponent                                          | Method                 | EndDirectAccess  |          |                | Mandatory     |

The DirectDeviceAccessType and each instance of this Type share the same Methods. The NodeId of these Methods will be fixed and defined in this document. FDI Clients therefore do not have to browse for these Methods. They can use the fixed NodeId as the MethodId of the Call Service.

The OPC UA StatusCode Bad\_MethodInvalid shall be returned from the Call Service for elements where the DirectDeviceAccess Methods are not supported.

### 9.4.3 DirectDeviceAccess Object

The support of DirectDeviceAccess for an Object is declared by aggregating an instance of the DirectDeviceAccess Type as illustrated in Figure 17.



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**Figure 17 – DirectDeviceAccess instance**

This Object is used as container for the DirectDeviceAccess Methods and shall have the BrowseName DirectAccess. It is formally defined in Table 29. HasComponent is used to reference from a TopologyElement (for example, a Device) to its "DirectDeviceAccess" Object.

The DirectDeviceAccessType and each DirectAccess Object share the same Methods.

**Table 29 – DirectDeviceAccess Instance Definition**

| Attribute         | Value        |                        |                   |                |               |
|-------------------|--------------|------------------------|-------------------|----------------|---------------|
| BrowseName        | DirectAccess |                        |                   |                |               |
| References        | NodeClass    | BrowseName             | DataType          | TypeDefinition | ModellingRule |
| HasTypeDefinition | ObjectType   | DirectDeviceAccessType | Defined in 9.4.2. |                |               |

#### 9.4.4 InitDirectAccess Method

InitDirectAccess opens a logic communication channel. The Device to access is specified via the ObjectId argument of the Call Service.

It is up to the FDI Server whether this Method already opens a connection to the physical device.

The signature of this Method is specified below. Table 30 and Table 31 specify the arguments and AddressSpace representation, respectively.

#### Signature

```
InitDirectAccess (
    [in] String      Context,
    [out] Int32      InitDirectAccessError);
```

**Table 30 – InitDirectAccess Method Arguments**

| Argument              | Description                                                                                                                                                                                                |
|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Context               | A string used to provide context information about the current activity going on in the FDI Client/UIP.                                                                                                    |
| InitDirectAccessError | 0 – OK<br>-1 – E_NotSupported – the device can not be directly accessed<br>-2 – E_LockRequired – the element is not locked as required<br>-3 – E_InvalidState – the device is already in DirectAccess mode |

**Table 31 – InitDirectAccess Method AddressSpace Definition**

| Attribute   | Value            |                 |            |                |               |
|-------------|------------------|-----------------|------------|----------------|---------------|
| BrowseName  | InitDirectAccess |                 |            |                |               |
| References  | NodeClass        | BrowseName      | DataType   | TypeDefinition | ModellingRule |
| HasProperty | Variable         | InputArguments  | Argument[] | PropertyType   | Mandatory     |
| HasProperty | Variable         | OutputArguments | Argument[] | PropertyType   | Mandatory     |

#### 9.4.5 EndDirectAccess Method

EndDirectAccess ends direct access. The directly accessed Device is specified via the ObjectId argument of the Call Service.

The signature of this Method is specified below. Table 32 and Table 33 specify the arguments and AddressSpace representation, respectively.

## Signature

```

EndDirectAccess (
    [in] Boolean      InvalidateCache,
    [out] Int32       EndDirectAccessError);

```

**Table 32 – EndDirectAccess Method Arguments**

| Argument             | Description                                                                                                                                                   |
|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| InvalidateCache      | If True, the FDI Server will invalidate any cached values for Device Parameters. This means that these Parameters will be re-read before they are used again. |
| EndDirectAccessError | 0 – OK<br>-1 – E_InvalidState – the device is not in DirectAccess mode.                                                                                       |

**Table 33 – EndDirectAccess Method AddressSpace Definition**

| Attribute   | Value           |                 |            |                |               |
|-------------|-----------------|-----------------|------------|----------------|---------------|
| BrowseName  | EndDirectAccess |                 |            |                |               |
| References  | NodeClass       | BrowseName      | Data Type  | TypeDefinition | ModellingRule |
| HasProperty | Variable        | InputArguments  | Argument[] | PropertyType   | Mandatory     |
| HasProperty | Variable        | OutputArguments | Argument[] | PropertyType   | Mandatory     |

### 9.4.6 Transfer Method

Transfer is used to transfer data to and from the Device. The format of send or receive data is protocol-specific.

The signature of this Method is specified below. Table 34 and Table 35 specify the arguments and AddressSpace representation, respectively.

## Signature

```

Transfer (
    [in] String      SendData,
    [out] String     ReceiveData,
    [out] Int32      TransferError);

```

**Table 34 – Transfer Method Arguments**

| Argument      | Description                                                                                                                                        |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| SendData      | XML document based on the TransferSendDataType as specified in the communication profile-specific XML schema. See IEC 62769-4 and IEC 62769-10x.   |
| ReceiveData   | XML document based on the TransferResultDataType as specified in the communication profile-specific XML schema. See IEC 62769-4 and IEC 62769-10x. |
| TransferError | 0 – OK<br>-1 – E_InvalidState – the device is not in DirectAccess mode.                                                                            |

**Table 35 – Transfer Method AddressSpace Definition**

| Attribute   | Value     |                 |            |                |               |
|-------------|-----------|-----------------|------------|----------------|---------------|
| BrowseName  | Transfer  |                 |            |                |               |
| References  | NodeClass | BrowseName      | DataType   | TypeDefinition | ModellingRule |
| HasProperty | Variable  | InputArguments  | Argument[] | PropertyType   | Mandatory     |
| HasProperty | Variable  | OutputArguments | Argument[] | PropertyType   | Mandatory     |

## 10 Parameter Types

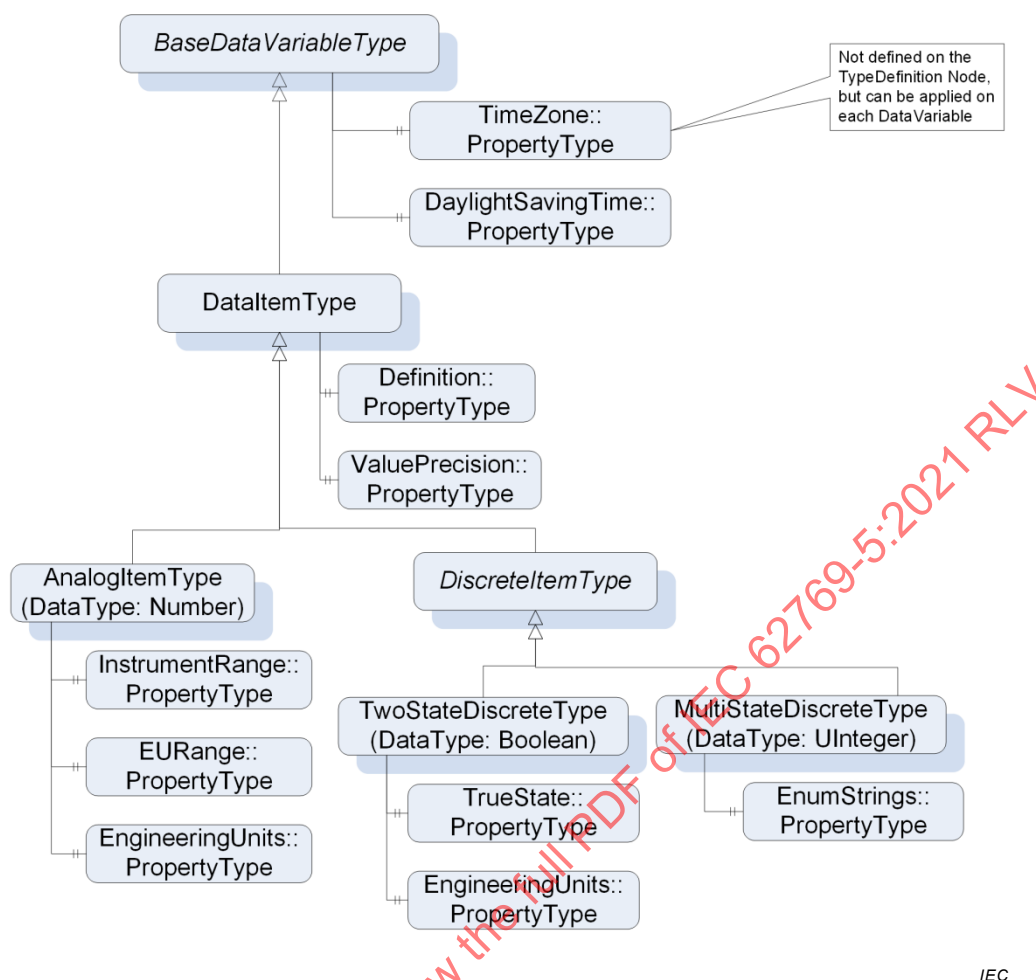
### 10.1 General

IEC 62541-100 defines a Parameter as "a variable of the Device that can be used for configuration, monitoring or control purposes. In the Information Model it is synonymous with an OPC UA DataVariable."

When discussing Parameter Types, we have to consider DataType and VariableType.

Each OPC UA DataVariable (Parameter) has a Value Attribute, which is of a certain DataType. OPC UA has already defined a set of built-in DataTypes, which are sufficient for the majority of types needed for FDI.

VariableTypes represent the type definition of (Data)Variables. Such a type definition typically defines certain behaviour as well as mandatory or optional Properties. The HasTypeDefinition Reference is used to define the VariableType for a Variable. OPC UA already defines a set of VariableTypes as illustrated in Figure 18. BaseDataVariableType is the base type and can be used if no more specialized type information is available (see IEC 62541-5). AnalogItemType and DiscreteItemTypes (see IEC 62541-8) are more concrete types.



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**Figure 18 – OPC UA VariableTypes including OPC UA DataAccess**

The mapping of EDD Data Types to OPC UA DataTypes and VariableTypes is specified in 15.6.

## 10.2 ScalingFactor Property

The Value Attribute of Variables contains the raw value returned from the device. However, Servers can expose the Property ScalingFactor. It is suggested that the (raw) value is multiplied by this factor before being displayed.

The Property shall be aggregated by each Variable that it applies to. It is formally defined in Table 36.

**Table 36 – ScalingFactor Property Definition**

| Name          | DataType | Description                                                                               |
|---------------|----------|-------------------------------------------------------------------------------------------|
| ScalingFactor | Double   | This Property specifies the scaling factor to be used when displaying the Variable value. |

## 10.3 Min\_Max\_Values Property

This Property specifies one or more ranges to which a Variable value shall be set. If there are multiple ranges, they shall not overlap. A "Null" for the MIN\_Value or the MAX\_Value indicates that this boundary is not limited.

The Property shall be aggregated by each Variable that it applies to. It is formally defined in Table 37.

**Table 37 – Min\_Max\_Values Property Definition**

| Name           | DataType        | Description                                                                         |
|----------------|-----------------|-------------------------------------------------------------------------------------|
| Min_Max_Values | Variant_Range[] | This Property specifies the range or ranges to which a Variable Value shall be set. |

The Variant\_Range structure specifies a single range (a MIN\_Value and a MAX\_Value). The BaseDataType is used, because such a range can be applied to Variables of different DataTypes – in particular integer, floating point, date and duration. The actual datatype used has to match the DataType of the Variable value. It can also be Null, which means that this boundary is not defined.

Its elements are defined in Table 38.

**Table 38 – Variant\_Range DataType Structure**

| Name          | Type         | Description                                                                                                       |
|---------------|--------------|-------------------------------------------------------------------------------------------------------------------|
| Variant_Range | structure    |                                                                                                                   |
| MIN_Value     | BaseDataType | Specifies the upper bound of values to which a Variable shall be set. Null indicates that MIN_Value has no limit. |
| MAX_Value     | BaseDataType | Specifies the lower bound of values to which a Variable shall be set. Null indicates that MAX_Value has no limit. |

Its representation in the AddressSpace is defined in Table 39.

**Table 39 – Variant\_Range Definition**

| Attributes | Value         |
|------------|---------------|
| BrowseName | Variant_Range |

## 11 FDI StatusCodes

Clause 11 defines OPC UA StatusCodes that are specific to FDI Servers.

The general structure of the StatusCode is specified in IEC 62541-4. It includes a set of common operational result codes, which also apply to FDI.

Table 40 contains Good (success) codes that are specifically defined for FDI.

**Table 40 – Good operation level result codes**

| Symbolic ID                | Description                                                                                                                                                                                                                                                                                            |
|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Good_Edited                | This status applies to Variable values that are part of an EditContext (see 9.3). It is returned with values that are read or received in a DataChangeNotification from a Subscription.<br><br>It defines that it is an edited value that has not been transferred from the EditContext to the Device. |
| Good_PostActionFailed      | The value of a Variable was successfully read or written but one of the post actions failed.                                                                                                                                                                                                           |
| Good_DependentValueChanged | This status applies to Variable values that are part of an EditContext (see 9.3). It is delivered with a dominant Variable value when any of its dependent Variables was changed and not yet applied.                                                                                                  |

Table 41 contains Uncertain codes that are specifically defined for FDI.

**Table 41 – Uncertain operation level result codes**

| Symbolic ID                     | Description                                                                                                                                                                                                                                                                                           |
|---------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Uncertain_DominantValueChanged  | This status applies to Variable values that are part of an EditContext (see 9.3). It is delivered with a dependent Variable value when a dominant value – e.g. an engineering unit – was changed and the dependent Variable may have to be recalculated.                                              |
| Uncertain_DependentValueChanged | This status applies to Variable values that are part of an EditContext (see 9.3). It is delivered with a dominant Variable value when any of its dependent Variables was changed and not yet applied. The "uncertain" status indicates that the dominant variable value itself has uncertain quality. |

Table 42 contains Bad codes that are specifically defined for FDI.

**Table 42 – Bad operation level result codes**

| Symbolic ID               | Description                                                                                                                                                                                                                                                                                     |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Bad_DominantValueChanged  | This status applies to Variable values that are part of an EditContext (see 9.3). It is delivered with a dependent Variable value when a dominant value – e.g. an engineering unit – was changed and the dependent Variable cannot be accessed.                                                 |
| Bad_DependentValueChanged | This status applies to Variable values that are part of an EditContext (see 9.3). It is delivered with a dominant Variable value when any of its dependent Variables was changed and not yet applied. The "uncertain" status indicates that the dominant variable value itself has bad quality. |

## 12 Specialized topology elements

Devices and other topology elements can be specialized using the modelling elements defined in this document or in IEC 62541-100. No specific ObjectType is needed. A Communication Device for instance will have the CommunicationServices capability (Communication Devices and CommunicationServices are specified in IEC 62769-7).

Other specializations are possible applying the same techniques, for example, a Modular Communication Device.

See IEC 62541-100 for the definition of Block Device and Modular Device.

## 13 Auditing

### 13.1 General

Auditing is a requirement in many systems. It provides a means for tracking activities that occur as part of the normal operation of the system. It also provides a means for tracking abnormal behaviour. It is also a requirement from a security standpoint.

When an audit trail is maintained by the FDI Server, all audit trail records related to services invoked by FDI Clients will be implicitly created. In addition, FDI Clients have means for providing additional audit context information as specified in 13.2 and 13.3.

FDI Servers shall generate AuditEvents as specified in IEC 62541-4 and IEC 62541-5. These standards define AuditEvents for the following OPC UA Services:

- Secure Channel Services,
- Session Services,
- NodeManagement Service Set (AddNode, DeleteNode),
- Write Service,
- Method Service ("Call").

No AuditEvents are defined for reading and for subscriptions.

The FDI Server generates AuditEvents using the standard OPC UA event mechanism. This allows an external OPC UA Client to subscribe to and store the audit entries in a log file or other storage location.

### 13.2 FDI Client-provided context information

FDI Clients have various means for providing context information for the purpose of auditing:

- the ClientDescription and SessionName passed by the FDI Client when creating the Session,
- the context text from the Methods to initialise Lock or Direct Device Access.

When an AuditUpdateMethodEvent is generated for the EnterLock and InitDirectAccess Methods, the audit context information will be used for the Message field of this event.

### 13.3 LogAuditTrailMessage Method

LogAuditTrailMessage is used by the FDI Client to insert information about the current activity going on in the FDI Client into the audit trail of the FDI Server. Since it is a Method, it will be also inserted into the stream of AuditEvents. The message will be timestamped in the FDI Server.

This Method shall be a component of the Server Object. The ObjectId parameter of the Call Service shall be the NodeId of the Server Object.

FDI Clients do not have to browse for the LogAuditTrailMessage Method. Rather, they can use the well known NodeId of the Method declaration as the MethodId of the Call Service.

The signature of this Method is specified below. Table 43 and Table 44 specify the arguments and AddressSpace representation, respectively.

## Signature

```
LogAuditTrailMessage (
    [in] String Message);
```

**Table 43 – LogAuditTrailMessage Method Arguments**

| Argument | Description                       |
|----------|-----------------------------------|
| Message  | Free text describing the context. |

**Table 44 – LogAuditTrailMessage Method AddressSpace Definition**

| Attribute   | Value                |                |            |                |               |
|-------------|----------------------|----------------|------------|----------------|---------------|
| BrowseName  | LogAuditTrailMessage |                |            |                |               |
| References  | NodeClass            | BrowseName     | DataType   | TypeDefinition | ModellingRule |
| HasProperty | Variable             | InputArguments | Argument[] | PropertyType   | Mandatory     |

When an AuditUpdateMethodEvent is generated for the LogAuditTrailMessage Method, the Message argument will be used for the Message field of this event.

## 14 FDI Server Version

The FDI Technology Version supported by an FDI Server is exposed via an FDI-specific Property. The version exposed with this Property applies to

- the Information Model, and
- the XML Schema as used for UIDs and Actions.

The Property shall be aggregated by the OPC UA Server Object. It is formally defined in Table 45.

**Table 45 – FDI Server Version Property Definition**

| Name             | DataType | Description                                                                                                                              |
|------------------|----------|------------------------------------------------------------------------------------------------------------------------------------------|
| FDIServerVersion | String   | This Property specifies the FDI Technology Version that this FDI Server supports. The syntax of the string is as defined in IEC 62769-4. |

## 15 Mapping FDI Package information to the FDI Information Model

### 15.1 General

Clause 15 defines the mapping of EDDL and other FDI Package Information to the FDI Information Model and the underlying OPC UA and OPC UA Devices information models, respectively.

The OPC UA Object Model provides a standard way for Servers to represent Objects to Clients. In order to meet this objective, the OPC UA Object Model allows the definition of Objects in terms of Variables and Methods. It also allows relationships to other Objects to be expressed.

On the other hand, EDDL defines a set of language constructs that are used to describe industrial field devices. Each construct supports its own set of attributes and references. EDD information adds semantic contents to the raw data values read from and written to the field devices.

The primary objective of the EDDL-OPC UA information model is to describe the correspondence between the OPC UA Object Model elements and the EDDL elements when an EDD is used to populate the FDI Server with Objects.

Completely meeting this objective means dealing both with enhanced data access through OPC UA and with UI interactions between OPC UA clients and servers.

## **15.2 Localization**

### **15.2.1 Localized text**

In various definitions, EDDs may contain information in multiple language variants. Examples are the LABEL and HELP attributes. The server has to select the proper language for each client as follows: when creating an OPC UA Session, the OPC UA Client passes the locale(s) that it requests to be used for all services within this Session. If the Server does not support any of the requested locales, it chooses an appropriate default locale.

### **15.2.2 Engineering units**

Variables with a UNIT CODE are represented in OPC UA as AnalogItem Variables. The UNIT CODE is exposed via the EngineeringUnit Property. Changing the EngineeringUnit will cause all EDD Variables that depend on the associated UNIT CODE to be recalculated. As a result, the OPC UA Variable values will be set as well.

Changing the EngineeringUnit will affect all Clients.

## **15.3 Device**

### **15.3.1 General**

Subclause 15.3 specifies the mapping of FDI Package elements to Device Types and Device Instances.

Devices may also have Blocks (see 15.4).

### **15.3.2 Mapping to Attributes to a specific DeviceType Node**

The BrowseName and NodeId Attributes are vendor-specific.

The DisplayName Attribute is created from the Package Catalog: DeviceType.Name.

The Description Attribute of a Device is the information that serves to further identify, manage, locate, and/or explain the device whose contents are defined by the user. For purely block-oriented devices, this will appear only on blocks. For example, in HART, the MESSAGE variable can be used here.

### **15.3.3 Mapping to Properties**

Type and instances share the same Properties.

Some of the Properties are created from information in the Package Catalog. Table 46 specifies the mapping of Properties to Package Catalog elements.

**Table 46 – DeviceType Property Mapping**

| Property             | Package Catalog element                               |
|----------------------|-------------------------------------------------------|
| Manufacturer         | ManufacturerName                                      |
| Model                | ListOfDeviceTypes[i].ListOfInterfaces[j].DeviceModel. |
| DeviceRevision       | ListOfDeviceTypes[i].ListOfInterfaces[j].Version.     |
| FDITechnologyVersion | FDITechnologyVersion.                                 |

The SerialNumber, RevisionCounter, SoftwareRevision, and HardwareRevision Properties correspond to the value of the protocol-specific "serial number", "revision counter", "software revision", and "hardware revision" Parameters, respectively.

The DeviceManual Property is an empty string. Documents can be found in the attachment set.

If a Picture element is available in the FDI Package, it can be mapped to the OPC UA Icon Property (see IEC 62541-3). If multiple resolutions are available, the host has to choose.

#### 15.3.4 Mapping to ParameterSet

Some devices are strictly block-oriented with no kinds of Variables on the device level. Mapping an EDD for these devices will result in an empty ParameterSet. When VARIABLE, VALUE\_ARRAY or LIST items exist on the device-level, the resulting Parameters are kept in the "ParameterSet" as a flat list of Parameters. FunctionalGroups reflect the structure of the device menus defined in the device's EDD.

A ParameterSet with all Parameters exists on the Type, the offline and the online instances.

See 15.6 on how EDDL attributes are used to create Parameter nodes.

#### 15.3.5 Mapping to Functional Groups

The top-level Functional Groups that are referenced directly from the Device Object correspond to the root MENU items, as defined in IEC 61804-4. Naming conventions are used to differentiate between Functional Groups for handheld and for PC-based applications.

There are no Functional Groups on the DeviceType.

#### 15.3.6 Mapping to DeviceTypeImage

The Variables in the DeviceTypeImage folder are created from the Package Catalog: DeviceTypes[i].ListOfDeviceImages. BrowseName and DisplayName represent the file name from the Relationship Type.

#### 15.3.7 Mapping to Documentation

The Variables in the Documentation folder are created from the Package Catalog: DeviceTypes[i].ListOfDocuments. BrowseName and DisplayName represent the file name from the Relationship Type.

#### 15.3.8 Mapping to ProtocolSupport

The Variables in the ProtocolSupport folder are created from the Package Catalog: DeviceTypes[i].ListOfInterfaces[j].ListOfCommunicationProfileSupportFiles. BrowseName and DisplayName represent the file name from the Relationship Type.

### 15.3.9 Mapping to ImageSet

The ImageSet contains Variable Nodes for all images from the EDD that are needed for UIDs.

### 15.3.10 Mapping to ActionSet

The ActionSet references OPC UA Objects that represent all EDD Methods except for the abort and the action methods as defined in IEC 61804-3. See 15.8 on how EDDL attributes are used to create Action Nodes

### 15.3.11 Mapping to MethodSet

The MethodSet (inherited from IEC 62541-100) is not used by the FDI.

## 15.4 Modular Device

Subclause 15.4 specifies the mapping of a modular device's package.

As described in IEC 62769-4, a package for a modular device contains a head station EDD and one or more module EDDs. The head station EDD contains COMPONENT constructs that identify the module EDDs.

The EDDs for head station Device and for each module shall be individually mapped in accordance with the mapping rules for single Devices.

The head station Device will show up as a modular Device as specified in IEC 62541-100.

- The SubDevices component in the instance of the head Device references instantiated modules.
- The SupportedTypes folder in the SubDevices component references all DeviceTypes for modules that may appear in the instance of the head Device.

## 15.5 Block

### 15.5.1 General

Subclause 15.5 specifies the mapping of EDDL elements to Block Types and instances.

EDDL supports the definition of devices that are block-oriented, and devices that are non-block oriented. When blocks (specifically, Block\_A) exist in an EDD, the resulting device shall be modelled as a block-oriented Device as specified in IEC 62541-100. The Block node instances are kept in the Blocks component. A Device that does not support EDDL-defined Blocks will not have the Blocks component.

The SupportedTypes folder in the Blocks component of a DeviceType references all BlockTypes that may appear in a Device Instance. The Blocks component in a Device Instance references instantiated Blocks.

### 15.5.2 Mapping to Attributes

The BrowseName and DisplayName correspond to the EDD Identifier and LABEL Attribute of the corresponding EDDL Block, respectively.

The NodeId is vendor-specific.

The Help attribute of the corresponding EDDL Block is mapped to the Description attribute of the Block instance node. Bad\_AttributeIdInvalid shall be used if EDD contains no Help.

### 15.5.3 Mapping to ParameterSet

All VARIABLE, VALUE\_ARRAY, LIST items specified for a Block are used as Parameters in the "ParameterSet". A ParameterSet with all Parameters exist on the Type, the offline and the online instances.

See 15.6 on how EDDL attributes are used to create Parameter nodes.

### 15.5.4 Mapping to Functional Groups

A Block may have FunctionalGroups that expose its Parameters in an organized fashion, reflecting the structure of the block menus defined in the device's EDD. The top-level Functional Groups that are referenced directly from the Block Object correspond to the root MENU items, as defined in IEC 61804-4. Naming conventions are used to differentiate between Functional Groups for handheld and for PC-based applications

The BrowseName of a FunctionalGroup is the EDD identifier of the corresponding EDDL MENU or COLLECTION.

There are no Functional Groups on the BlockType.

### 15.5.5 Mapping to ActionSet

The ActionSet references OPC UA Objects that represent all EDD Methods defined for a specific BLOCK, except for the abort and the action methods as defined in IEC 61804-3. See 15.8 on how EDDL attributes are used to create Action Nodes.

### 15.5.6 Mapping to MethodSet

The MethodSet (inherited from IEC 62541-100) is not used by the FDI.

### 15.5.7 Instantiation rules

The BrowseName of a Block is generated by the FDI Server from the EDD identifier of the corresponding EDDL BLOCK\_A by adding a numeric suffix that the OPC UA server generates in order to make the BrowseName unique. For example, \_\_analog\_input\_0, \_\_analog\_input\_1, \_\_pid\_control\_0.

The DisplayName of a BLOCK\_B Block is the LABEL attribute.

The DisplayName of a BLOCK\_A Block is defined in the protocol annex.

The Description of a Block is the HELP attribute of the corresponding EDDL BLOCK. Bad\_AttributeInvalid shall be used if the EDD contains no Help.

## 15.6 Parameter

### 15.6.1 General

EDDL Parameters (for devices or blocks) are mapped to OPC UA Variables. The VariableType used may be of any sub-type of the abstract BaseVariableType. In most cases, they will be mapped to the VariableTypes defined in IEC 62541-8, for example, DataItemType, AnalogItemType or DiscreteItemType. This document includes additional VariableTypes for more sophisticated EDDL types. See Table 48 for the mapping of EDDL types.

The BrowseName of a Parameter is the EDD identifier of the corresponding EDDL VARIABLE, RECORD or VALUE\_ARRAY.

The DisplayName of a Parameter is the LABEL attribute of the corresponding EDDL VARIABLE, RECORD or VALUE\_ARRAY.

The Description of a Parameter is the HELP attribute of the corresponding EDDL VARIABLE, RECORD or VALUE\_ARRAY. Bad\_AttributeIdInvalid shall be used if the EDD contains no Help.

Parameters have also a set of Attributes that are common to all VariableTypes. Table 47 summarizes the Variable Attributes and describes how they are set from the EDDL description information.

**Table 47 – Setting OPC UA Variable Attributes from EDDL variable attributes**

| Attributes              | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                     |     |             |             |   |                                                                    |              |   |                                                                     |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|-----|-------------|-------------|---|--------------------------------------------------------------------|--------------|---|---------------------------------------------------------------------|
| Value                   | The most recent value of the Variable that the FDI Server has read from the device.                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                     |     |             |             |   |                                                                    |              |   |                                                                     |
| DataType                | The EDDL data type is translated into an OPC UA standard data type in accordance with Table 48.                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                     |     |             |             |   |                                                                    |              |   |                                                                     |
| ValueRank               | Either set to "Scalar" or – when the Parameter is an array – the number of dimensions.                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                     |     |             |             |   |                                                                    |              |   |                                                                     |
| ArrayDimensions         | Specifies the length of each dimension if the Parameter is an array. This attribute is not exposed if the length is unknown or dynamic.                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                     |     |             |             |   |                                                                    |              |   |                                                                     |
| AccessLevel             | <div>The AccessLevel Attribute is set based on the EDDL variable HANDLING attribute according to the following table:<table><tr><th>Field</th><th>Bit</th><th>Description</th></tr><tr><td>CurrentRead</td><td>0</td><td>Set if EDDL variable HANDLING is defined as READ. Reset otherwise.</td></tr><tr><td>CurrentWrite</td><td>1</td><td>Set if EDDL variable HANDLING is defined as WRITE. Reset otherwise.</td></tr></table></div> <div>If the HANDLING attribute is missing, the Parameter will be defined as readable and writeable.</div> | Field                                                               | Bit | Description | CurrentRead | 0 | Set if EDDL variable HANDLING is defined as READ. Reset otherwise. | CurrentWrite | 1 | Set if EDDL variable HANDLING is defined as WRITE. Reset otherwise. |
| Field                   | Bit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Description                                                         |     |             |             |   |                                                                    |              |   |                                                                     |
| CurrentRead             | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Set if EDDL variable HANDLING is defined as READ. Reset otherwise.  |     |             |             |   |                                                                    |              |   |                                                                     |
| CurrentWrite            | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Set if EDDL variable HANDLING is defined as WRITE. Reset otherwise. |     |             |             |   |                                                                    |              |   |                                                                     |
| UserAccessLevel         | The AccessLevel with possible restrictions based on client identity as defined by the FDI Server.                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                     |     |             |             |   |                                                                    |              |   |                                                                     |
| MinimumSamplingInterval | The MinimumSamplingInterval Attribute indicates how fast the FDI Server can reasonably sample the value for changes. It is suggested that the FDI Server checks the variable CLASS attribute to differentiate static variables from dynamic variables regarding the sampling interval. Static variables might be sampled only once and then only when the RevisionCounter changes. For static variables, the FDI Server can use the MinimumSamplingInterval -1 (indeterminate).                                                                   |                                                                     |     |             |             |   |                                                                    |              |   |                                                                     |

The Value Attribute is the Parameter value, and – for the online representation – reflects the device data value.

The DataType Attribute is an OPC UA DataType chosen to match the EDDL type and size. Table 48 shows the correspondence between the EDDL types and sizes and the OPC UA VariableTypes and standard DataTypes.

**Table 48 – Correspondence between EDDL and OPC UA standard data types**

| EDDL Data Type   | OPC UA VariableType                  | OPC UA DataType                                                                                                       | Constraints                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|------------------|--------------------------------------|-----------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Arithmetic       |                                      |                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| INTEGER          | BaseDataVariableType, AnalogItemType | SByte                                                                                                                 | When the size specified in EDDL is 1 byte.                                                                                                                                                                                                                                                                                                                                                                                                                               |
|                  |                                      | Int16                                                                                                                 | When the size specified in EDDL is 2 bytes.                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                  |                                      | Int32                                                                                                                 | When the size specified in EDDL is 3 or 4 bytes.                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                  |                                      | Int64                                                                                                                 | When the size specified in EDDL is 5, 6, 7 or 8 bytes.                                                                                                                                                                                                                                                                                                                                                                                                                   |
| UNSIGNED_INTEGER | BaseDataVariableType, AnalogItemType | Byte                                                                                                                  | When the size specified in EDDL is 1 byte.                                                                                                                                                                                                                                                                                                                                                                                                                               |
|                  |                                      | UInt16                                                                                                                | When the size specified in EDDL is 2 bytes.                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                  |                                      | UInt32                                                                                                                | When the size specified in EDDL is 3 or 4 bytes.                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                  |                                      | UInt64                                                                                                                | When the size specified in EDDL is 5, 6, 7 or 8 bytes.                                                                                                                                                                                                                                                                                                                                                                                                                   |
| DOUBLE           | BaseDataVariableType, AnalogItemType | Double                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| FLOAT            | BaseDataVariableType, AnalogItemType | Float                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| ENUMERATED       | See 15.6.5                           | Byte                                                                                                                  | When the size specified in EDDL is 1 byte.                                                                                                                                                                                                                                                                                                                                                                                                                               |
|                  |                                      | UInt16                                                                                                                | When the size specified in EDDL is 2 bytes.                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                  |                                      | UInt32                                                                                                                | When the size specified in EDDL is 3 or 4 bytes.                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                  |                                      | UInt64                                                                                                                | When the size specified in EDDL is 5, 6, 7 or 8 bytes.                                                                                                                                                                                                                                                                                                                                                                                                                   |
| BIT_ENUMERATED   | See 15.6.6                           | Byte                                                                                                                  | When the size specified in EDDL is 1 byte.                                                                                                                                                                                                                                                                                                                                                                                                                               |
|                  |                                      | UInt16                                                                                                                | When the size specified in EDDL is 2 bytes.                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                  |                                      | UInt32                                                                                                                | When the size specified in EDDL is 3 or 4 bytes.                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                  |                                      | UInt64                                                                                                                | When the size specified in EDDL is 5, 6, 7 or 8 bytes.                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Date and Time    |                                      |                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| DATE             | BaseDataVariableType                 | UtcTime (a 64-bit signed integer which represents the number of 100 nanosecond intervals since January 1, 1601 (UTC)) | The data type DATE consists of a calendar date. This data type has special codification in the device. Conversion to UtcTime is necessary when reading it from the device. Conversion back to DATE is necessary when writing it to the device. On write, if invalid data is written, the service returns an appropriate error in the serviceResult and the diagnosticInfo data members of the ResponseHeader and does not accept the data.                               |
| DATE_AND_TIME    | BaseDataVariableType                 | UtcTime                                                                                                               | The data type DATE_AND_TIME consists of a calendar date and a time. This data type has special codification in the device. Conversion to UtcTime is necessary when reading it from the device. Conversion back to DATE_AND_TIME is necessary when writing it to the device. On writing, if invalid data is written the service returns an appropriate error in the serviceResult and the diagnosticInfo data members of the ResponseHeader and does not accept the data. |

| EDDL Data Type | OPC UA VariableType  | OPC UA DataType                                                                                                                         | Constraints                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|----------------|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DURATION       | BaseDataVariableType | Duration<br>(a <i>Double</i> that defines an interval of time in milliseconds (fractions can be used to define sub-millisecond values)) | The DURATION data type is a time difference that consists of a time in milliseconds and an optional day count. This data type has special codification in the device. Conversion to TIME is necessary when reading it from the device. Conversion back to DURATION is necessary when writing it to the device. On writing, if invalid data is written, the service returns an appropriate error in the serviceResult and the diagnosticInfo data members of the ResponseHeader and does not accept the data. The OPC Duration type is limited to approximately 49,7 days, which is less than the theoretical maximum of the EDDL DURATION type. If the DURATION exceeds the OPC maximum, the quality should be set to indicate this condition. |
| TIME           | BaseDataVariableType | UtcTime                                                                                                                                 | The TIME data type consists of a time and an optional date. This data type has special codification in the device. Conversion to UtcTime is necessary when reading it from the device. Conversion back to TIME is necessary when writing it to the device. On writing, if invalid data is written, the service returns an appropriate error in the serviceResult and the diagnosticInfo data members of the ResponseHeader and does not accept the data.                                                                                                                                                                                                                                                                                       |
| TIME_VALUE[4]  | BaseDataVariableType | Duration                                                                                                                                | TIME_VALUE is the "number of 1/32 ms". The "Duration" is calculated by multiplying the TIME_VALUE by 0,031 25 (which is the float equivalent for 1/32 ms).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| TIME_VALUE[8]  | BaseDataVariableType | UtcTime                                                                                                                                 | The data type TIME_VALUE is used to represent date and time in the required precision for application clock synchronization. This data type has special codification in the device. Conversion to UtcTime is necessary when reading it from the device. Conversion back to TIME_VALUE is necessary when writing it to the device. On writing, if invalid data is written, the service returns an appropriate error in the serviceResult and the diagnosticInfo data members of the ResponseHeader and does not accept the data.                                                                                                                                                                                                                |
| String         |                      |                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| ASCII          | BaseDataVariableType | String                                                                                                                                  | Conversion to String is necessary when reading it from the device. Conversion back to ASCII is necessary when writing it to the device. On writing, if invalid characters are written, the service returns an appropriate error in the serviceResult and the diagnosticInfo data members of the ResponseHeader and does not accept the string.                                                                                                                                                                                                                                                                                                                                                                                                 |
| BIT_STRING     | BaseDataVariableType | ByteString                                                                                                                              | Conversion to ByteString is necessary when reading it from the device. Conversion back to BIT_STRING is necessary when writing it to the device. On writing, if invalid characters are written, the service returns an appropriate error in the serviceResult and the diagnosticInfo data members of the ResponseHeader and does not accept the string.                                                                                                                                                                                                                                                                                                                                                                                        |

| EDDL Data Type | OPC UA VariableType  | OPC UA DataType | Constraints                                                                                                                                                                                                                                                                                                                                           |
|----------------|----------------------|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| EUC            | BaseDataVariableType | String          | Conversion to String is necessary when reading it from the device. Conversion back to EUC is necessary when writing it to the device. On writing, if invalid characters are written, the service returns an appropriate error in the serviceResult and the diagnosticInfo data members of the ResponseHeader and does not accept the string.          |
| PACKED_ASCII   | BaseDataVariableType | String          | Conversion to String is necessary when reading it from the device. Conversion back to PACKED_ASCII is necessary when writing it to the device. On writing, if invalid characters are written, the service returns an appropriate error in the serviceResult and the diagnosticInfo data members of the ResponseHeader and does not accept the string. |
| PASSWORD       | BaseDataVariableType | String          | Conversion to String is necessary when reading it from the device.<br><br>FDI Servers shall allow PASSWORD Variables to be read only when a secure OPC UA channel has been created, i.e. a channel with encryption.                                                                                                                                   |
| VISIBLE        | BaseDataVariableType | String          | Conversion to String is necessary when reading it from the device. Conversion back to VISIBLE is necessary when writing it to the device. On writing, if invalid characters are written, the service returns an appropriate error in the serviceResult and the diagnosticInfo data members of the ResponseHeader and does not accept the string.      |
| OCTET          | BaseDataVariableType | ByteString      |                                                                                                                                                                                                                                                                                                                                                       |
| INDEX          | see 15.6.5           | String          |                                                                                                                                                                                                                                                                                                                                                       |
| BOOLEAN        | BaseDataVariableType | Boolean         |                                                                                                                                                                                                                                                                                                                                                       |

As Table 48 shows, EDDL supports a variety of variable types. While that table shows the correspondence between the EDDL data types and the OPC UA VariableType, it does not provide any details on how other EDDL VARIABLE TYPE construct attributes are supported. It does not provide any details on how other OPC UA BaseDataVariableType attributes should be set either. Subclause 15.6 is intended to provide details for each EDDL data type.

### 15.6.2 Private Parameters

The Parameters specified in an FDI Package may be declared private using the PRIVATE Attribute specified in IEC 61804-3. The FDI Server shall create Nodes in the Information Model for the private Parameters but they shall not be browsable. The FDI Server shall return the NodeIds of private Parameters when the name of such a Parameter is passed to TranslateBrowsePathsToNodeIds (the startingNode argument shall be the "ParameterSet" Object). Once the FDI Client has obtained the NodeId, all Service requests for private Parameters will be processed in the same way as for public (browsable) Parameters.

An example of private parameters is parameters that should only be modified through an Action. These parameters should not be visible to FDI Clients to prevent direct access. FDI Clients invoke Actions to access these private parameters.

### 15.6.3 MIN\_Value and MAX\_Value

If one or more MIN\_VALUE and MAX\_VALUE attributes are specified for a variable in EDDL, they shall be mapped to the Min\_Max\_Values Properties defined in 10.3.

### 15.6.4 Engineering units

The EngineeringUnits Property defined in IEC 62541-3 and IEC 62541-8 shall be used:

- If the variable has the CONSTANT\_UNIT defined for itself in EDDL. In this case, the EngineeringUnits Property keeps the EDD CONSTANT\_UNIT variable attribute. The FDI Server shall deal with the fact that CONSTANT\_UNIT can be conditional.
- If the variable is involved in an EDD UNIT relation, it is the FDI Server's responsibility to implement the unit code update mechanism. An EDD UNIT relation specifies a reference to a variable holding a unit code and a list of dependent variables. When the variable holding the unit code is modified, the list of affected variables using that unit code shall be refreshed. When an affected variable is displayed, the value of its unit code shall also be displayed.

The standard OPC UA notifications can be used to report to the FDI Clients that the unit code has changed.

### 15.6.5 Enumerated Parameters

An OPC UA DataVariable with the VariableType MultiStateValueDiscreteType (defined in IEC 62541-8) is used for each enumerator in the EDDL enumerated variable definition.

The Value Attribute of the DataVariable is the numeric value of the state, and corresponds to the value attribute of the EDDL ENUMERATED TYPE.

The ValueAsText Property of the DataVariable exposes the display value of the state, which corresponds to the description attribute of the EDDL ENUMERATED TYPE.

The EnumValues Property of the DataVariable contains the complete list of enumerations, i.e. a table where each element is a structure consisting of EDDL ENUMERATED TYPE attributes "value", "description", and "help". If no help attribute exists in the EDD, the value of the description attribute will also be used for this purpose.

### 15.6.6 Bit-enumerated Parameters

A DataVariable of OPC UA OptionSet VariableType is used for each EDDL BIT ENUMERATED VARIABLE definition. The OPC UA DataType is an array of Boolean where one Boolean is used per bit in the EDDL BIT\_ENUMERATED VARIABLE definition.

The Boolean array of the DataVariable reflects the status of all bits. TRUE is used when a bit is set and FALSE when a bit is reset.

The EnumValues Property of the DataVariable contains the complete list of bit enumerations, i.e. a table where each element is a structure consisting of EDDL BIT ENUMERATED TYPE attributes "bit position", "description", and "help". If no help attribute exists in the EDD, the value of the description attribute will also be used for this purpose.

### 15.6.7 Representation of records

A complex DataVariable is used to represent EDDL RECORD Parameters. The root DataVariable represents the record itself. It will have component DataVariables that represent the EDDL RECORD MEMBERS. (The MEMBERS of an EDDL RECORD are defined in EDDL by means of a reference to an EDDL VARIABLE.).

See Figure 19 for an example of how records are represented in the OPC UA AddressSpace.

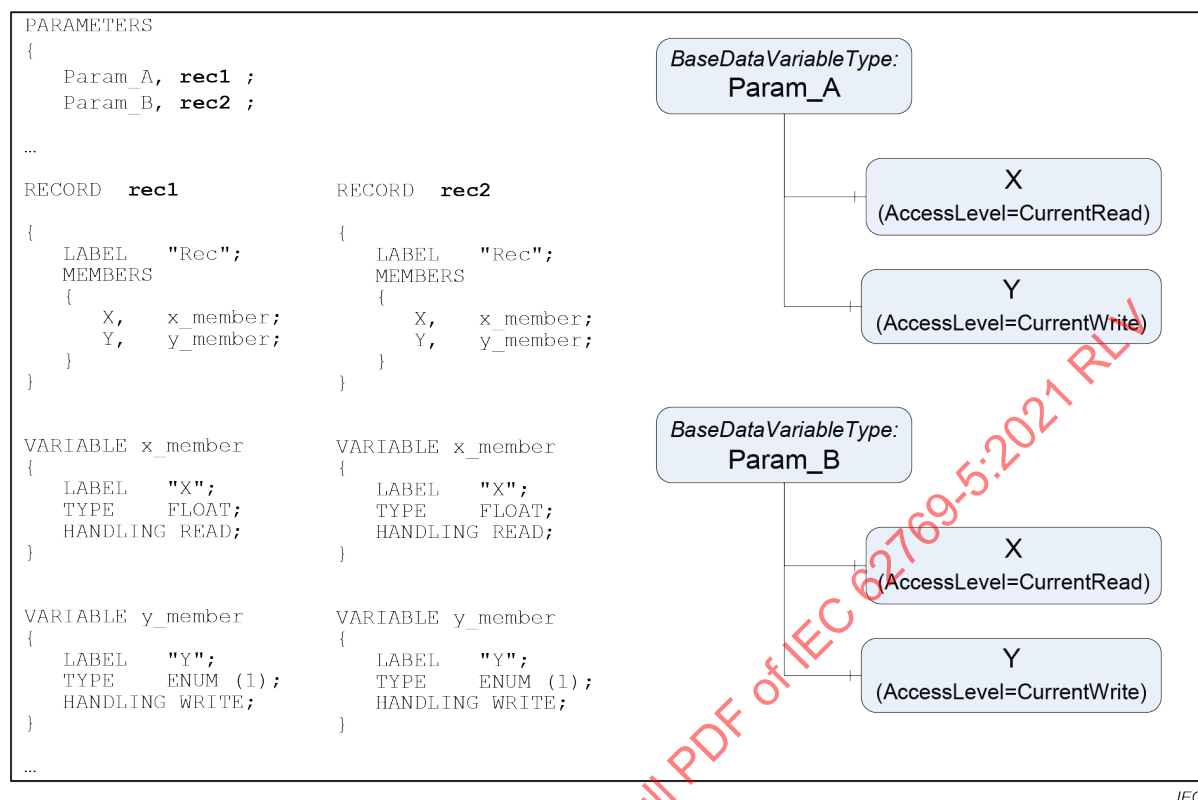


**Figure 19 – Example: Complex variable representing a RECORD**

BrowseName and DisplayName of the root DataVariable are set to the EDD identifier of the EDDL VARIABLE that implements this RECORD type. The DataType Attribute of the "root" DataVariable is BaseDataType. The ValueRank Attribute is used to specify that the value contains an array. The Value Attribute represents the values of all members in the order as defined for the RECORD. According to the example in Figure 19, the first variant will contain a floating-point value and the second will be a numeric value representing the Enumeration.

For each component DataVariable that represents an EDDL RECORD MEMBER:

- The BrowseName is the identifier of the corresponding EDDL VARIABLE.
- The DisplayName is the LABEL attribute of the corresponding EDDL VARIABLE.
- The Description is the HELP attribute of the corresponding EDDL VARIABLE. Bad\_AttributeIdInvalid shall be used if the EDD contains no Help.
- The AccessLevel is derived from the HANDLING attribute. Readable and Writeable shall be used if the EDD contains no HANDLING attribute.

#### 15.6.8 Representation of arrays, and lists of Parameters with simple data types

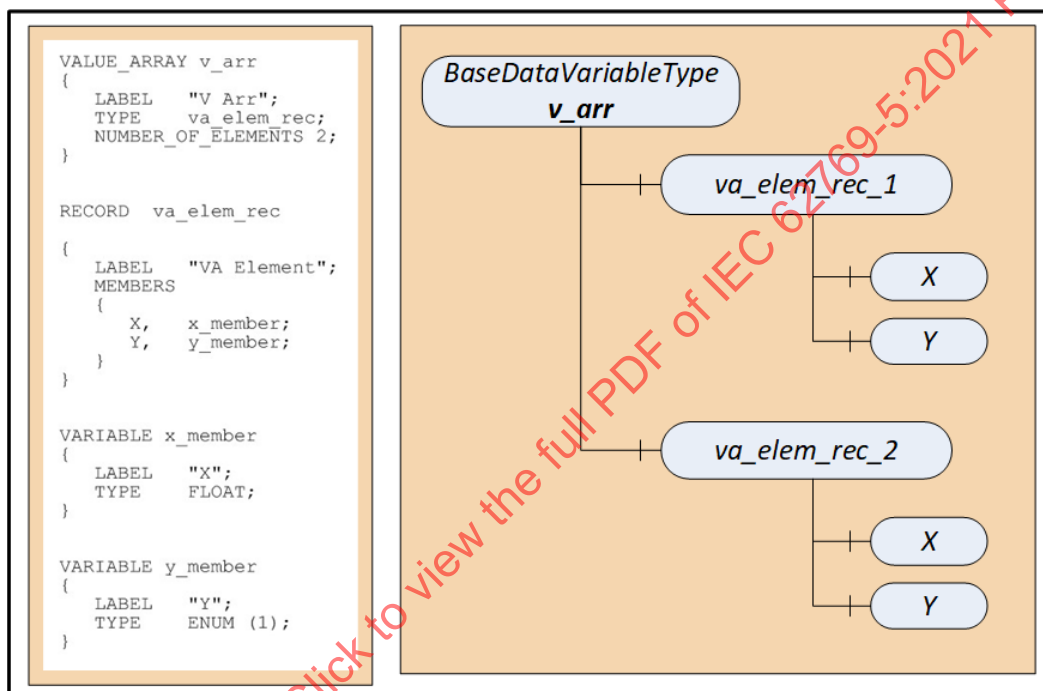
A single DataVariable will represent an EDDL VALUE\_ARRAY or LIST item when the data type of the referenced array element has a simple data type.

The OPC UA DataVariable Attributes are set as follows:

- DataType is set to the type of the array element (see Table 48 for the data type mapping).
- The ValueRank Attribute is used to specify that the value contains an array. In case of an EDDL VALUE\_ARRAY the number of elements is exposed in the ArrayDimensions Attribute. In the case of an EDDL LIST, the ArrayDimensions Attribute is not exposed. The number of elements is unspecific since the size can change dynamically.

### 15.6.9 Representation of values arrays, and lists of RECORD Parameters

Value arrays or lists of non-simple data types will be represented as OPC UA array of complex variables. Figure 20 shows the EDDL sample code of a VALUE\_ARRAY of RECORDs and the corresponding complex variable in the OPC UA AddressSpace.



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**Figure 20 – Complex variable representing a VALUE\_ARRAY of RECORDs**

In the FDI Server AddressSpace, a complex DataVariable is used to represent the entire VALUE\_ARRAY. Each VALUE\_ARRAY element, which is in fact a RECORD, is represented as a component complex DataVariable. The RECORD MEMBERS are also represented as component DataVariables. The FDI Client refers to the X member of the first record in the array through the BrowseName v\_arr.va\_elem\_1.x\_member. Note that the index always begins with '1'.

The DataType Attribute of all complex root DataVariables is BaseDataType. The ValueRank Attribute is used to specify that the value contains an array. The Value Attribute represents all VALUE\_ARRAY entries. The first element corresponds to the first array entry and so on. Each element in turn contains an array. This may either be an array of simple types or an array of BaseDataType. A RECORD is always represented as an array of BaseDataType.

### 15.6.10 Representation of COLLECTION and REFERENCE ARRAY

The EDDL constructs COLLECTION and REFERENCE ARRAY are mapped to Functional Group Objects (see 15.7) when used for grouping only.

### 15.6.11 SCALING\_FACTOR

If the EDD includes a SCALING\_FACTOR attribute for an EDD VARIABLE, it shall be mapped as follows.

- The Parameter value and associated Properties (like Ranges) shall be exposed in raw format (not scaled by the FDI Server). Any scaling is responsibility of the FDI Client (or UIP, respectively).
- The SCALING\_FACTOR shall be provided in a Property with the BrowseName "ScalingFactor". The DataType shall be "Double". If the SCALING\_FACTOR in the EDD is an expression, this expression will be computed by the EDD Interpreter.
- The SCALING\_FACTOR is also included in UID documents.

## 15.7 Functional Groups

FunctionalGroups are used to group Variables (EDDL parameters) or Actions (EDDL methods). They have a recursive definition, that is, FunctionalGroups may reference other FunctionalGroups.

Both Devices and Blocks may have FunctionalGroups. EDDL MENUs, EDDL BLOCK\_A PARAMETERS, COLLECTIONs, and REFERENCE ARRAYS are the building blocks for FunctionalGroups. The proper attributes of these EDDL constructs control which elements are referenced by the Functional Group.

- VARIABLE, RECORD, or VALUE\_ARRAY will cause a reference to the corresponding FDI Parameter.
- METHODS will be used to organise FDI Action Objects.
- Elements that represent one of the building blocks again will cause a reference to a subordinate Functional Group.

Root MENUs as defined in IEC 61804-4 will be top-level Functional Groups. The FDI Server generates the whole hierarchy of FunctionalGroups by browsing the EDDL MENU and their ITEMS attribute definitions. The FunctionalGroups reproduce the same structure of the MENUs as they are defined in EDD for the Device or Block.

All FunctionalGroups are instantiated in both the offline and the online representation of a Device. Naming conventions defined in IEC 61804-4 can be used to determine if a FunctionalGroup is relevant for offline or online.

The BrowseName Attribute of a FunctionalGroup is the EDD identifier of the menu or the instance identifier of the block. The naming conventions defined in IEC 61804-4 can be used to determine if a FunctionalGroup is relevant for PC or handheld.

The DisplayName Attribute of a FunctionalGroup is the LABEL attribute of the corresponding building block.

The Description Attribute of a FunctionalGroup is the value of the HELP attribute of the corresponding building block. Bad\_AttributeIdInvalid shall be used if the EDD contains no Help.

FunctionalGroups exposing standard sets of Parameters such as diagnostic information will be created for an EDD, which comply with the menu conventions for PC-based application as defined in IEC 61804-4.

### 15.8 AXIS elements in UIDs

AXIS elements are not represented as instances in the FDI information model. However, an EDDL AXIS has writable VIEW\_MIN/VIEW\_MAX attributes. They shall be modified by the FDI Client to inform the server about the zooming, scrolling or positioning.

To enable this modification, the FDI Server shall create variable nodes for each of these attributes in the Information Model. They need not be browsable. The NodeIds of these nodes are included into the UID document as described in the UID schema.

### 15.9 Actions

FDI Actions are used to represent EDD METHODS. Only EDD METHODS that are to be called by the FDI Client as part of a UID or a UIP shall be exposed as FDI Actions. If METHODS defined in IEC 61804-3, which include the pre or post read, edit and write actions, are exposed as Actions, they shall not be browsable. The names of these actions will be communicated to the Client as part of a UID document. These names can be passed to TranslateBrowsePathsToNodeIds to get the matching NodeId.

All Actions are instantiated in both the offline and the online representation of a Device.

The BrowseName Attribute of an Action is the EDD identifier of the METHOD.

The DisplayName Attribute of an Action is the LABEL attribute of the EDDL METHOD.

The Description Attribute of an Action is the HELP attribute of the EDDL METHOD. Bad\_AttributeIdInvalid shall be used if the EDD contains no Help.

The execution of an Action causes the execution of the EDD Method implementation. This is specified in detail in IEC 62769-2.

The METHODS specified in an FDI Package may be declared private using the PRIVATE Attribute specified in IEC 61804-3. The FDI Server shall create Action Objects in the Information Model for the private METHODS but they shall not be browsable. The FDI Server shall return the NodeIds of private Actions when the name of such an Action is passed to TranslateBrowsePathsToNodeIds (the startingNode argument shall be the "ActionSet" Object). Once the FDI Client has obtained the NodeId, private Actions can be invoked and processed in the same way as public (browsable) Actions.

### 15.10 UIPs

UIPs are specified in the FDI Package via the SupportedUIPs element. Each UIP is uniquely identified by a UUID.

UIPs are not exposed in the FDI AddressSpace but they can be referenced and accessed using the UUID. This is specified in IEC 62769-2.

### 15.11 Protocols, Networks and Connection Points

The FDI Server will create specific Protocol Types (sub-type of the ProtocolType defined in IEC 62541-100) for natively supported Protocols. Additional Protocol Types might be created for Communication Servers based on the Protocols they support.

Specific ConnectionPoint Types (sub-types of the ConnectionPointType defined in IEC 62541-100) will be created for natively supported Protocols. Additional Types might be created for Communication Servers based on the Protocols they support.

The types are created as specified in the protocol-specific series of standards IEC 62769-1xx.

## 16 Profiles

This clause defines the profiles and conformance units for the OPC UA Information Model for FDI Clients and FDI Servers. Profiles are named groupings of conformance units. Facets are profiles that will be combined with other Profiles to define the complete functionality of an OPC UA Server or Client.

FDI Servers (FDI Hosts) that implement a subset of the FDI Information Model that is relevant for generic OPC UA Clients shall implement as a minimum the BaseDevice\_Server\_Facet specified in IEC 62541-100 (OPC UA for Devices).

Table 49 specifies the facet for FDI Servers (FDI Hosts) that support FDI Clients.

**Table 49 – FDI Server Facet Definition**

| Conformance Unit      | Description                                                                                | Optional/<br>Mandatory |
|-----------------------|--------------------------------------------------------------------------------------------|------------------------|
| FDI Information Model | Support Objects that conform to the Types specified in this document and in IEC 62541-100. | M                      |

Table 50 defines the facet for FDI Clients that use the FDI Information Model.

**Table 50 – FDI Client Facet Definition**

| Conformance Unit             | Description                                                                                | Optional/<br>Mandatory |
|------------------------------|--------------------------------------------------------------------------------------------|------------------------|
| FDI Client Information Model | Consume Objects that conform to the Types specified in this document and in IEC 62541-100. | M                      |

## **Annex A** (normative)

### **Namespace and Mappings**

This annex defines the numeric identifiers for all of the numeric NodeIds defined in this document. The identifiers are specified in a CSV file with the following syntax:

`<SymbolName>, <Identifier>, <NodeClass>`

where the SymbolName is either the BrowseName of a Type Node or the BrowsePath for an Instance Node that appears in the specification and the Identifier is the numeric value for the NodeId.

The BrowsePath for an Instance Node is constructed by appending the BrowseName of the instance Node to the BrowseName for the containing instance or type. An underscore character is used to separate each BrowseName in the path.

The NamespaceUri `http://fdi-cooperation.com/OpcUa/FDI5/` is applied to NodeIds defined here.

An electronic version of the complete Information Model defined in this document is also provided. It follows the XML Information Model Schema syntax defined in IEC 62541-6.

The Information Model Schema released with this version of the document is in a separate file named:

`OPCUA_Part5_Model_V1.1\Opc.Ua.Fdi5.NodeSet2.xml`

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## COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

## INTÉGRATION DES APPAREILS DE TERRAIN (FDI) –

## Partie 5: Modèle d'Information

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- 9) L'attention est attirée sur le fait que certains des éléments de la présente Publication de l'IEC peuvent faire l'objet de droits de brevet. L'IEC ne saurait être tenue pour responsable de ne pas avoir identifié de tels droits de brevets et de ne pas avoir signalé leur existence.

La Norme internationale IEC 62769-5 a été établie par le sous-comité 65E: Les dispositifs et leur intégration dans les systèmes de l'entreprise, du comité d'études 65 de l'IEC: Mesure, commande et automation dans les processus industriels.

Cette deuxième édition annule et remplace la première édition parue en 2015. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

- a) prise en charge de l'extension de protocoles génériques qui vise à accélérer l'adoption d'autres technologies;
- b) prise en charge de nouveaux protocoles;
- c) extension de protocoles génériques qui permet l'adoption d'autres protocoles de communication;
- d) d'après l'extension de protocoles génériques: Modbus RTU.

Le texte de cette Norme internationale est issu des documents suivants:

| FDIS         | Rapport de vote |
|--------------|-----------------|
| 65E/762/FDIS | 65E/772/RVD     |

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette Norme internationale.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 62769, publiées sous le titre général *Intégration des appareils de terrain (FDI)*, peut être consultée sur le site web de l'IEC.

La présente norme contient des fichiers joints sous la forme d'un schéma XML. Ces fichiers sont destinés à être utilisés comme des fichiers complémentaires et ne forment pas une partie intégrante de la norme.

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## INTRODUCTION

La série IEC 62769 est publiée sous le titre général "*Intégration des appareils de terrain (FDI)*" et comporte les parties suivantes:

- Partie 1: Vue d'ensemble
- Partie 2: Client FDI
- Partie 3: Serveur FDI
- Partie 4: Paquetages FDI
- Partie 5: Modèle d'Information
- Partie 6: Mapping de technologies FDI
- Partie 7: Appareils de Communication FDI
- Partie 100: Profils – Extensions de protocoles génériques
- Partie 101-1: Profils – Foundation Fieldbus H1
- Partie 101-2: Profils – Foundation Fieldbus HSE
- Partie 103-1: Profils – PROFIBUS
- Partie 103-4: Profils – PROFINET
- Partie 109-1: Profils – HART et WirelessHART
- Partie 115-2: Profils – Définitions spécifiques au protocole pour Modbus-RTU
- Partie 150-1: Profils – ISA 100.11a

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# INTÉGRATION DES APPAREILS DE TERRAIN (FDI) –

## Partie 5: Modèle d'Information

### 1 Domaine d'application

La présente partie de l'IEC 62769 définit le Modèle d'Information FDI. L'un des principaux objectifs du Modèle d'Information est de refléter la topologie du système d'automatisation. Par conséquent, il représente les appareils du système d'automatisation ainsi que les réseaux de communication connectés, y compris leurs propriétés, leurs relations et les opérations dont ils peuvent faire l'objet. Les types présents dans l'AddressSpace (Espace d'adressage) du Serveur FDI constituent un catalogue, construit à partir des *FDI Packages* (Paquetages FDI).

Les types fondamentaux pour le Modèle d'Information FDI sont définis dans l'OPC UA pour les Appareils (IEC 62541-100). Le Modèle d'Information FDI spécifie des extensions pour quelques cas spéciaux et explique la façon dont ces types sont utilisés et dont les contenus sont construits à partir des éléments de DevicePackages.

L'architecture FDI complète est représentée à la Figure 1. Les composants architecturaux qui relèvent du domaine d'application du présent document ont été mis en évidence dans cette représentation.

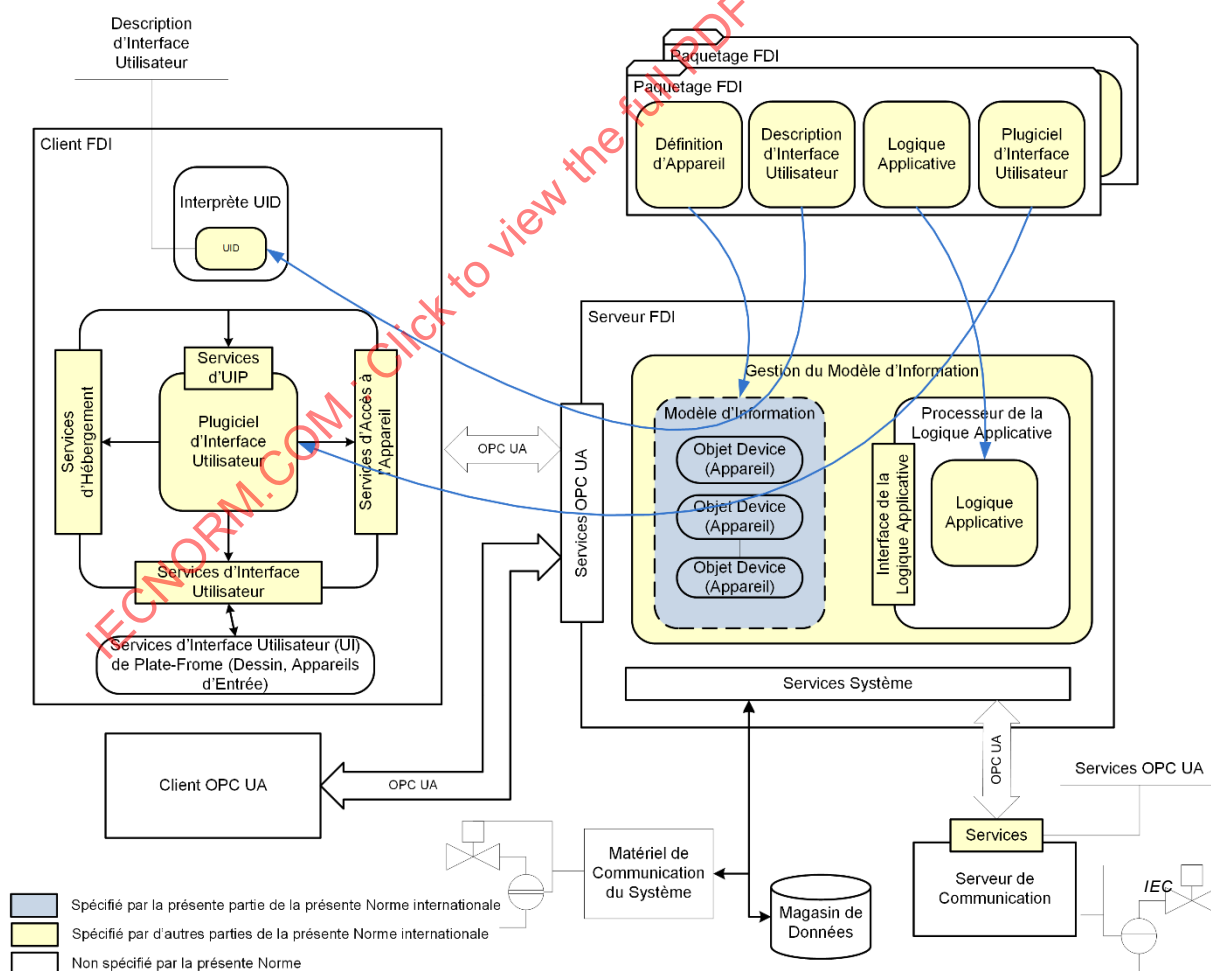


Figure 1 – Diagramme de l'architecture FDI

## 2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu'ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 61784-1, *Réseaux de communication industriels – Profils – Partie 1: Profils de bus de terrain*

IEC 61804-3, *Blocs Fonctionnels (FB) pour les procédés industriels et le Langage de Description Electronique de Produit (EDDL) – Partie 3: Sémantique et syntaxe EDDL*

IEC 61804-4, *Blocs fonctionnels (FB) pour les procédés industriels et le langage de description électronique de produit (EDDL) – Partie 4: Interprétation EDD*

IEC 62541-3, *Architecture unifiée OPC – Partie 3: Modèle d'Espace d'Adressage*

IEC 62541-4, *Architecture Unifiée OPC – Partie 4: Services*

IEC 62541-5, *Architecture unifiée OPC – Partie 5: Modèle d'informations*

IEC 62541-6, *Architecture unifiée OPC – Partie 6: Correspondances*

IEC 62541-8, *Architecture unifiée OPC – Partie 8: Accès aux données*

IEC 62541-100, *Architecture unifiée OPC – Partie 100: Interface d'appareils*

IEC 62769-1, *Intégration des appareils de terrain (FDI) – Partie 1: Vue d'ensemble*

IEC 62769-2, *Intégration des appareils de terrain (FDI) – Partie 2: Client FDI*

IEC 62769-4, *Intégration des appareils de terrain (FDI) – Partie 4: Paquetages FDI*

IEC 62769-7, *Intégration des appareils de terrain (FDI) – Partie 7: Appareils de Communication FDI*

## 3 Termes, définitions, termes abrégés et conventions

### 3.1 Termes et définitions

Pour les besoins du présent document, les termes et définitions de l'IEC 62769-1 s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse <http://www.electropedia.org/>
- ISO Online browsing platform: disponible à l'adresse <http://www.iso.org/obp>

### 3.2 Termes abrégés

Pour les besoins du présent document, les termes abrégés de l'IEC 62769-1, ainsi que les suivants s'appliquent.

|       |                                                                                                       |
|-------|-------------------------------------------------------------------------------------------------------|
| IHM   | Interface Homme Machine                                                                               |
| SCADA | Supervisory Control and Data Acquisition (Système de supervision, contrôle et acquisition de données) |
| TCP   | Transmission Control Protocol (Protocole de contrôle de transmission)                                 |

### 3.3 Conventions

Pour les besoins du présent document, les conventions données dans l'IEC 62769-1 s'appliquent.

### 3.4 Conventions pour la notation graphique

L'OPC UA définit une notation graphique pour un AddressSpace de l'OPC UA. Elle définit des symboles graphiques pour tous les NodeClasses et pour la façon dont les différents types de références entre les Nodes peuvent être visualisés. La Figure 2 représente les symboles pour les NodeClasses utilisés dans le présent document. Les types qui représentent des NodeClasses comportent toujours une ombre.

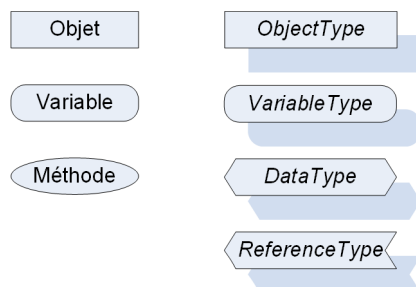


**Figure 2 – Notation graphique de l'OPC UA pour les NodeClasses**

La Figure 3 représente les symboles pour les ReferenceTypes utilisés dans le présent document. Le symbole de Référence pointe généralement du Nœud d'origine vers le Nœud cible. La seule exception est la Référence HasSubType. Les Références les plus importantes, telles que HasComponent, HasProperty, HasTypeDefinition et HasSubType comportent des symboles spécifiques qui permettent de ne pas indiquer le nom de la Référence. Pour les autres ReferenceTypes ou ReferenceTypes dérivés, le nom du ReferenceType est utilisé avec le symbole.

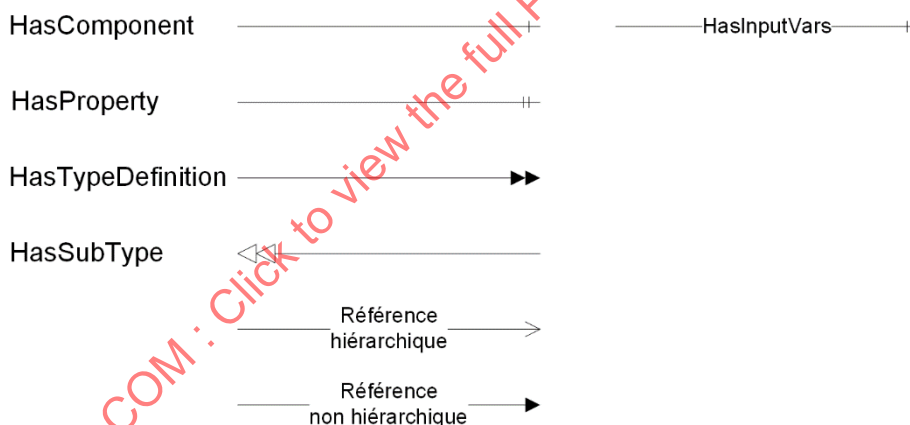


**Figure 3 – Notation graphique de l'OPC UA pour les Références**

La Figure 4 représente un exemple typique de l'utilisation de la notation graphique. Object\_A et Object\_B sont des instances d'ObjectType\_Y indiquées par les Références HasTypeDefinition. L'ObjectType\_Y est dérivé de l'ObjectType\_X indiqué par la Référence HasSubType. L'Object\_A comporte les composants Variable\_1, Variable\_2 et Method\_1.

Afin de décrire les composants d'un Object sur l'ObjectType, les mêmes NodeClasses et Références sont utilisées sur l'Object et sur l'ObjectType, comme indiqué dans l'exemple pour l'ObjectType\_Y. Les Nodes utilisés pour décrire un ObjectType sont des Nodes de déclaration d'instance.

Afin de fournir des informations plus détaillées pour un Node, un sous-ensemble ou l'ensemble des Attributs et leurs valeurs peuvent être ajoutés à un symbole graphique (voir, par exemple, Variable\_1, le composant de l'Object\_A à la Figure 4).

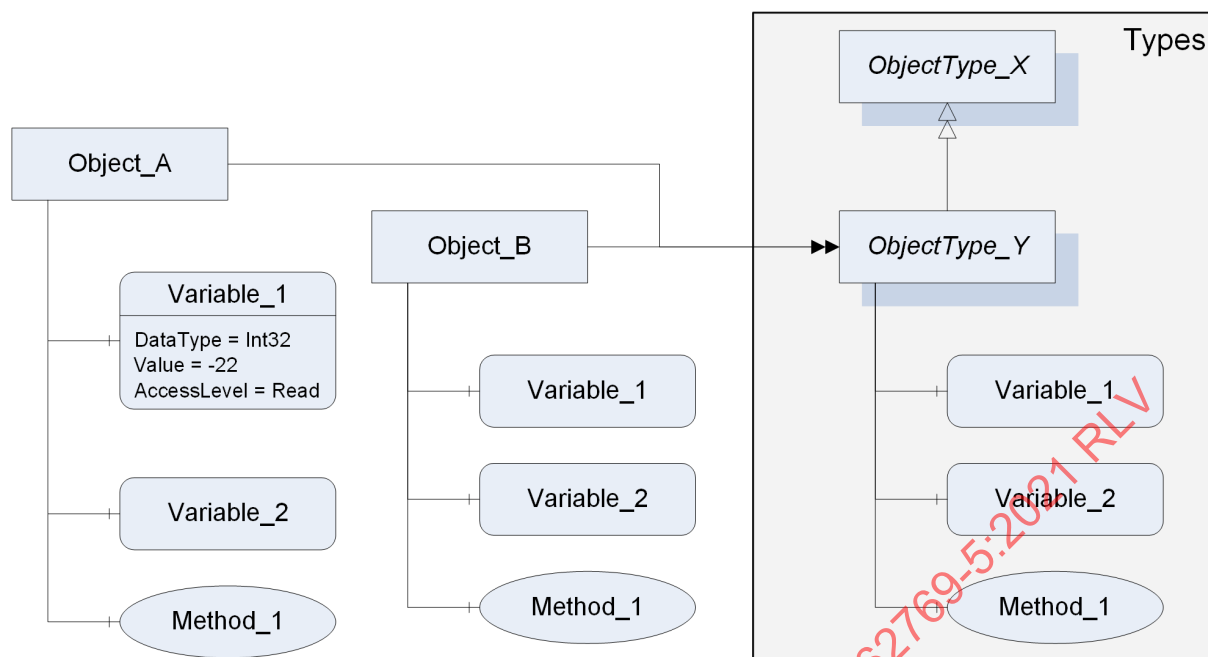


**Figure 4 – Exemple de notation graphique de l'OPC UA**

Afin d'améliorer la lisibilité, le présent document inclut fréquemment le nom de type à l'intérieur de la boîte d'instance, plutôt que d'afficher les deux boîtes et la référence entre celles-ci. Cette optimisation est représentée à la Figure 5.

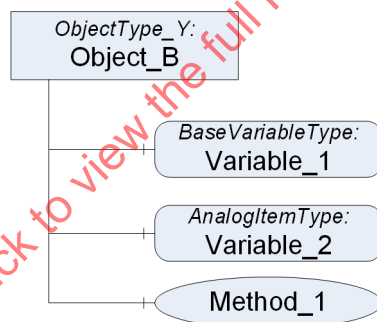


**Figure 5 – Référence de Type optimisée**

## 4 Vue d'ensemble de l'Architecture Unifiée OPC

### 4.1 Généralités

Le principal cas d'utilisation pour les normes OPC est l'échange de données en ligne entre des appareils et des systèmes IHM ou SCADA. Dans ce cas d'utilisation, les données de l'appareil sont fournies par un serveur OPC et sont consommées par un client OPC intégré dans le système IHM ou SCADA. L'OPC fournit une fonctionnalité qui permet de naviguer dans des espaces de nom hiérarchiques qui contiennent des éléments de données afin de lire, d'écrire et de surveiller ces éléments pour les modifications de données. Les identifiants numériques des NodeIds sont définis à l'Annexe A.

L'OPC UA comprend des fonctionnalités telles que l'Accès aux Données, les Alarmes et les Données Historiques, par l'intermédiaire de mécanismes de communication indépendants de la plate-forme et des capacités de modélisation génériques, extensibles et orientées objet, pour les informations qu'un système souhaite exposer.

La version actuelle de l'OPC UA définit un protocole TCP binaire optimisé pour la communication intranet haute performance ainsi qu'un mapping aux Services Web. Le modèle de service abstrait ne dépend pas d'un mapping à un protocole spécifique et permet d'ajouter de nouveaux protocoles ultérieurement. Des fonctionnalités telles que la sécurité, le contrôle de l'accès et la fiabilité sont directement incluses dans les mécanismes de transport. Sur la base de l'indépendance des protocoles vis-à-vis de la plate-forme, les serveurs et les clients OPC UA peuvent être directement intégrés dans les appareils et les contrôleurs.

Le modèle d'information OPC UA apporte aux serveurs une méthode normalisée pour exposer des Objets aux Clients. Dans les termes de l'OPC UA, les Objets sont composés d'autres Objets, de Variables et de Méthodes. L'OPC UA permet également d'exprimer des relations avec d'autres Objets.

L'ensemble des Objets et des informations connexes qu'un Serveur OPC UA met à la disposition des Clients est appelé son AddressSpace. Les éléments d'un Modèle d'Objet OPC UA sont représentés dans l'AddressSpace par un ensemble de Nœuds décrits par des Attributs et interconnectés par des Références. L'OPC UA définit diverses classes de Nœuds pour représenter les composants de l'AddressSpace, surtout les Objets (Objects), Variables, Méthodes (Methods), ObjectTypes (Types d'Objets), DataTypes (Types de Données) et ReferenceTypes (Types de Références). Chaque NodeClass possède un ensemble défini d'Attributs.

Les Objets (Objects) sont utilisés pour représenter des composants tels que des dossiers, des Appareils ou des Réseaux. Un Objet est associé à un ObjectType correspondant qui fournit les définitions de cet Objet.

Les Variables sont utilisées pour représenter des valeurs. Deux catégories de Variables sont définies, les Propriétés et les DataVariables.

Les Propriétés (Properties) sont des caractéristiques définies par un Serveur pour les Objets, les DataVariables et d'autres Nœuds. Il n'est pas admis de définir des Propriétés pour d'autres Propriétés. La Propriété Manufacturer (Fabricant) d'un Appareil est un exemple de Propriété d'un Objet.

Les DataVariables représentent le contenu d'un Objet. Les DataVariables peuvent avoir des DataVariables comme composants. Elles sont utilisées généralement par les Serveurs pour exposer des éléments individuels de matrices et de structures. Le présent document utilise les DataVariables principalement pour représenter les Paramètres des Appareils.

## 4.2 Vue d'ensemble des Appareils OPC UA

La norme Architecture unifiée OPC pour Interface d'Appareils (IEC 62541-100) est une extension de la série globale de normes pour l'Architecture Unifiée OPC et définit les modèles d'information associés aux Appareils. L'IEC 62541-100 décrit trois modèles qui s'appuient les uns sur les autres, comme suit:

- Le Modèle d'Appareil (de base) a pour but de fournir une vue unifiée des appareils, quels que soient les protocoles d'appareil sous-jacents.
- Le Modèle de Communication d'Appareil ajoute des éléments d'information de Réseau et de Connexion afin de pouvoir créer les topologies de communication.
- Enfin, le Modèle Device Integration Host (Hôte d'Intégration d'Appareil) ajoute des éléments et des règles supplémentaires exigés pour que les systèmes hôtes gèrent l'intégration pour un système complet. Il permet également de refléter la topologie du système d'automatisation avec les appareils ainsi qu'avec les réseaux de communication connectés.

Le modèle d'information des Appareils spécifie les différents ObjectTypes et d'autres éléments de l'AddressSpace utilisés pour représenter les Appareils et les composants liés, comme l'infrastructure de communication dans un AddressSpace de l'OPC UA. Les principaux cas d'utilisation sont la configuration et le diagnostic d'Appareil, mais ce modèle permet d'apporter une méthode générale et normalisée pour permettre aux applications d'accéder aux informations liées à un Appareil.

La Figure 6 représente un exemple de contrôleur de température représenté sous forme d'Objet d'Appareil. Il s'agit d'un Objet DeviceType qui a un sous-type de TopologyElementType et hérite de tous les composants de ce type. Le composant ParameterSet contient toutes les Variables qui décrivent l'Appareil. Le composant MethodSet contient toutes les Méthodes fournies par l'Appareil. Les Composants du type FunctionalGroupType sont utilisés pour regrouper les Paramètres et les Méthodes de l'Appareil dans des groupes logiques. Le FunctionalGroupType et le concept de regroupement sont définis dans l'IEC 62541-100, mais les groupes sont spécifiques au DeviceType, c'est-à-dire que les groupes ProcessData et Configuration sont définis par le TemperatureControllerType dans cet exemple.

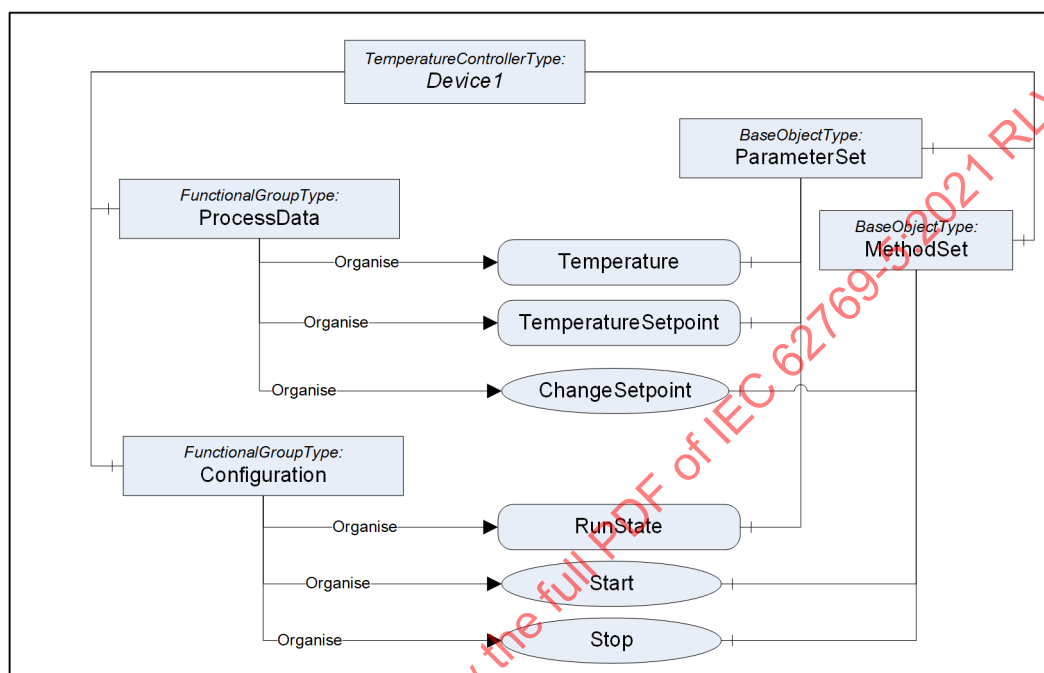


**Figure 6 – Exemple d'Appareils OPC UA: Groupes Fonctionnels**

Un autre concept défini dans l'IEC 62541-100 est représenté à la Figure 7. Le ConfigurableObjectType est utilisé pour fournir une méthode de regroupement des sous-composants d'un Appareil et pour indiquer quels types de sous-composants peuvent être instanciés. Les types autorisés sont référencés depuis le dossier SupportedTypes. Ces informations peuvent être utilisées par des clients de configuration pour permettre à un utilisateur de sélectionner le type à instancier en tant que sous-composant de l'Appareil.

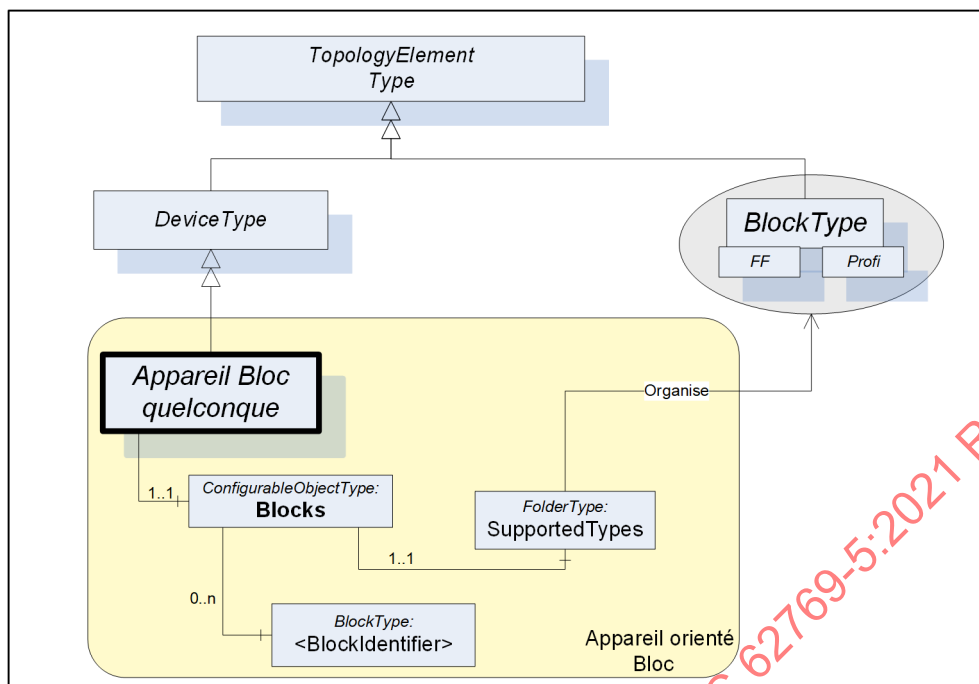


Figure 7 – Exemple d'Appareils OPC UA: Composants configurables

Le dossier SupportedTypes peut contenir différents sous-ensembles d'ObjectTypes pour différentes instances de l'Appareil orienté Bloc, en fonction de leur configuration actuelle, puisque la liste contient uniquement des types qui peuvent être instanciés pour la configuration actuelle.

## 5 Concepts

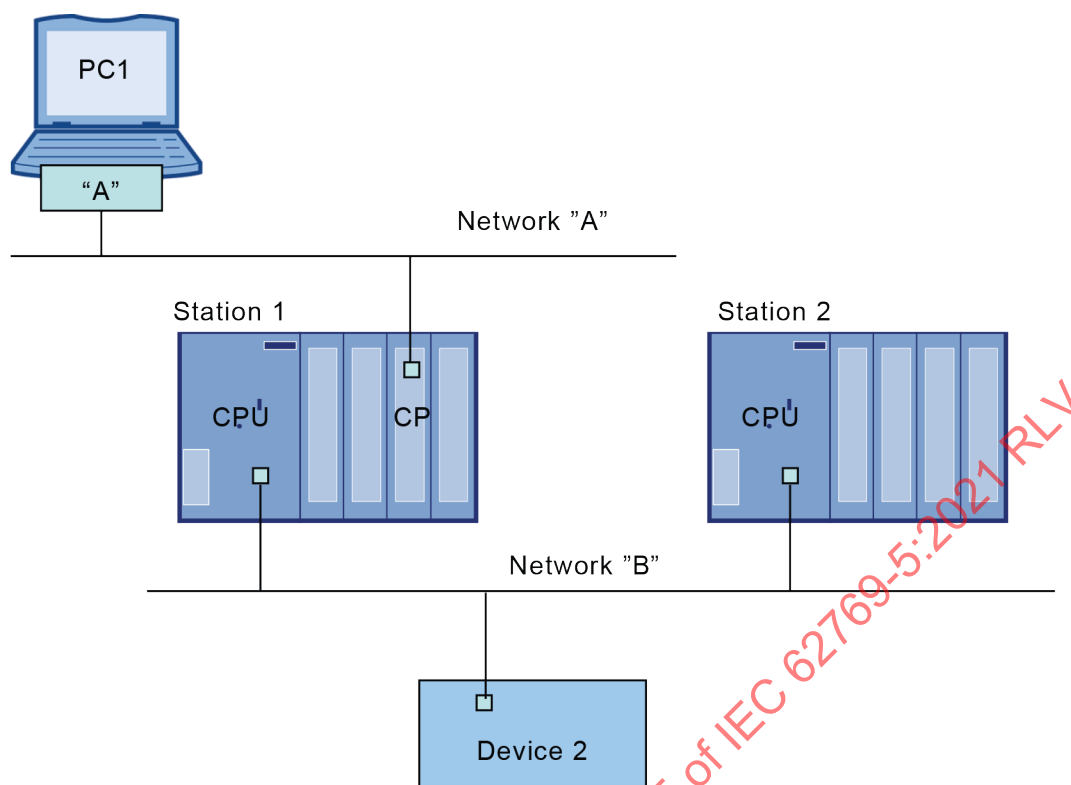
### 5.1 Généralités

Le Serveur FDI fournit aux Clients FDI l'accès aux informations sur les instances d'Appareil et les types d'Appareils, indépendamment du lieu de stockage des informations, par exemple, dans l'Appareil lui-même ou dans un magasin de données. Ces informations sont fournies par les Services OPC UA et sont appelées Modèle d'Information FDI.

Le Modèle d'Information FDI spécifie les entités qui peuvent être accessibles dans le Serveur FDI, y compris leurs propriétés, leurs relations et les différentes opérations dont elles peuvent faire l'objet. Le fait de savoir quels types d'Appareil ou autres éléments topologiques sont disponibles dans un Serveur FDI donné dépend en grande partie des informations contenues dans les Paquetages FDI.

### 5.2 Topologie d'appareil

L'un des principaux objectifs du Modèle d'Information est de refléter la topologie du système d'automatisation. Le Modèle d'Information représente donc les Appareils du système d'automatisation ainsi que les réseaux de communication de connexion. Le point d'entrée Topologie d'Appareil est le point de départ au sein du Modèle d'Information pour la topologie du système d'automatisation. Le point d'entrée Appareils de Communication contient les appareils de communication utilisés par le Serveur FDI pour accéder aux éléments de la topologie. La Figure 8 et la Figure 9 représentent un exemple de configuration et de la topologie configurée telle qu'elle apparaît dans l'AddressSpace du Serveur FDI (omission des informations détaillées).



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**Figure 8 – Exemple de système d'automatisation**

Le PC dans la Figure 8 représente le boîtier du Serveur FDI. Le Serveur FDI communique avec les appareils connectés au Réseau "A" par une Communication Native, et il communique avec les appareils connectés au Réseau "B" par une Communication Imbriquée.

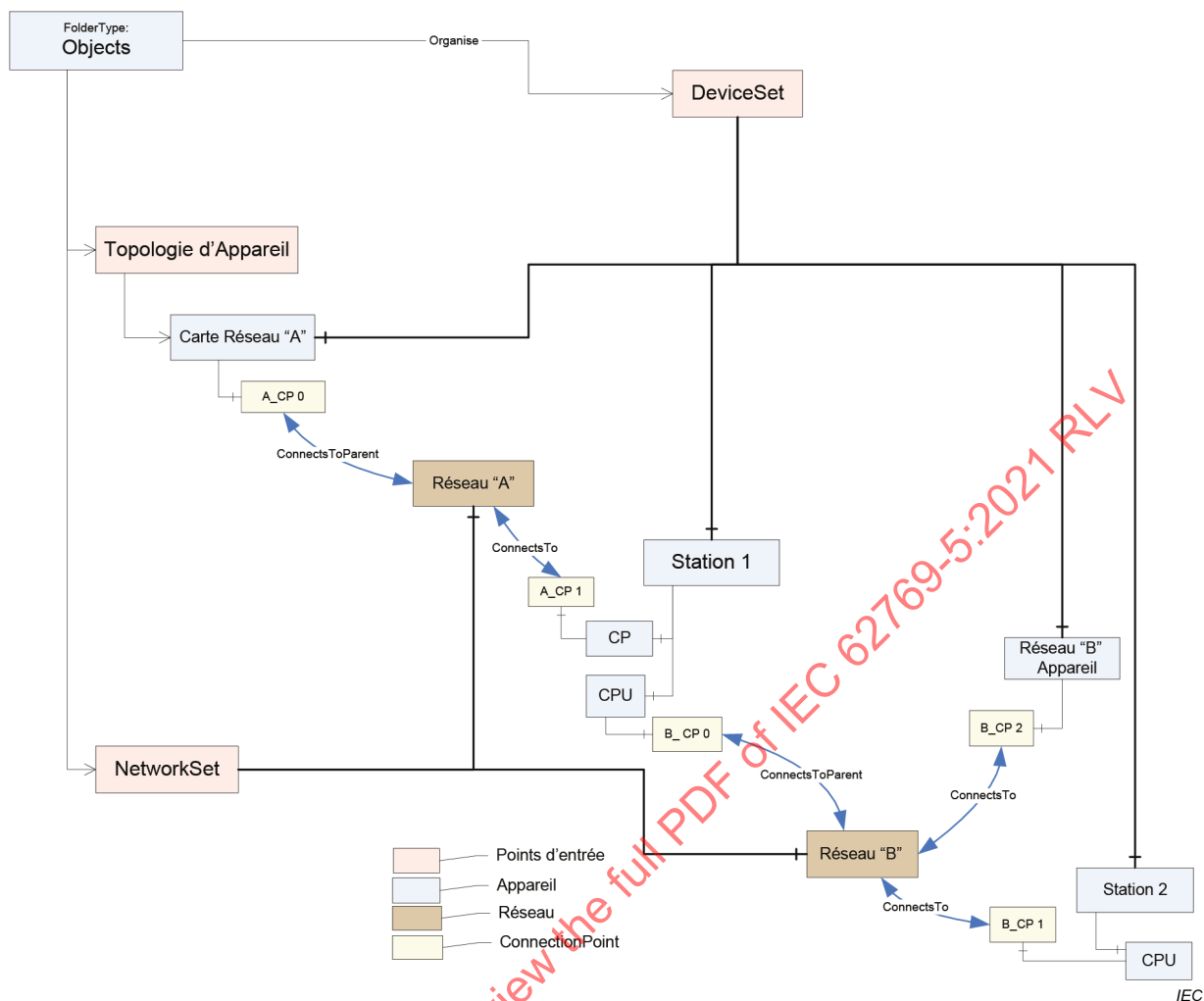


**Figure 9 – Exemple de Topologie d'un Appareil**

Des rectangles de couleur sont utilisés afin de reconnaître facilement les différents types d'informations.

Les rectangles en marron représentent les réseaux. Les rectangles en bleu clair représentent les Appareils et le jaune clair est utilisé pour les Points de Connexion.

Les rectangles en rose clair représentent les points d'entrée qui assurent un comportement commun à travers différentes mises en œuvre:

- DeviceTopology: Nœud de départ pour la configuration de la topologie.
- DeviceSet: Tous les Appareils instanciés sont des composants de cet Objet, c'est-à-dire qu'ils existent dans l'AddressSpace indépendamment de la Topologie d'Appareil.
- NetworkSet: Tous les Réseaux sont des composants de cet Objet.

### 5.3 En ligne/Hors ligne

La gestion de la Topologie d'Appareil est une tâche de configuration, c'est-à-dire que les éléments dans la topologie (Appareils, Réseaux et Points de connexion) sont généralement configurés "hors ligne" et seront validés, ultérieurement, sur la base de leur représentation physique dans un réseau réel.

Afin de prendre en charge l'accès explicite aux informations en ligne ou hors ligne, chaque élément est représenté par deux instances schématiquement identiques, c'est-à-dire qu'il existe un ParameterSet, des FunctionalGroups, et ainsi de suite. Une Référence relie les représentations en ligne et hors ligne et permet de naviguer entre elles.

## 5.4 Catalogue (Définitions de Type)

Les (sous-ensembles de) TopologyElements pris en charge sont organisés en tant que définitions de Type dans l'AddressSpace OPC UA, et forment ainsi une sorte de catalogue. Ces définitions sont généralement générées à partir d'informations descriptives qui proviennent des Paquetages FDI. Les définitions de Type contiennent les Paramètres et les valeurs par défaut des Paramètres, Méthodes, Actions et Groupes Fonctionnels, y compris les éléments de l'interface utilisateur. Le Serveur FDI peut inclure des dossiers dans le modèle de type, afin d'organiser les types selon le fabricant ou d'autres critères.

Les définitions de type peuvent alors être utilisées pour créer des instances d'Appareil dans l'AddressSpace OPC UA. Les instances peuvent être créées soit hors ligne, soit selon des données déterminées par un Balayage. La Figure 10 représente un exemple de certaines définitions de Type (omission des informations détaillées) telles qu'elles peuvent exister dans l'AddressSpace.

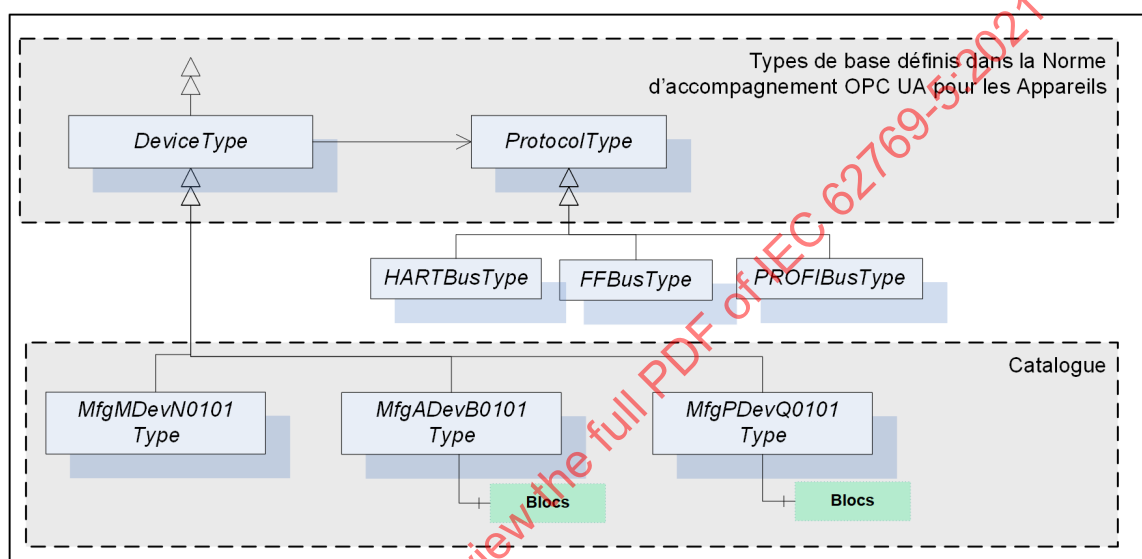


Figure 10 – Exemple de Types d'Appareils représentant un catalogue

## 5.5 Communication

Afin d'intégrer des Appareils, il est nécessaire que le Serveur FDI soit capable de communiquer avec eux. Cette communication est possible au moyen d'une Communication Native ou d'une Communication Imbriquée.

L'exemple donné dans la Figure 9 ci-dessus spécifie que le Serveur FDI a un accès direct au Réseau PROFINET en utilisant sa carte réseau PROFINET. Afin d'accéder à la "Station 2", le Serveur FDI doit passer par la Station 1 qui fournit les services de communication pour le réseau PROFIBUS DP (voir l'IEC 61784-1, CPF 3). Cette procédure peut être effectuée avec une Communication Imbriquée, qui est spécifiée dans l'IEC 62769-4. Les Appareils de Communication et les Serveurs de Communication sont spécifiés dans l'IEC 62769-7.

## 6 Organisation de l'AddressSpace

Afin de prendre en charge l'interopérabilité des Clients FDI et des Serveurs FDI, un ensemble d'Objets et des relations sont définis dans les Articles 7, 8, 9 et 10. Les Serveurs FDI peuvent mettre en œuvre un sous-ensemble de ces Nœuds normalisés, en fonction de leurs capacités.

Selon les règles de l'OPC UA, un Serveur OPC UA sépare l'AddressSpace en deux parties:

- La partie "Types" contient les informations relatives à tous les composants qui ont été générés en fonction des informations descriptives qui proviennent des Paquetages FDI (voir 5.4).
- La partie "Objets" contient la Topologie d'Appareil avec tous les composants instanciés. Toutes les instances de l'AddressSpace sont reliées à un type du dossier Types.
  - Les points d'entrée DeviceSet, NetworkSet et DeviceTopology sont formellement définis dans l'IEC 62541-100.
    - DeviceTopology est utilisé pour agréger les Réseaux du niveau supérieur qui fournissent un accès à toutes les instances qui constituent la Topologie d'Appareil ((sous-)réseaux, appareils et éléments de communication). Certains éléments sont donnés en exemple à l'Article 7 et sont signalés par la couleur verte.
    - Tous les Appareils instanciés sont des composants de l'Objet DeviceSet, c'est-à-dire qu'ils existent dans l'AddressSpace indépendamment de la Topologie d'Appareil. Tous les Réseaux sont des composants de l'Objet NetworkSet.

Les Serveurs FDI peuvent soit créer des Objets d'Appareil automatiquement, soit montrer uniquement les types disponibles (dossier SupportedTypes) et laisser l'utilisateur créer ses propres instances. Lors de l'utilisation d'une communication native, le système fournit typiquement la Topologie d'Appareil sans devoir la faire configurer par le Client FDI.

## 7 Modèle d'Appareil pour FDI

### 7.1 Généralités

Comme mentionné à l'Article 6, l'IEC 62541-100 spécifie les types fondamentaux nécessaires pour le FDI comme le TopologyElementType, le DeviceType et le ProtocolType (le protocole de bus de terrain). L'Article 7 reprend brièvement les éléments de conception importants spécifiés dans l'IEC 62541-100 et spécifie des types supplémentaires qui ne sont pas présents dans l'IEC 62541-100.

### 7.2 En ligne/Hors ligne

Tous les éléments qui apparaissent dans la Topologie d'Appareil (Appareils, Réseaux et Points de Connexion), y compris leur relation, correspondent aux informations stockées dans la base de données de configuration du Serveur FDI. La gestion de ces éléments exige dans la plupart des cas l'accès au composant/appareil physique (appelé données en ligne dans la présente norme), ainsi que le stockage et l'administration des données connexes dans une base de données de configuration (appelées données hors ligne).

Afin de prendre en charge l'accès explicite aux informations en ligne ou hors ligne, chaque élément est représenté par deux instances schématiquement identiques, c'est-à-dire qu'il existe un ParameterSet, des FunctionalGroups, et ainsi de suite. Une Référence relie les représentations en ligne et hors ligne, et permet de naviguer entre elles (représentation à la Figure 11).

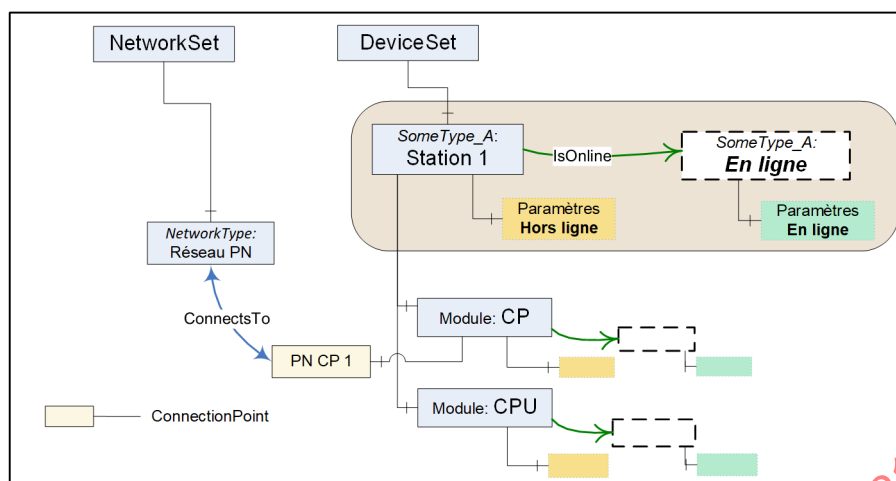


**Figure 11 – Composant en ligne pour l'accès aux données d'appareil**

La prise en charge en ligne/hors-ligne est obligatoire pour les Serveurs FDI. Des informations détaillées sur le modèle et les définitions formelles sont spécifiées dans l'IEC 62541-100.

### 7.3 Santé de l'Appareil

#### 7.3.1 Mapping DeviceHealth

La Propriété DeviceHealth indique le statut d'un appareil tel que défini par le document NAMUR NE107. Les Clients FDI peuvent lire et surveiller cette Propriété afin de déterminer l'état de l'appareil.

Les Serveurs déterminent le statut de santé à l'aide de la METHOD GetHealthStatus de l'EDD, qui est définie dans l'IEC 62769-4. La fréquence à laquelle les Serveurs examinent effectivement le statut de santé peut varier de quelques secondes à quelques minutes.

Le mapping des valeurs de retour de GetHealthStatus à l'OPC UA est spécifié dans le Tableau 1.

**Tableau 1 – Mapping DeviceHealth**

| GetHealthStatus                                                                                                                                   | OPC UA                                                                                                                                                                                                                                                                                                                                                                                                    |
|---------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0 – Indeterminate (Indéterminé)                                                                                                                   | "Indéterminé" (Indeterminate) n'est pas défini dans le type de données DeviceHealth défini dans l'IEC 62541-100. Les Serveurs qui ne peuvent pas déterminer le statut de santé de l'appareil doivent renvoyer une opération OPC UA Read (Lecture) pour cette Propriété avec un code de statut OPC UA, par exemple:<br><br>Bad_NotConnected<br>Bad_OutOfService<br>Bad_NoCommunication<br>Bad_NotSupported |
| Les valeurs suivantes peuvent être mappées aux valeurs correspondantes définies pour le type de données DeviceHealth défini dans l'IEC 62541-100. |                                                                                                                                                                                                                                                                                                                                                                                                           |
| GetHealthStatus                                                                                                                                   | Valeurs du type de données DeviceHealth                                                                                                                                                                                                                                                                                                                                                                   |
| 1 – Failure (Échec)                                                                                                                               | FAILURE_1                                                                                                                                                                                                                                                                                                                                                                                                 |
| 2 – Function Check (Vérification fonctionnelle)                                                                                                   | CHECK_FUNCTION_2                                                                                                                                                                                                                                                                                                                                                                                          |
| 3 – Out of Specifications (Hors des spécifications)                                                                                               | OFF_SPEC_3                                                                                                                                                                                                                                                                                                                                                                                                |
| 4 – Maintenance Required (Maintenance exigée)                                                                                                     | MAINTENANCE_REQUIRED_4                                                                                                                                                                                                                                                                                                                                                                                    |
| 5 – Good (Correct)                                                                                                                                | GOOD_0                                                                                                                                                                                                                                                                                                                                                                                                    |

À la différence de l'OPC UA pour les Appareils (IEC 62541-100), la prise en charge de la Propriété DeviceHealth est obligatoire pour les Objets Appareil dans la FDI (représentation dans le Tableau 2). Le modèle DeviceType complet et sa définition formelle sont spécifiés dans l'IEC 62541-100.

**Tableau 2 – Définition de DeviceType (extrait applicable au présent article)**

| Attribut                                                            | Valeur     |              |              |                      |               |
|---------------------------------------------------------------------|------------|--------------|--------------|----------------------|---------------|
| BrowseName                                                          | DeviceType |              |              |                      |               |
| IsAbstract                                                          | True       |              |              |                      |               |
| Références                                                          | NodeClass  | BrowseName   | DataType     | TypeDefinition       | ModellingRule |
| Le sous-type du TopologyElementType est défini dans l'IEC 62541-100 |            |              |              |                      |               |
| .....                                                               |            |              |              |                      |               |
| HasComponent                                                        | Variable   | DeviceHealth | DeviceHealth | BaseDataVariableType | Mandatory     |
| .....                                                               |            |              |              |                      |               |

### 7.3.2 Diagnostics de DeviceHealth

Dans certains cas, un Appareil peut avoir des informations supplémentaires associées au statut de santé, par exemple, la cause éventuelle d'un statut DeviceHealth anormal et les mesures suggérées pour un retour à la normale.

Ces informations supplémentaires sont disponibles avec la Variable DeviceHealthDiagnostics. Elles sont définies formellement dans le Tableau 3.

**Tableau 3 – Définition de DeviceType avec DeviceHealth et DeviceHealthDiagnostics**

| Attribut                                                            | Valeur     |                           |               |                      |               |
|---------------------------------------------------------------------|------------|---------------------------|---------------|----------------------|---------------|
| BrowseName                                                          | DeviceType |                           |               |                      |               |
| IsAbstract                                                          | True       |                           |               |                      |               |
| Références                                                          | NodeClass  | BrowseName                | DataType      | TypeDefinition       | ModellingRule |
| Le sous-type du TopologyElementType est défini dans l'IEC 62541-100 |            |                           |               |                      |               |
| .....                                                               |            |                           |               |                      |               |
| HasComponent                                                        | Variable   | DeviceHealth              | DeviceHealth  | BaseDataVariableType | Mandatory     |
| HasComponent                                                        | Variable   | DeviceHealthDiagnostics[] | LocalizedText | BaseDataVariableType | Mandatory     |
| .....                                                               |            |                           |               |                      |               |

DeviceHealthDiagnostics est une matrice de LocalizedText. Chaque élément de matrice contient des informations de diagnostic associées. Le langage doit correspondre aux paramètres régionaux spécifiés dans la Session OPC UA. Voir 15.2.1 concernant la manière de sélectionner le langage correct pour la Session OPC UA actuelle.

Lorsque DeviceHealth est demandé, le Serveur doit toujours extraire les DeviceHealthDiagnostics correspondants. Le Serveur doit assurer que les valeurs sont synchronisées par l'exécution de GetHealthStatus en premier lieu, et par la lecture de DeviceHealthDiagnostics ensuite. Le Serveur met en cache DeviceHealthDiagnostics dans le cadre de la Session OPC UA jusqu'à une nouvelle demande de DeviceHealth.

Si DeviceHealthDiagnostics est lu avec une demande séparée de service, le Serveur doit renvoyer les informations de diagnostic associées avec le statut DeviceHealth lu dernièrement. Si le statut DeviceHealth n'a pas été lu dans la Session OPC UA actuelle, le Serveur doit retourner Bad\_NotReadable.

Si aucune information de diagnostic n'est disponible, la Valeur retournée est Null (Nulle).

Voir l'IEC 62769-4 concernant la méthode de mapping de DeviceHealthDiagnostics aux informations EDD correspondantes.

Exemple de valeur DeviceHealthInformation avec deux éléments de matrice:

- [0]:  
 "Panne d'alimentation critique\n  
 Cause possible: Une panne d'alimentation critique s'est produite\n  
 Mesure suggérée: Prière de vérifier l'appareil/l'environnement/le processus.\n"
- [1]:  
 "Dysfonctionnement de l'Appareil\n  
 Cause possible: L'appareil a détecté une grave erreur ou panne matérielle.\n  
 Mesure suggérée: Vérifier le diagnostic détaillé de l'appareil si possible et/ou remplacer le matériel de l'appareil si nécessaire.\n"

## 7.4 Éléments de l'interface utilisateur

### 7.4.1 Généralités

L'IEC 62541-100 définit, de manière abstraite, la façon dont les Serveurs peuvent exposer des éléments d'interface utilisateur aux Clients, afin d'afficher une interface utilisateur spécifique à un FunctionalGroup d'un TopologyElement.

Le Paragraphe 7.4 spécifie deux types concrets d'éléments utilisateur: les éléments d'interface utilisateur descriptive (les UID) et les éléments d'interface utilisateur programmée (exécutable) (les UIP). Les UIP ne sont jamais référencés directement à partir d'un FunctionalGroup. Ils sont toujours référencés indirectement à partir d'un UID au moyen de leur Uipld.

La Figure 12 représente la hiérarchie de types des éléments d'interface utilisateur définis dans l'IEC 62541-100 et dans le présent document.

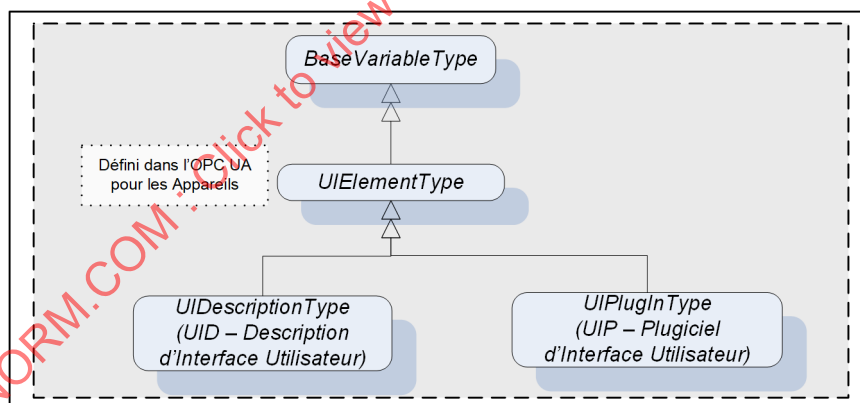


Figure 12 – Hiérarchie des Types d'interfaces utilisateur

### 7.4.2 Type UI Description

Les Serveurs FDI peuvent fournir un élément d'interface utilisateur descriptif (un UID) pour chaque FunctionalGroup. Un tel élément est fourni par le Client FDI. L'UIDescriptionType est formellement spécifié dans le Tableau 4.

**Tableau 4 – Définition de l'UIDescriptionType**

| Attribut                                                              | Valeur            |            |          |                |               |
|-----------------------------------------------------------------------|-------------------|------------|----------|----------------|---------------|
| BrowseName                                                            | UIDescriptionType |            |          |                |               |
| DataType                                                              | String            |            |          |                |               |
| IsAbstract                                                            | False             |            |          |                |               |
| Références                                                            | NodeClass         | BrowseName | DataType | TypeDefinition | ModellingRule |
| Hérite des Propriétés de l'UIElementType défini dans l'IEC 62541-100. |                   |            |          |                |               |

L'Attribut de Valeur fournit l'UID sous forme de Chaîne qui contient un élément XML. Voir l'IEC 62769-2 pour la syntaxe des éléments UID. Le Schéma XML pour la Valeur UID de tous les appareils exposés respecte la même Version de Technologie FDI que celle qui est indiquée par la Propriété FDIServerVersion (voir Article 14).

#### 7.4.3 Type UI Plug-in

Un Plugiciel d'Interface Utilisateur (UIP) est un module logiciel qui est hébergé et exécuté par un Client FDI. Contrairement à une Description d'Interface Utilisateur (UID), il s'agit d'un élément d'UI exécutable.

Les informations détaillées sur l'hébergement et l'exécution des Plugiciels sont spécifiées dans l'IEC 62769-2. L'UIPlugInType est formellement spécifié dans le Tableau 5.

**Tableau 5 – Définition de l'UIPlugInType**

| Attribut                                                              | Valeur                                                  |                      |          |                |               |
|-----------------------------------------------------------------------|---------------------------------------------------------|----------------------|----------|----------------|---------------|
| BrowseName                                                            | UIPlugInType                                            |                      |          |                |               |
| DataType                                                              | Byte                                                    |                      |          |                |               |
| ValueRank                                                             | 1 – matrice unidimensionnelle                           |                      |          |                |               |
| ArrayDimensions                                                       | UInt32[1] – la longueur (nombre d'octets) de la matrice |                      |          |                |               |
| IsAbstract                                                            | False                                                   |                      |          |                |               |
| Références                                                            | NodeClass                                               | BrowseName           | DataType | TypeDefinition | ModellingRule |
| Hérite des Propriétés de l'UIElementType défini dans l'IEC 62541-100. |                                                         |                      |          |                |               |
| HasProperty                                                           | Variable                                                | UIPVariantVersion    | String   | PropertyType   | Mandatory     |
| HasProperty                                                           | Variable                                                | FDITechnologyVersion | String   | PropertyType   | Mandatory     |
| HasProperty                                                           | Variable                                                | RuntimeId            | String   | PropertyType   | Mandatory     |
| HasProperty                                                           | Variable                                                | CpuInformation       | String   | PropertyType   | Mandatory     |
| HasProperty                                                           | Variable                                                | PlatformId           | String   | PropertyType   | Mandatory     |
| HasProperty                                                           | Variable                                                | Style                | String   | PropertyType   | Mandatory     |
| HasProperty                                                           | Variable                                                | StartElementName     | String   | PropertyType   | Mandatory     |
| HasComponent                                                          | Object                                                  | Documentation        |          | FolderType     | Optional      |

Les UIP peuvent exister dans de nombreuses variantes pour différentes plates-formes ou pour prendre en charge différentes versions. L'UiId (un identificateur unique défini dans le Paquetage FDI) identifie l'UIP, pas une variante spécifique.