

Interoperability in action: TwinCAT OPC UA, Pub/Sub and Companion Specifications driving machine-level integration

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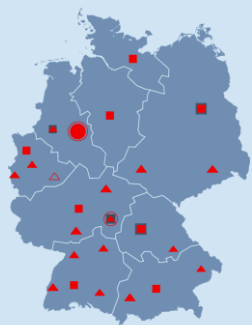


Michael Knossalla

Product Manager TwinCAT
Connectivity and IoT

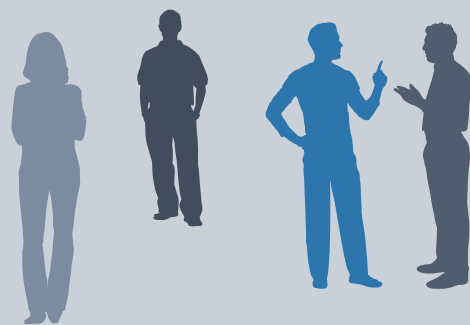


Verl, Germany



Headquarters

5,300



Employees worldwide

2,000



Engineers

23



Sales/business locations in Germany

41



Subsidiaries/
representative offices

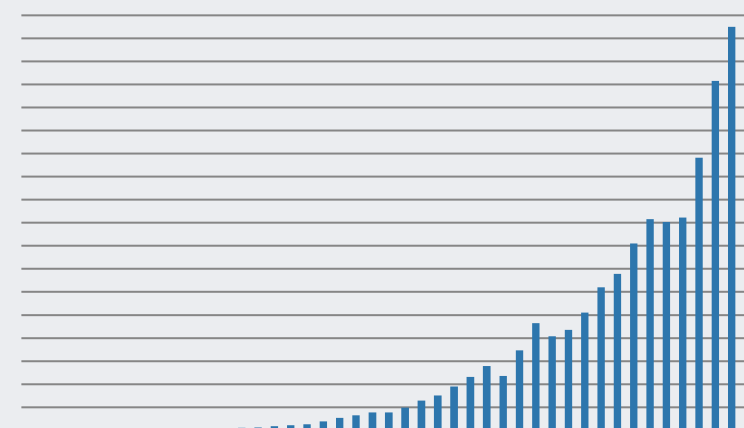
> 75



Representatives
worldwide

**€1.17
billion**

Sales
worldwide 2024



Components for industrial automation

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The IPC Company



The I/O Company



The Motion Company



The Automation Company

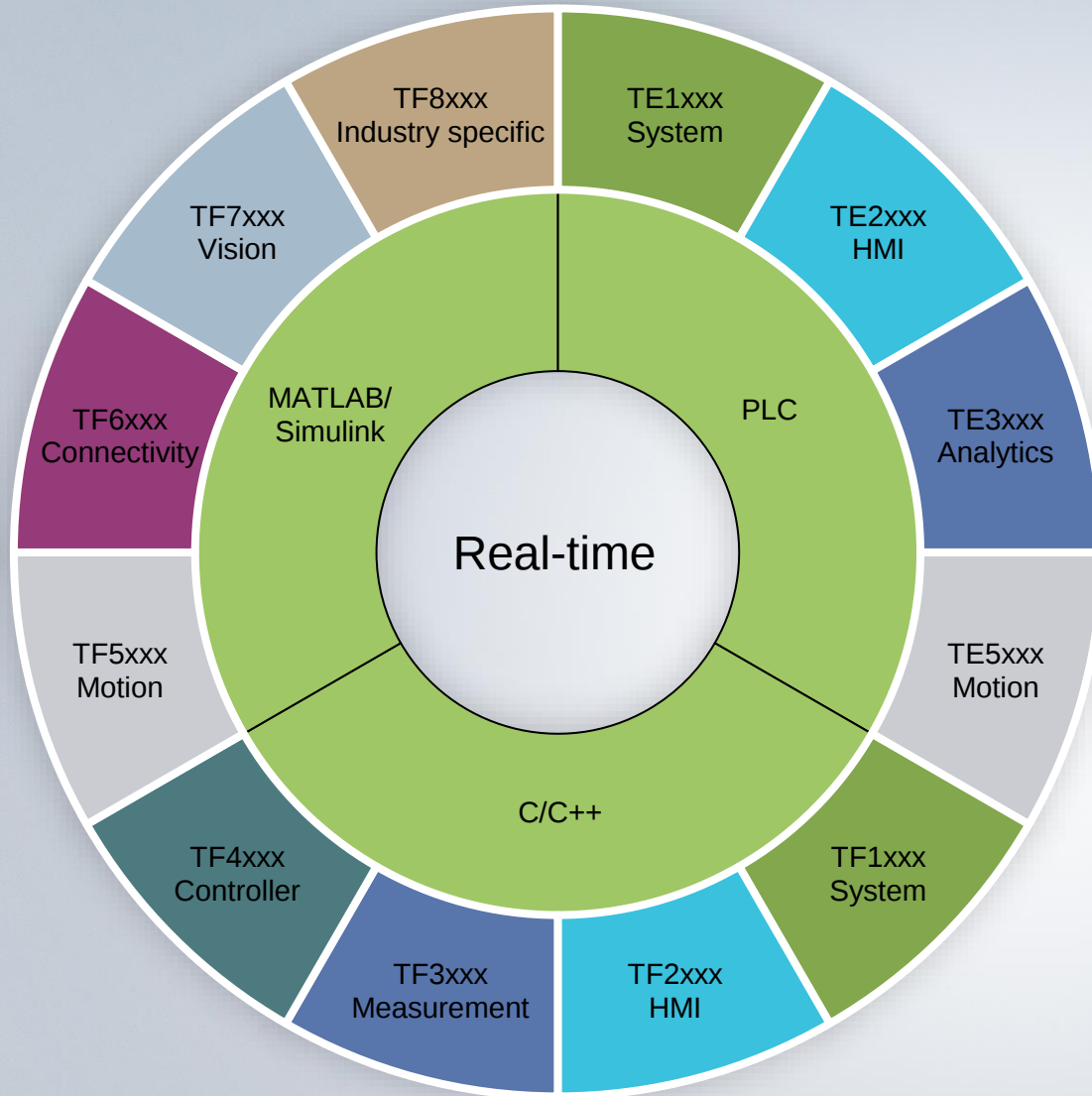


The System Company



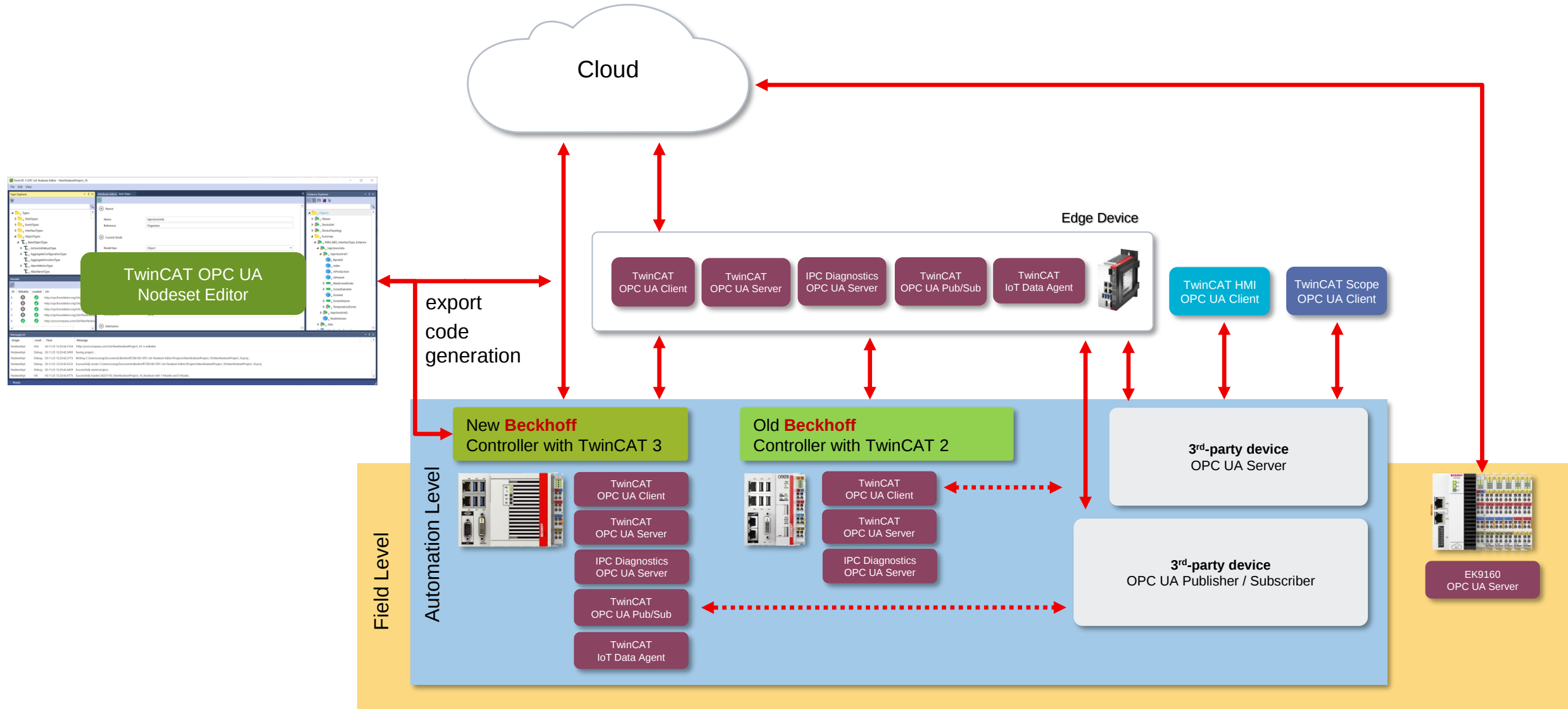
The Vision Company





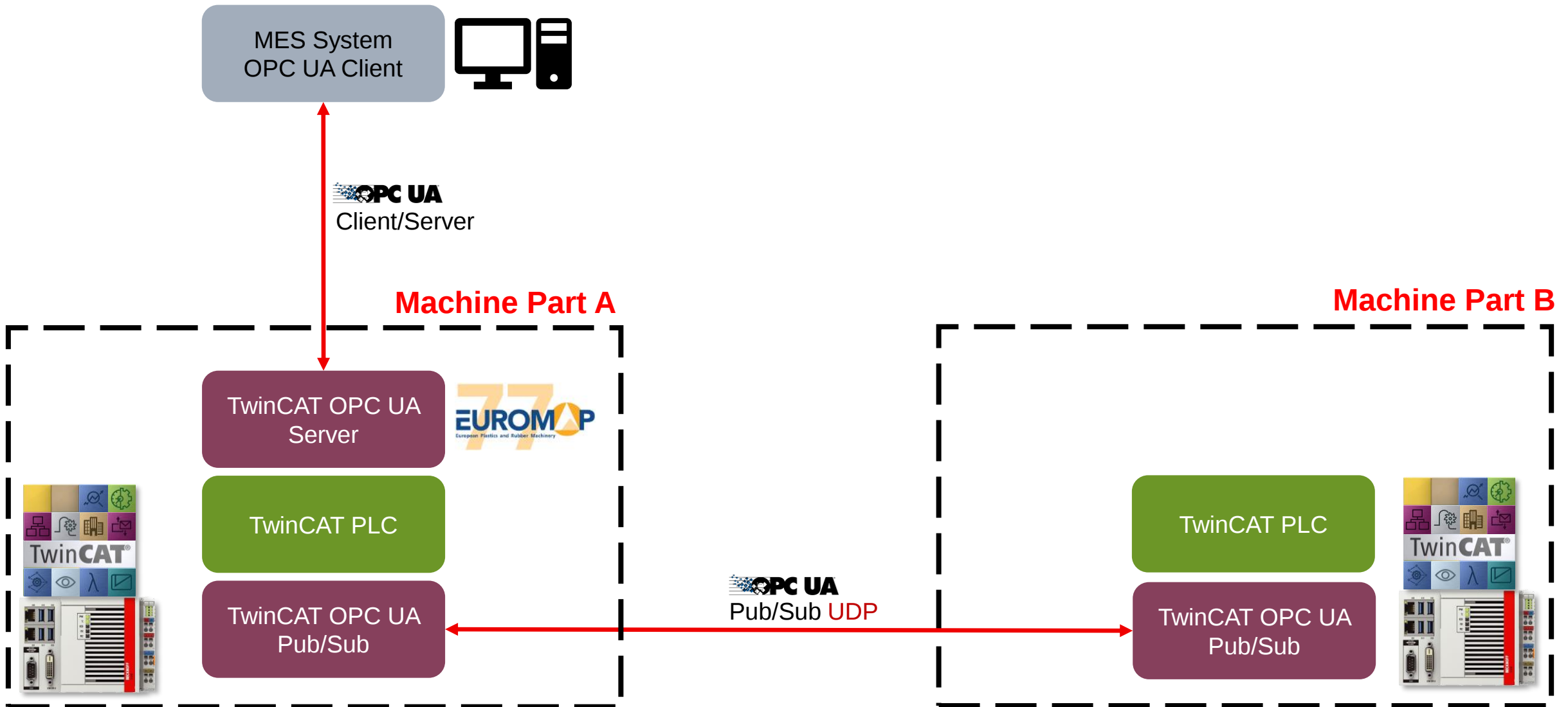
TwinCAT OPC UA Overview

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Example: Injection moulding machine with Euromap 77

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How do we get the TwinCAT OPC UA Server in our sample machine ready for Euromap 77?

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Import of Companion Specifications and vendor-specific models

Instance creation of objects and variables

Mapping to PLC variables and long-running methods

Export of Nodeset configuration to OPC UA Server

Future scope: Automatic code generation

The screenshot displays the TwinCAT 3 OPC UA Nodeset Editor (2.0.22) interface. The main window shows the configuration for an object named 'InjectionUnit_01'. The 'Name' field is set to 'InjectionUnits', and the 'NodeClass' is set to 'Object'. The 'URI' is 'http://beckhoff.com/UA/TwinCAT_Nodeset_Project/'. The 'Type Definition' is 'InjectionUnitType (ns=2; uri=http://beckhoff.com/UA/TwinCAT_Nodeset_Project/)'. The 'Additional Attributes' section shows 'NodeID' set to '1026', 'DisplayName' set to 'InjectionUnit_01', 'BrowseName' set to 'InjectionUnit_01', and 'Description' set to 'Description and status of an injection unit'. The 'EventNotifier' is set to 'None'. The 'Extensions' and 'Children' sections are empty.

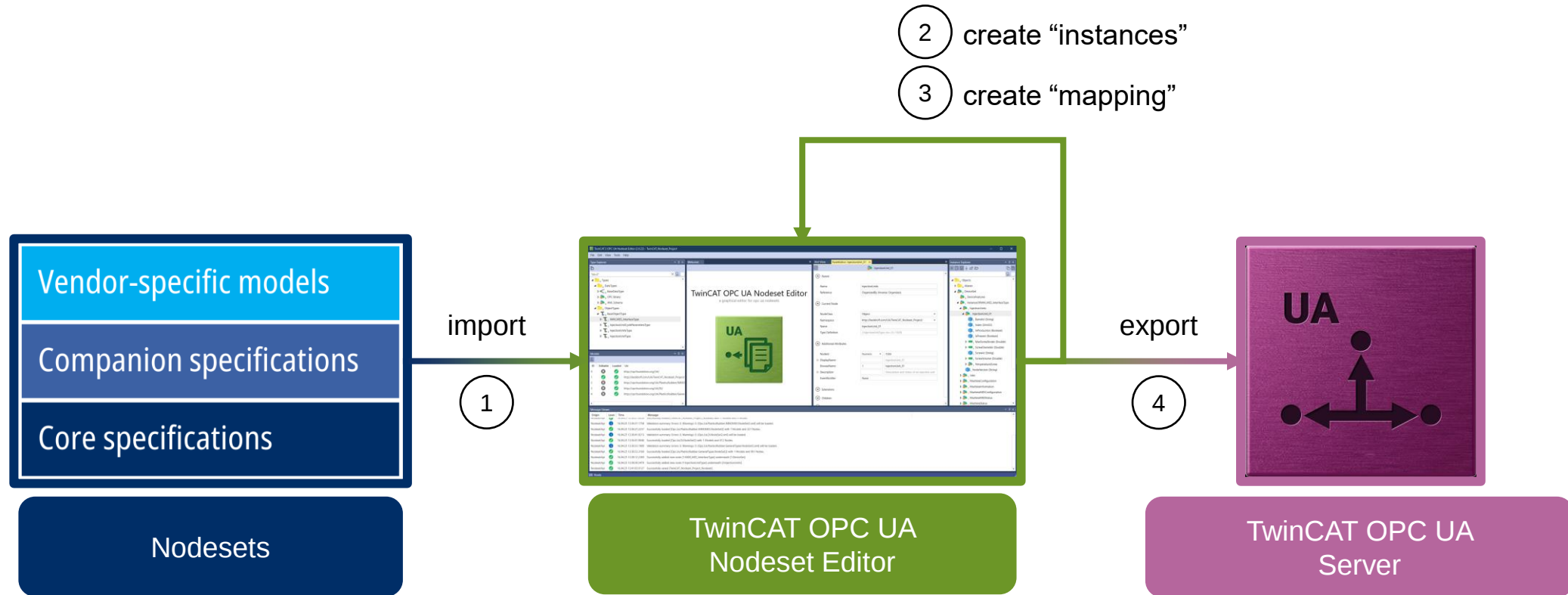
On the left, the 'Models' table lists the loaded models:

ID	Editable	Loaded	Uri
0	X	✓	http://opcfoundation.org/UA/
1	✓	✓	http://beckhoff.com/UA/TwinCAT_Nodeset_Project/
2	X	✓	http://opcfoundation.org/UA/PlasticsRubber/IMM2
3	X	✓	http://opcfoundation.org/UA/DI/
4	X	✓	http://opcfoundation.org/UA/PlasticsRubber/Gener

On the right, the 'Instance Explorer' shows the hierarchy of objects and variables. The 'InjectionUnit_01' object is expanded, showing its properties: 'BarrelId (String)', 'Index (UInt32)', 'InProduction (Boolean)', 'IsPresent (Boolean)', 'MaxScrewStroke (Double)', 'ScrewDiameter (Double)', 'ScrewId (String)', 'ScrewVolume (Double)', 'TemperatureZones', and 'NodeVersion (String)'. Below these are 'Jobs', 'MachineConfiguration', 'MachineInformation', 'MachineMESConfiguration', 'MachineMESStatus', and 'MachineStatus'.

At the bottom, the 'Message Viewer' shows a log of messages:

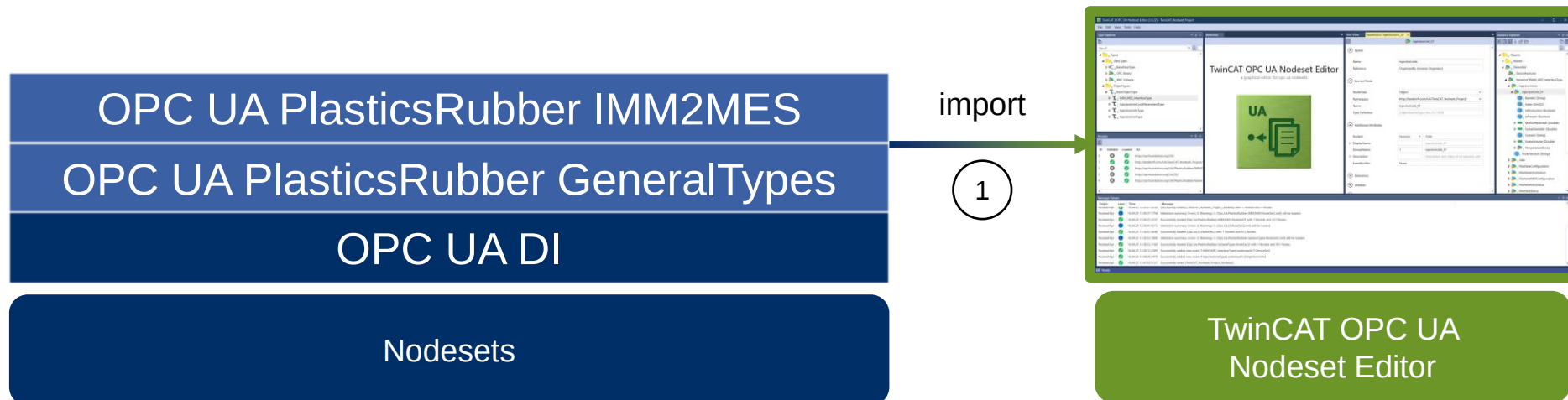
Origin	Level	Time	Message
NodesetApi	✓	16.04.25 12:36:37.1758	Validation summary: Errors: 0, Warnings: 0. [Opc.Ua.PlasticsRubber.IMM2MES.NodeSet2.xml] will be loaded.
NodesetApi	✓	16.04.25 12:36:37.2237	Successfully loaded [Opc.Ua.PlasticsRubber.IMM2MES.NodeSet2] with 1 Models and 321 Nodes.
NodesetApi	✓	16.04.25 12:36:41.9213	Validation summary: Errors: 0, Warnings: 0. [Opc.Ua.Di.NodeSet2.xml] will be loaded.
NodesetApi	✓	16.04.25 12:36:41.9646	Successfully loaded [Opc.Ua.Di.NodeSet2] with 1 Models and 412 Nodes.
NodesetApi	✓	16.04.25 12:36:53.1900	Validation summary: Errors: 0, Warnings: 0. [Opc.Ua.PlasticsRubber.GeneralTypes.NodeSet2.xml] will be loaded.
NodesetApi	✓	16.04.25 12:36:53.3160	Successfully loaded [Opc.Ua.PlasticsRubber.GeneralTypes.NodeSet2] with 1 Models and 961 Nodes.
NodesetApi	✓	16.04.25 12:38:12.2369	Successfully added new node [1:IMM_MES_InterfaceType] underneath [1:DeviceSet]
NodesetApi	✓	16.04.25 12:38:30.5470	Successfully added new node [1:InjectionUnitType] underneath [3:InjectionUnits]
NodesetApi	✓	16.04.25 12:41:03.9127	Successfully saved [TwinCAT_Nodeset_Project_Nodeset].



How do we get the TwinCAT OPC UA Server in our sample machine ready for Euromap 77?

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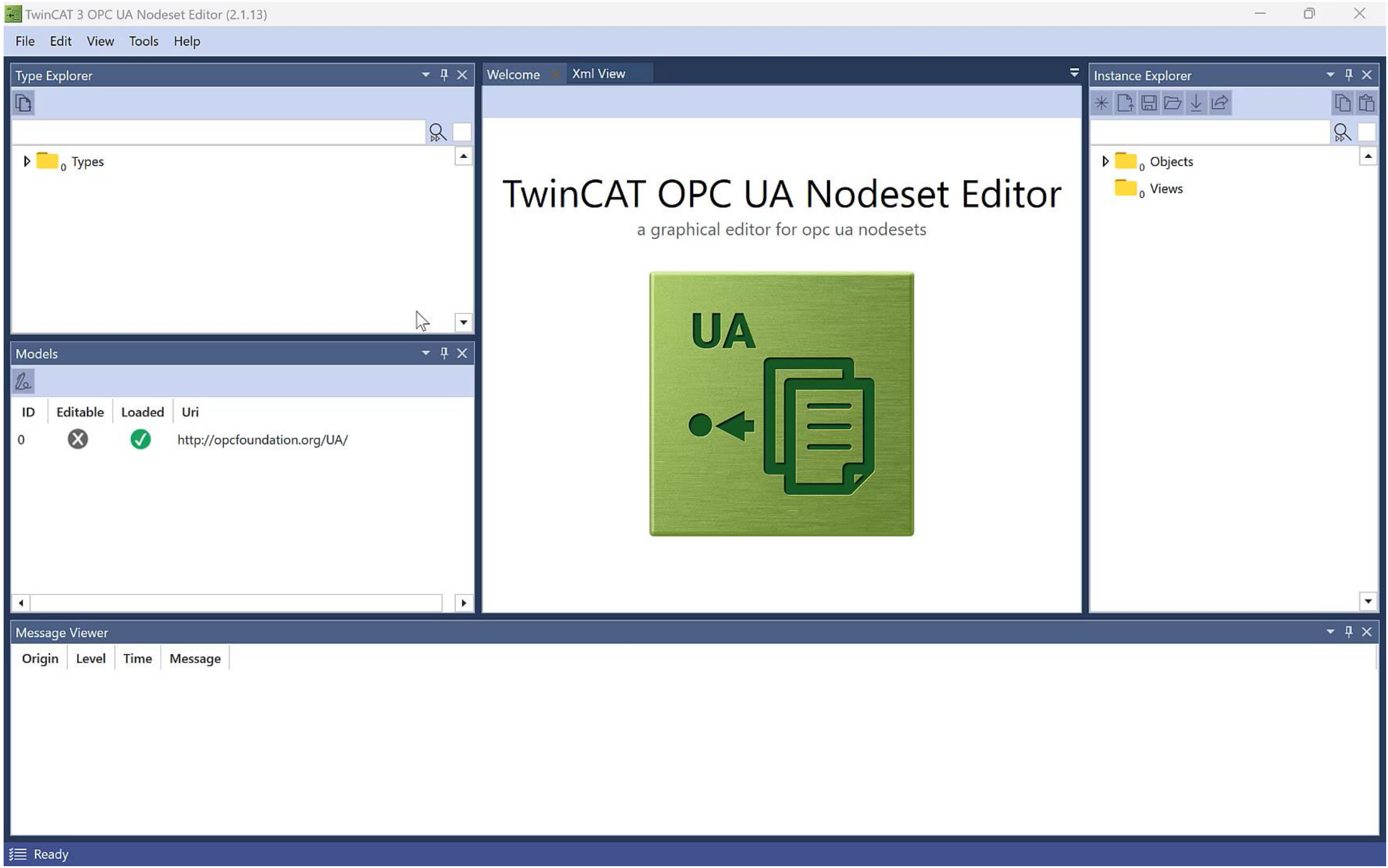
Step 1:



Vendor-specific models

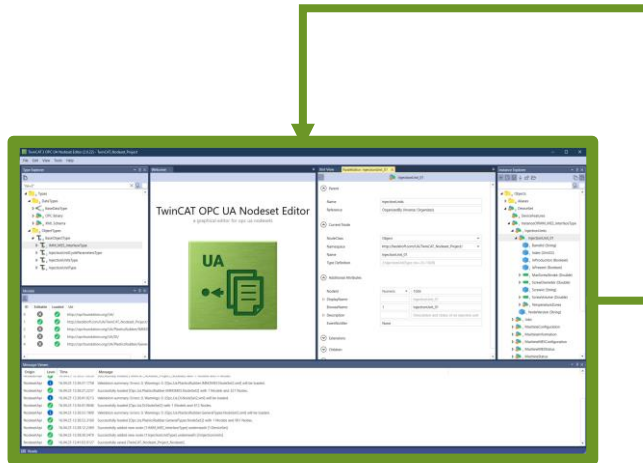
Companion specifications

Core specifications



Step 2:

2 create "instances"



TwinCAT OPC UA
Nodeset Editor

2

IMM_MES_InterfaceType
InjectionUnitType

Type Explorer

MM

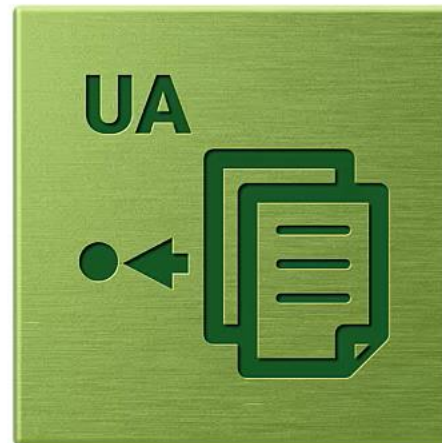
- Types
 - DataTypes
 - EventTypes
 - InterfaceTypes
 - ObjectTypes
 - ReferenceTypes
 - VariableTypes

Models

ID	Editable	Loaded	Uri
0	✗	✓	http://opcfoundation.org/UA/
1	✓	✓	http://yourcompany.com/UA/TwinCAT_Nodeset_Proj
2	✗	✓	http://opcfoundation.org/UA/PlasticsRubber/Genera
3	✗	✓	http://opcfoundation.org/UA/DI/
4	✗	✓	http://opcfoundation.org/UA/PlasticsRubber/IMM2M

TwinCAT OPC UA Nodeset Editor

a graphical editor for opc ua nodesets



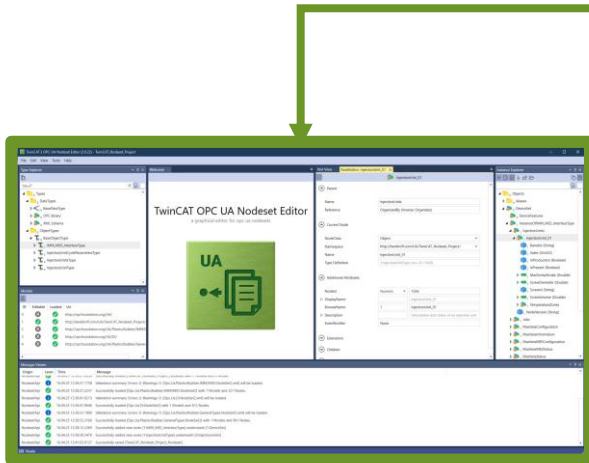
Objects

Views

Origin	Level	Time	Message
NodesetApi	✓	04.12.25 23:41:56.4337	Successfully loaded [Opc.Ua.PlasticsRubber.GeneralTypes.NodeSet2] with 1 Models and 961 Nodes.
NodesetApi	i	04.12.25 23:41:56.5018	Validation summary: Errors: 0, Warnings: 0. [Opc.Ua.PlasticsRubber.IMM2MES.NodeSet2.xml] will be loaded.
NodesetApi	✓	04.12.25 23:41:56.6024	Successfully loaded [Opc.Ua.PlasticsRubber.IMM2MES.NodeSet2] with 1 Models and 321 Nodes.
NodesetApi	i	04.12.25 23:41:56.6282	Validation summary: Errors: 0, Warnings: 0. [Opc.Ua.Di.NodeSet2.xml] will be loaded.
NodesetApi	✓	04.12.25 23:41:56.7309	Successfully loaded [Opc.Ua.Di.NodeSet2] with 1 Models and 412 Nodes.
NodesetApi	i	04.12.25 23:41:56.7455	Successfully loaded 4 out of 4 Nodesets.

Step 3:

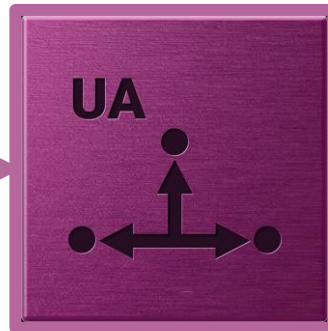
3 create "mapping"



TwinCAT OPC UA
Nodeset Editor

export

4



TwinCAT OPC UA
Server

3

InjectionUnitType.BarrelId
MAIN.sBarrelId

InjectionUnitType.Index
MAIN.nIndex

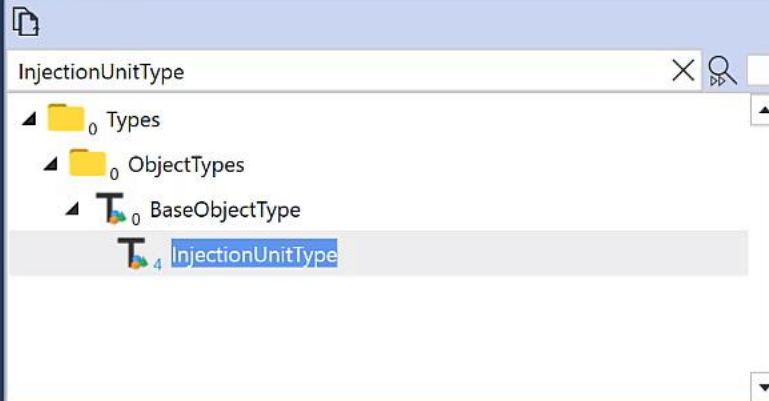
InjectionUnitType.InProduction
MAIN.bIsInProduction

4



TwinCAT_Nodeset_Project_03_Nodeset.xml

Type Explorer



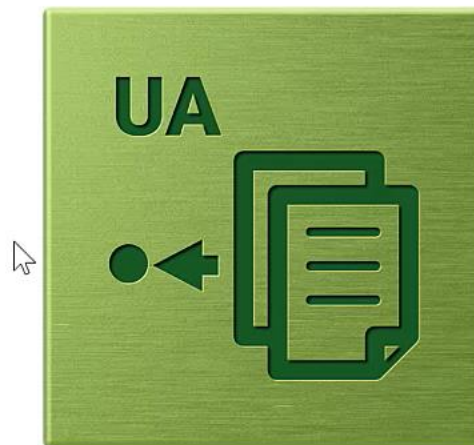
Models

ID	Editable	Loaded	Uri
0			http://opcfoundation.org/UA/
1			http://yourcompany.com/UA/TwinCAT_Nodeset_Proj
2			http://opcfoundation.org/UA/PlasticsRubber/Genera
3			http://opcfoundation.org/UA/DI/
4			http://opcfoundation.org/UA/PlasticsRubber/IMM2M

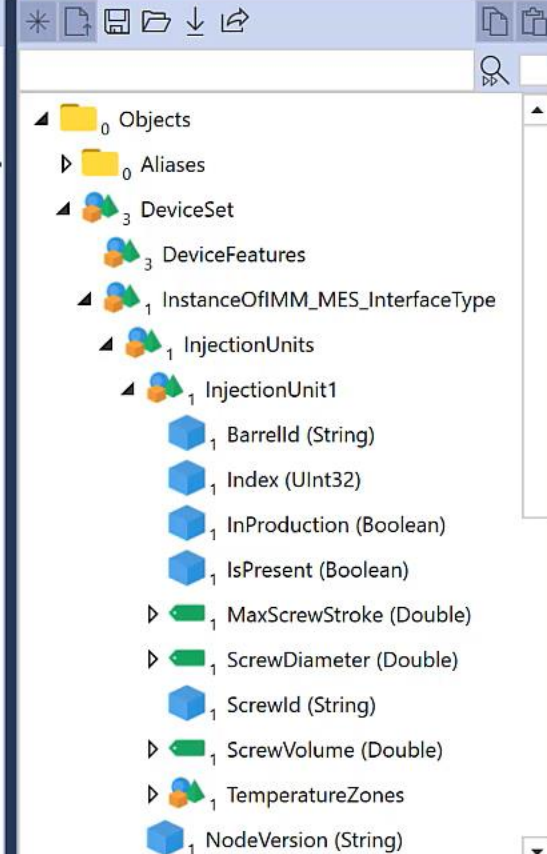
Welcome Xml View

TwinCAT OPC UA Nodeset Editor

a graphical editor for opc ua nodesets

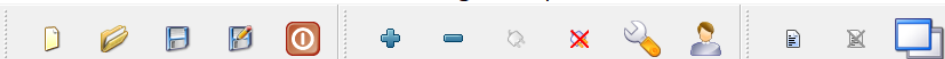


Instance Explorer



Message Viewer

Origin	Level	Time	Message
NodesetApi		04.12.25 23:41:56.6024	Successfully loaded [Opc.Ua.PlasticsRubber.IMM2MES.NodeSet2] with 1 Models and 321 Nodes.
NodesetApi		04.12.25 23:41:56.6282	Validation summary: Errors: 0, Warnings: 0. [Opc.Ua.Di.NodeSet2.xml] will be loaded.
NodesetApi		04.12.25 23:41:56.7309	Successfully loaded [Opc.Ua.Di.NodeSet2] with 1 Models and 412 Nodes.
NodesetApi		04.12.25 23:41:56.7455	Successfully loaded 4 out of 4 Nodesets.
NodesetApi		04.12.25 23:44:06.4849	Successfully added new node [1:IMM_MES_InterfaceType] underneath [1:DeviceSet]
NodesetApi		04.12.25 23:44:40.1027	Successfully added new node [1:InjectionUnitType] underneath [3:InjectionUnits]



Project

- ▼ Project
 - ▼ Servers
 - TcOpcUaServer@MichaelKn-NB04
 - ▼ Documents
 - Data Access View

Address Space

- ⚙ No Highlight
- Root
 - ▼ Objects
 - > AlarmsConditions
 - > Configuration
 - ▼ DeviceSet
 - > DefaultConfiguration
 - > DeviceFeatures
 - ▼ InstanceOfIMM_MES_InterfaceType
 - ▼ InjectionUnits
 - ▼ InjectionUnit1
 - BarrelId
 - InProduction
 - Index
 - IsPresent
 - > MaxScrewStroke
 - > ScrewDiameter
 - ScrewId
 - > ScrewVolume
 - > TemperatureZones

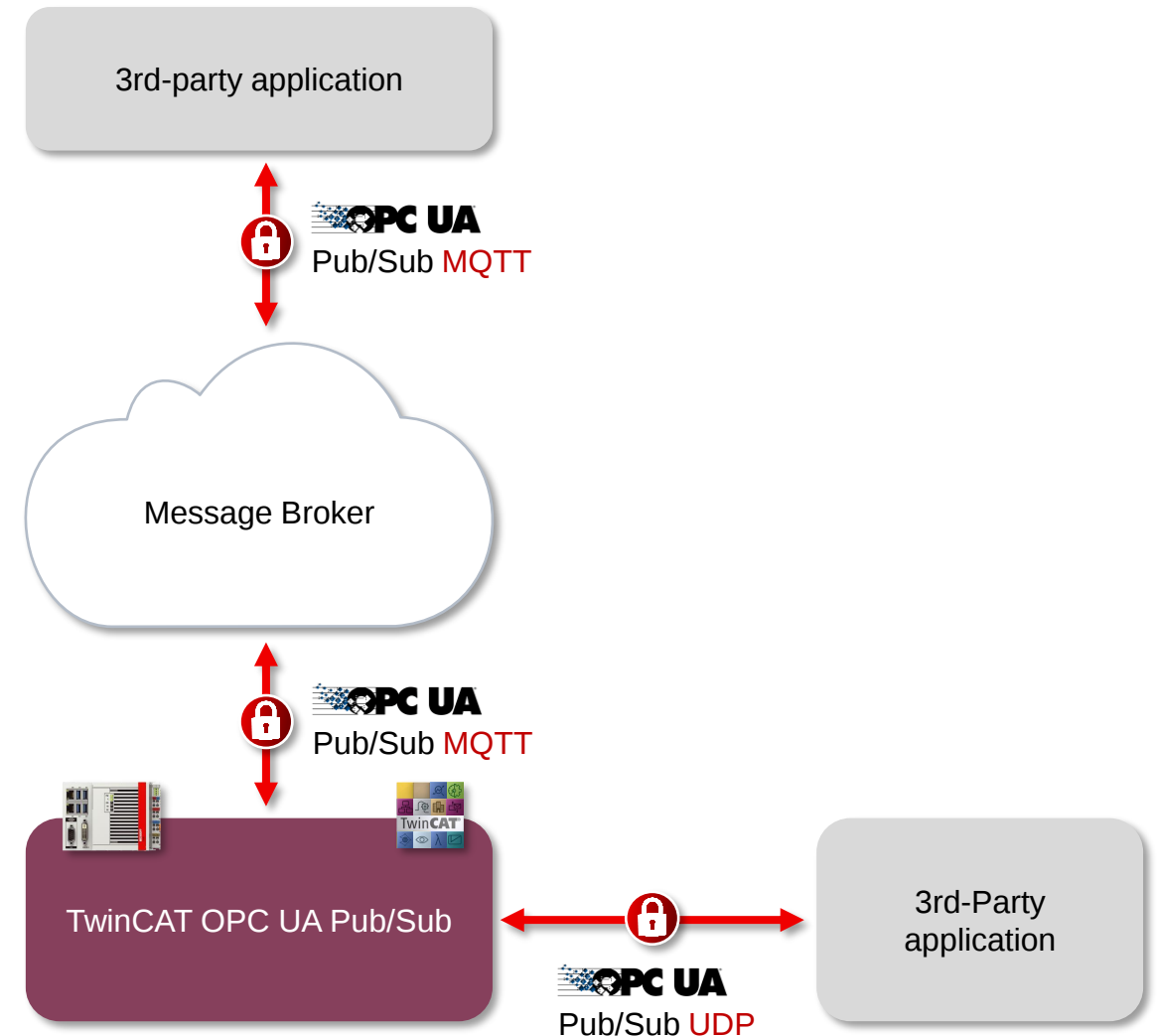
Data Access View

#	Server	Node Id	Display Name	Value	Datatype	Source Timestamp	Server Timestamp	Statuscode
1	TcOpcUaServer...	NS10 Numeric ...	BarrelId	Barrel 13	String	00:00:55.672	00:00:55.672	Good
2	TcOpcUaServer...	NS10 Numeric ...	InProduction	true	Boolean	00:00:55.672	00:00:55.672	Good
3	TcOpcUaServer...	NS10 Numeric ...	Index	10	UInt32	00:00:55.672	00:00:55.672	Good

How do we ensure that both our machine parts can communicate via OPC UA Pub/Sub UDP?

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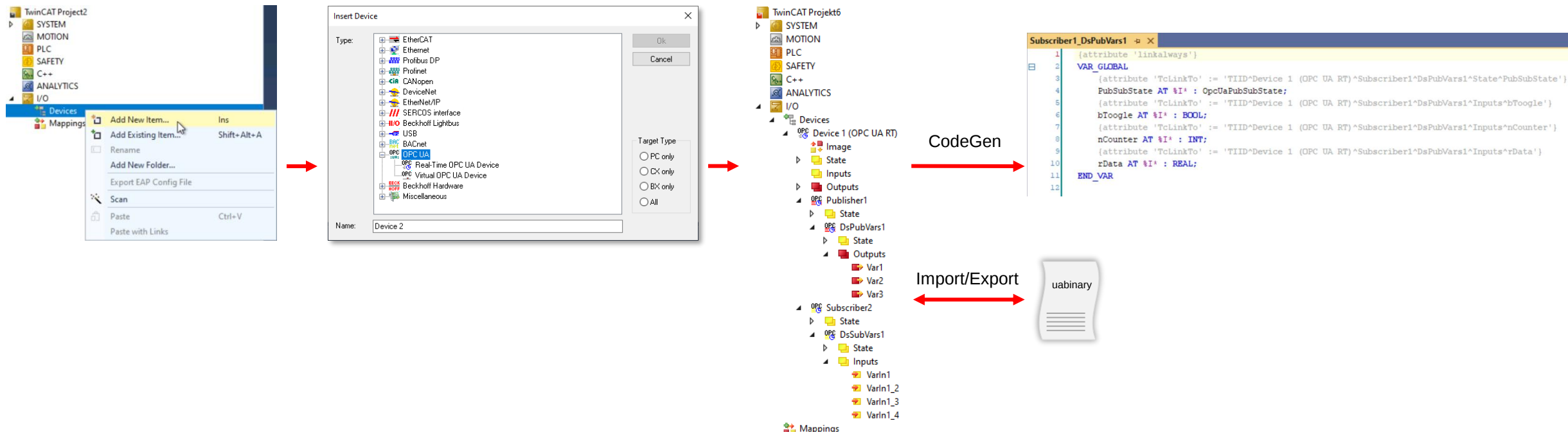
- TwinCAT OPC UA Pub/Sub implements OPC UA Pub/Sub (OPC10000-14)
- Supported transport protocols:
 - UDP: use case “Device-to-Device”
 - MQTT: use case “Device-to-Cloud”
- Configuration interface available via TwinCAT OPC UA Server
- Publishing interval is configured based on base ticks of PLC runtime



How do we ensure that both our machine parts can communicate via OPC UA Pub/Sub UDP?

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- Configuration via TwinCAT XAE environment
- Dedicated I/O device for OPC UA Pub/Sub
- PLC code generation for convenience
- Standardized Import/Export file for configuration exchange



- **Configuration of header layout**
- Support of pre-defined header layouts
 - UADP PeriodicFixed (default)
 - UADP Dynamic
- Support of flexible header layout
 - Customer can freely decide which header fields are sent
 - Flexibility increases implementation effort

The screenshot shows the 'Settings' tab of the TwinCAT OPC UA configuration window. The 'Configuration' section has 'Enabled' checked, 'Name' set to 'Publisher1', 'Header Layout' set to 'UADP Dynamic', and 'Transport' set to 'Flexible'. The 'Address settings' section shows 'Destination Addr' as '239.0.0.1', 'UDP Port' as '4840', and 'Time to Live' as '0'. The 'Network Message Content Mask' section on the right has 'Publisher ID' and 'Payload Header' checked, while 'Group Header', 'WriterGroup ID', 'Group Version', 'Network Message Number', 'Sequence Number', 'Timestamp', 'Pico Seconds', and 'DataSetClass ID' are unchecked.

The screenshot shows the 'Settings' tab of the TwinCAT OPC UA configuration window. The 'Configuration' section has 'Enabled' checked, 'Name' set to 'Publisher1', 'Header Layout' set to 'Flexible', and 'Transport' set to 'UDP/UADP'. The 'Address settings' section shows 'Destination Addr' as '239.0.0.1', 'UDP Port' as '4840', and 'Time to Live' as '0'. The 'Network Message Content Mask' section on the right has 'Publisher ID' and 'Payload Header' checked, while 'Group Header', 'WriterGroup ID', 'Group Version', 'Network Message Number', 'Sequence Number', 'Timestamp', 'Pico Seconds', and 'DataSetClass ID' are unchecked.

- Tools for troubleshooting communication problems
- Diagnosis tab on each OPC UA RT device

The screenshot displays the TwinCAT software interface. On the left, the 'Solution Explorer' shows a project structure for 'TwinCAT Project2'. Under the 'I/O' folder, the 'Devices' sub-folder is expanded, and 'Device 1 (OPC UA RT)' is selected and highlighted with a red box. On the right, the 'TwinCAT Project2' window is open, showing the 'Diagnosis' tab (also highlighted with a red box). This tab displays 'OPC UA Real-Time Device Statistics' in a table format.

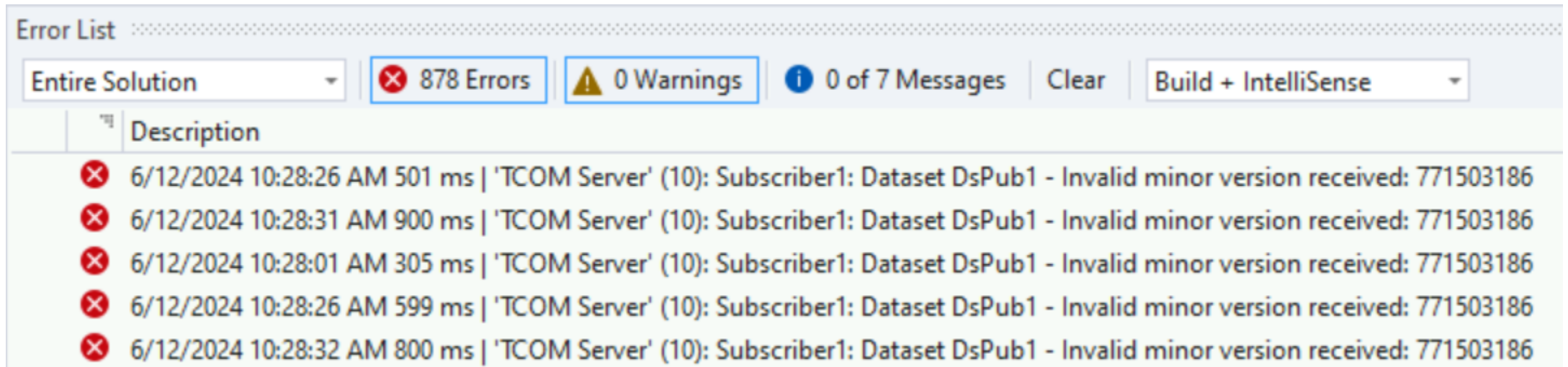
Name	Value
EthernetDevice	Frames: Recv 0 - Send 3
ethStat	(0;3)
txRxErrCnt	(0;0)
IpStack	Packets: Recv 0 - Send 3
Ip	(3;0;0;0)
ArpRequest	(0;0;0;0)
ArpReply	(0;0;0;0)
EchoRequest	(0;0;0;0)
EchoReply	(0;0;0;0)
LinkStatusChanges	1
nAllocFailCnt	0
nArpTimeoutFrames	0
nDroppedFrames	0

- **Tools for troubleshooting communication problems**
- Diagnosis tab on each OPC UA RT device
- Diagnosis tab on each Publisher and each Subscriber

The screenshot displays the TwinCAT software interface. On the left, the 'Solution Explorer' shows a project tree for 'TwinCAT Project2'. Under the 'I/O' folder, 'Devices' is expanded, showing 'Device 1 (OPC UA RT)'. Within 'Device 1', 'Publisher1' is highlighted with a red box. On the right, the 'TwinCAT Project2' window is open, showing the 'Diagnosis' tab. This tab displays 'OPC UA Real-Time Device Statistics' in a table format.

Name	Value
NetworkMessages	(721;0;0;0)
DataKeyMessages	(721;0;0;0)
DeltaFrameMessages	(0;0;0;0)
EventMessages	(0;0;0;0)
KeepAliveMessages	(0;0;0;0)
MetadataMessages	(0;0;0;0)
EncryptedFrames	(0;0;0;0)
SignedFrames	(0;0;0;0)
DiscoveryRequests	(0;0;0;0)
DiscoveryResponses	(0;0;0;0)
ChunkMessages	(0;0;0;0)
StateInfo	(Operational;Operational)

- **Tools for troubleshooting communication problems**
- Diagnosis tab on each OPC UA RT device
- Diagnosis tab on each Publisher and each Subscriber
- TwinCAT error list



- **Tools for troubleshooting communication problems**
- Diagnosis tab on each OPC UA RT device
- Diagnosis tab on each Publisher and each Subscriber
- TwinCAT error list
- Wireshark

16	2.740000000	172.17.98.153	224.0.0.1	OPCUA UADP	52	4840 → 4840	Len=10
20	3.740000000	172.17.98.153	224.0.0.1	OPCUA UADP	52	4840 → 4840	Len=10
24	4.740000000	172.17.98.153	224.0.0.1	OPCUA UADP	52	4840 → 4840	Len=10
27	5.740000000	172.17.98.153	224.0.0.1	OPCUA UADP	52	4840 → 4840	Len=10
30	6.740000000	172.17.98.153	224.0.0.1	OPCUA UADP	52	4840 → 4840	Len=10
37	7.740000000	172.17.98.153	224.0.0.1	OPCUA UADP	52	4840 → 4840	Len=10
46	8.740000000	172.17.98.153	224.0.0.1	OPCUA UADP	52	4840 → 4840	Len=10
49	9.740000000	172.17.98.153	224.0.0.1	OPCUA UADP	52	4840 → 4840	Len=10
54	10.740000000	172.17.98.153	224.0.0.1	OPCUA UADP	52	4840 → 4840	Len=10

```
UADP Network Message
> NetworkMessage Header
  Payload Header
  DataSet Payload
    DataSetMessage[0] (Data Key Frame Data)
      DataSetFlags1
      Data Key Frame
        Field Count: 1
        DataSetField[0] (Variant Encoding)
          Variant Encoding Mask: 4
          Value (Int16)
            18889
```

- Goal of all automation manufacturers: Generic support for different Companion Specifications
- First step with tools for information modeling
 - In our case: TwinCAT OPC UA Nodeset Editor
- Information modeling tools used for mapping between Nodesets and PLC variables
- Open points on the way to fulfill this goal
 - Bridge between OPC UA technologies and PLC world
 - Dynamic array length, Variant data type, ValueRank “Any” etc.

