University of Stuttgart
Institute for Control Engineering of Machine Tools and Manufacturing Units (ISW)

OPC Unified Architecture and its use in SeRoNet

Sebastian Friedl

Agenda

1. Basics of OPC UA
2. Technical introduction
3. Information modeling
4. OPC UA in SeRoNet

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Agenda

1 Basics of OPC UA

2 Technical introduction

3 Information modeling

4 OPC UA in SeRoNet

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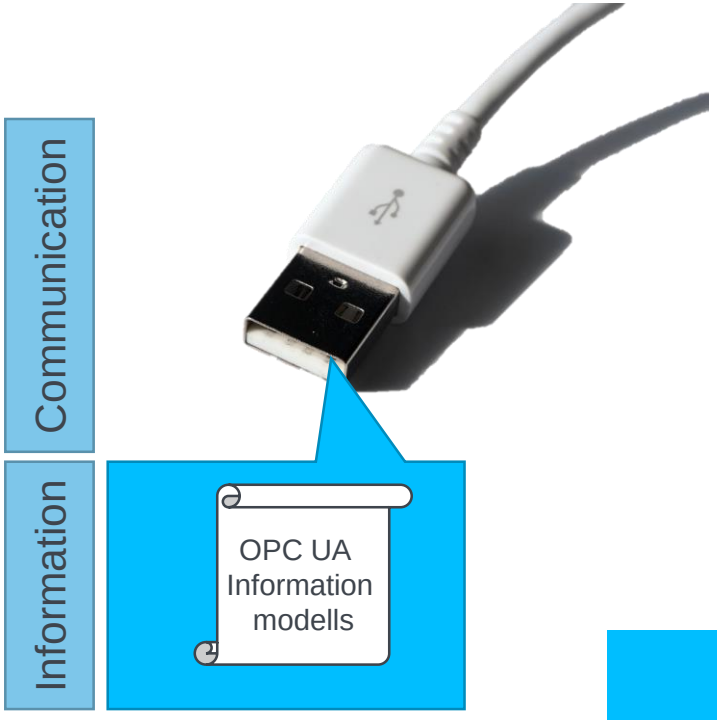
What is OPC Unified Architecture?

Overview



- OPC UA is an information centric architecture including:
  - M2M-Communication
  - Security
  - Information modeling
- OPC UA is
  - Platform Independent
  - Scalable
  - Vendor Interoperablity

OPC UA is much more than a protocol

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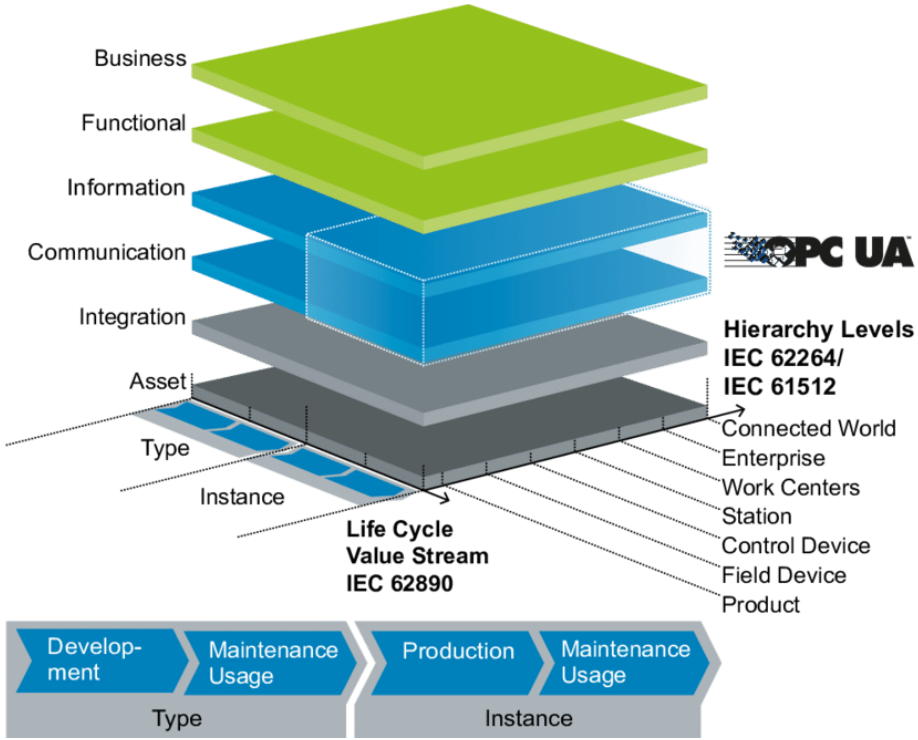
What is OPC Unified Architecture?

OPC UA and other standards



- **IEC 62541** is the standard for OPC Unified Architecture.
- fits into **Industrie 4.0**
- 40 domain specific information models completed or in progress
  - 15 from VDMA

Source: VDMA Industrie 4.0 Comm**unication Guideline Based on OPC UA / VMDA Info Day**

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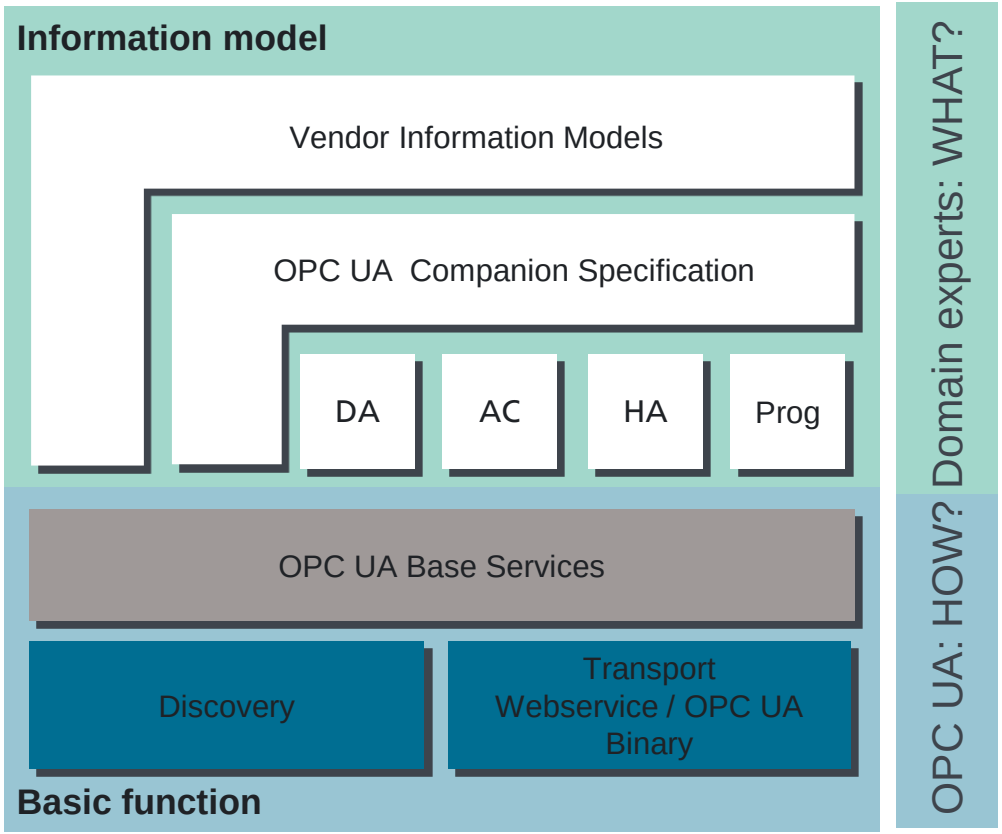
Technical introduction

OPC UA Architecture

- Base Services and data models for
  - Data accesses
  - Methoden calls
  - Event-Handling
- Possibility to specify own information models
- Independent communication stack
- High performance
- Integrated security



DA Data Access
AC Alarms & Conditions
HA Historial Access
Prog Program

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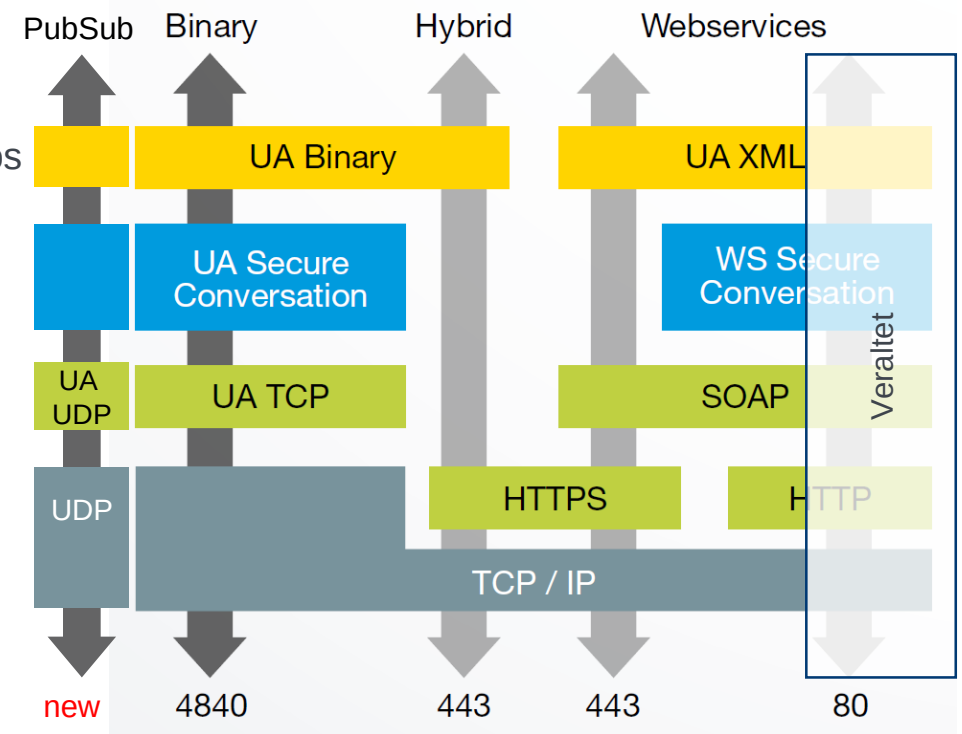
Technical introduction

Transport and security

- Authentication and Authorization
  - Software- und Applikationscertificates
  - Users: User name and password, Kerberos tokens or X.509 certificates
  - Integrity and confidentiality
  - Signing, signing and encrypting
- Transport profile :
  - Performance: UA Binary (Port 4840)
  - Web Service: UA XML (Port 443 bzw. Port 80)
  - *New: Web Service: UA JSON*



Bildquelle: OPC Unified Architecture. Wegbereiter der 4. industriellen (R)evolution

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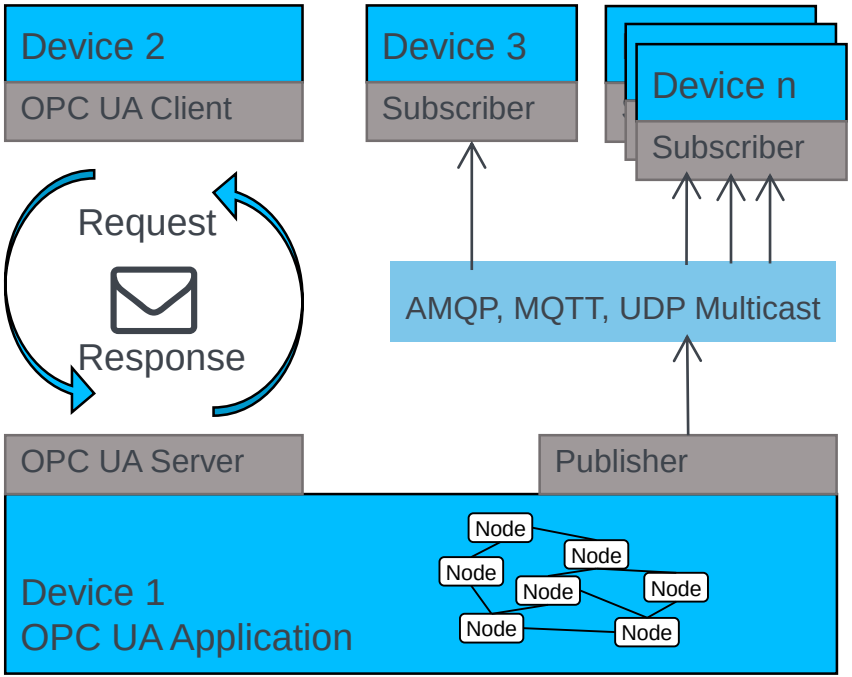
Technical introduction

Communication Layer



Quelle: Dr. Christian Mosch | VDMA Info Day 2018

Client/Server (Request/Response)

- Fix 1:1 Connections
- many connections(>500) ➔ High resource consumption
- UseCase: huge amount of flexible data

Publisher/Subscriber (UDP based)

- Connection-less, broadcast-style
- Many subscribtions ➔ low resource consumption
- UseCase: small amount of fixed data

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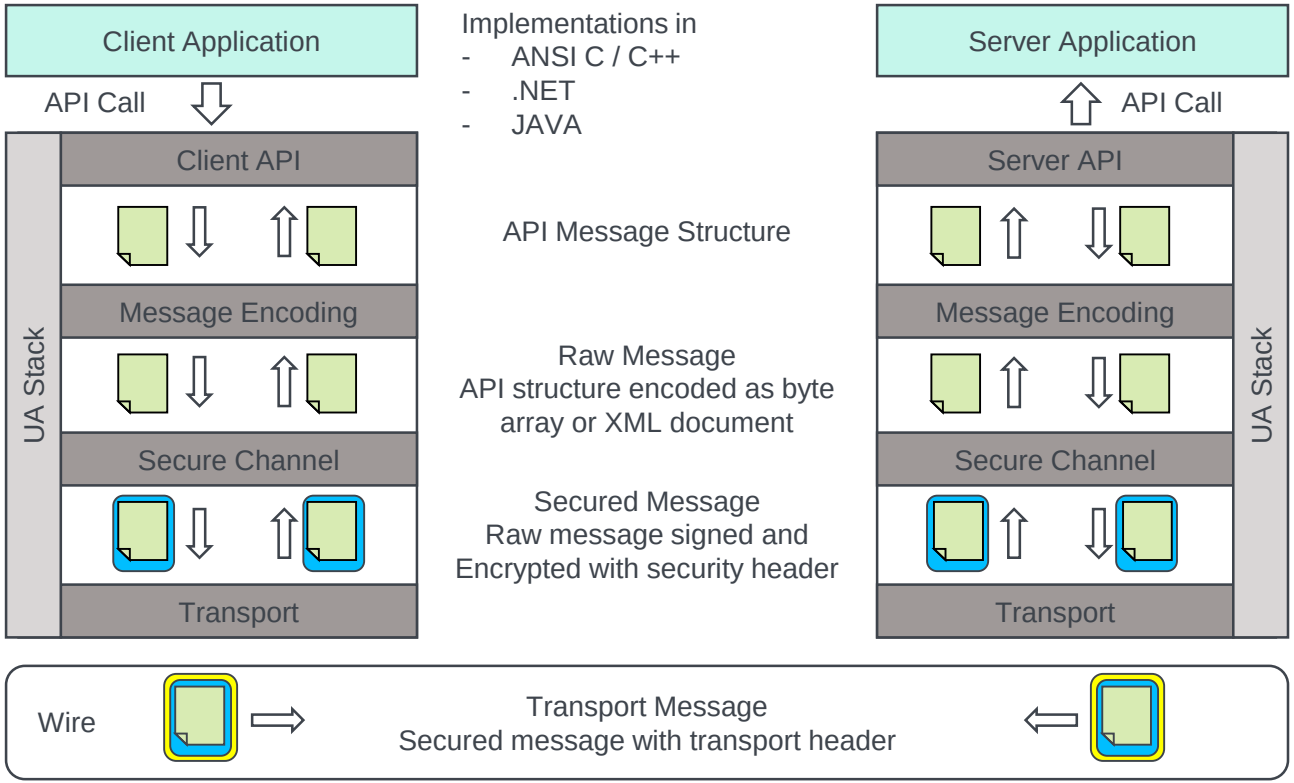
Technical introduction

Communication stack



Bildquelle: nach OPC Foundation

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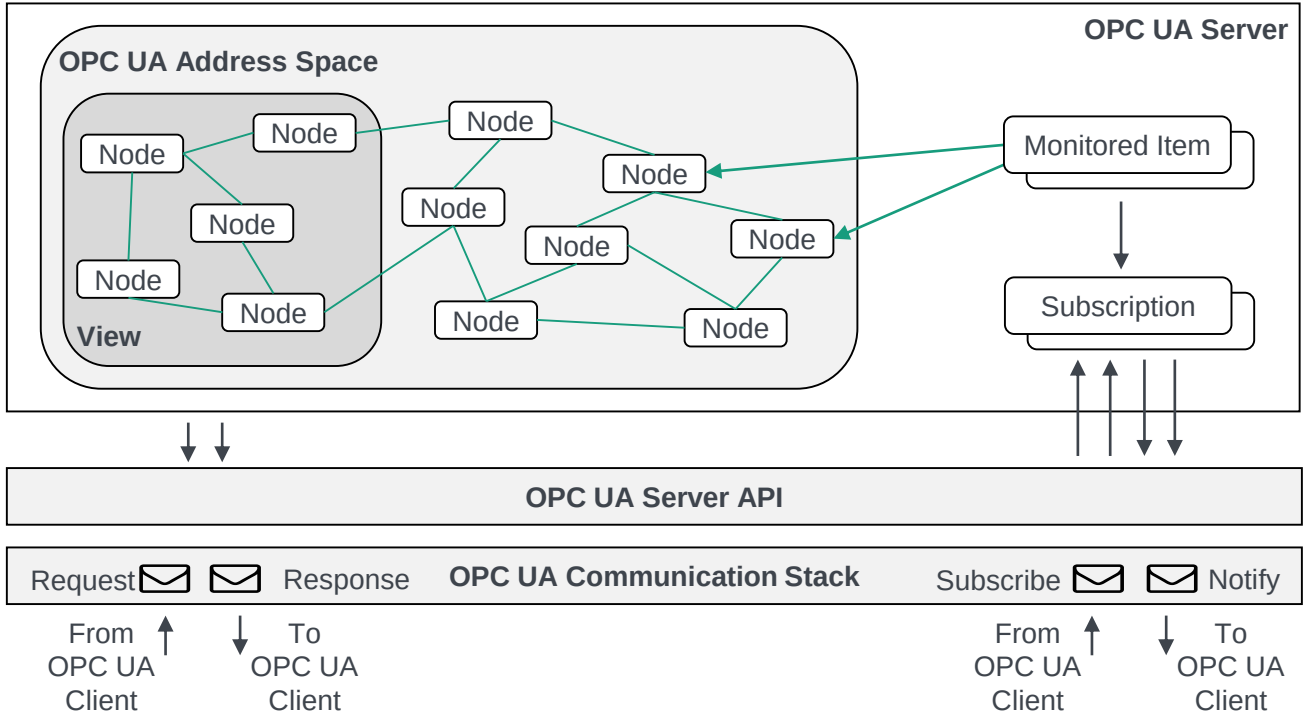
Technical introduction

address space concept



Bildquelle: gemäß http://image.slidesharecdn.com/iibmanufacturingpackv1001-141223103200-conversion-gate02/95/iib-manufacturing-pack-v1001-10-638.jpg?cb=1419352380

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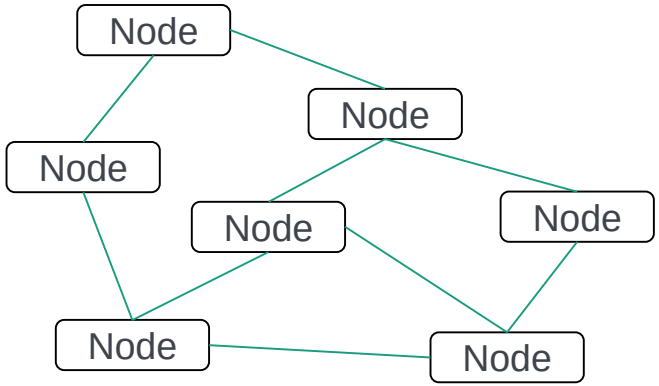
Technical introduction

What is a node?

- OPC UA defines a network of nodes
- 8 Classes of Nodes
- References define the edges
- Each Nodes contain standard attributes
  - Identifier
  - NodeClass
  - BrowseName
  - …
- and specific attributes (depending on the NodeClass)
  - Executable (Methoden)
  - Value (variables)
  - …



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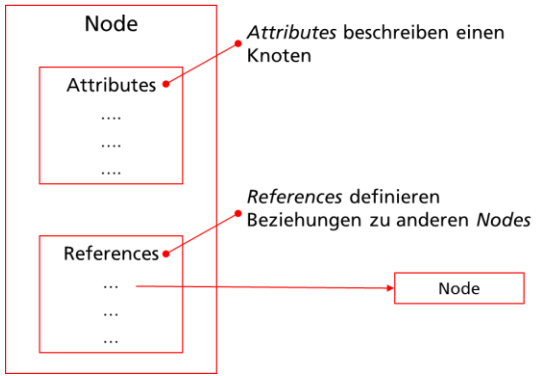
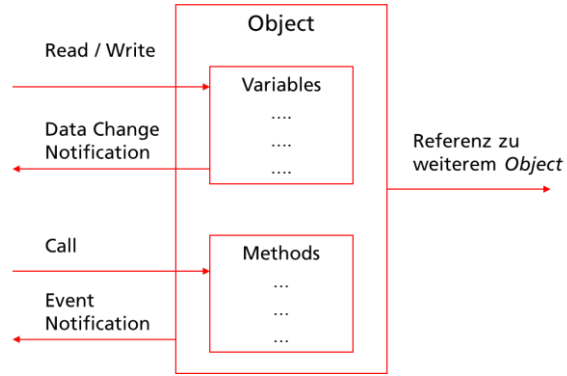
Technical introduction

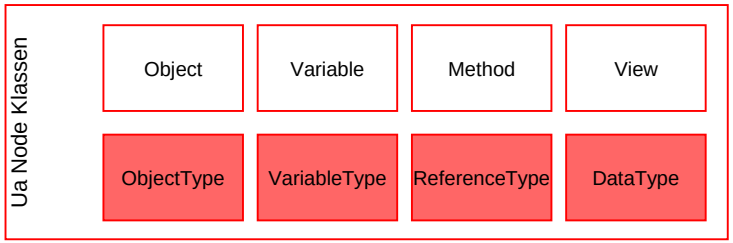
address space concept



Node-Modell



Object-Modell



Node-Klassen

Bildquellen: gemäß http://documentation.unified-automation.com/uasdkcpp/1.5.2/html/L2UaAddressSpaceConcepts.html

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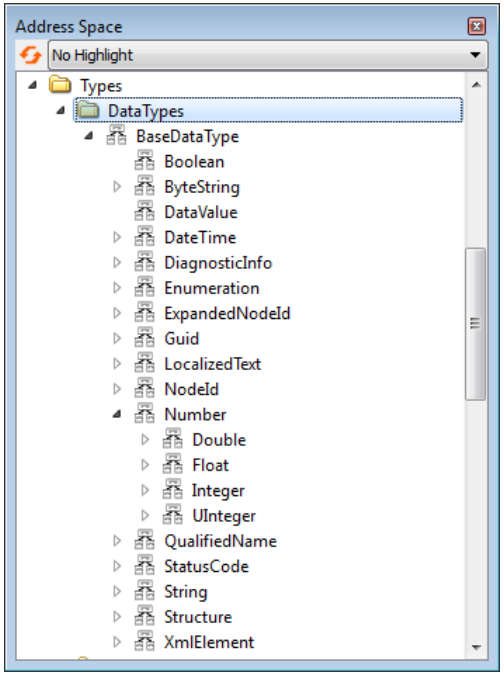
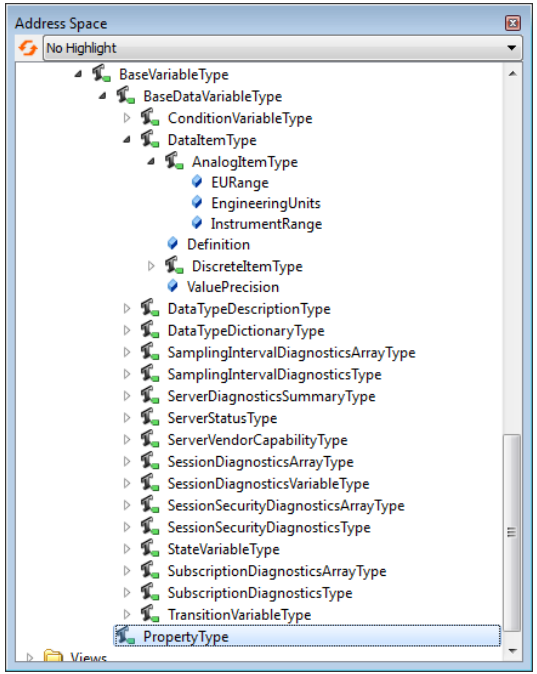
Technical introduction

Datatypes

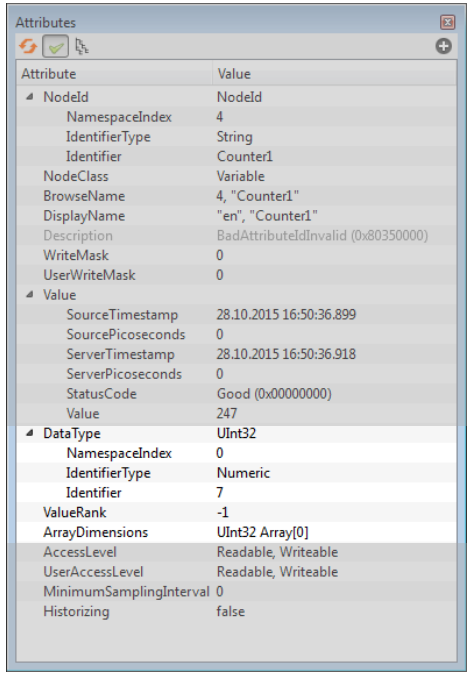
PRIMITIVE DATATYPES



COMPLEX DATATYPES



ARRAYS



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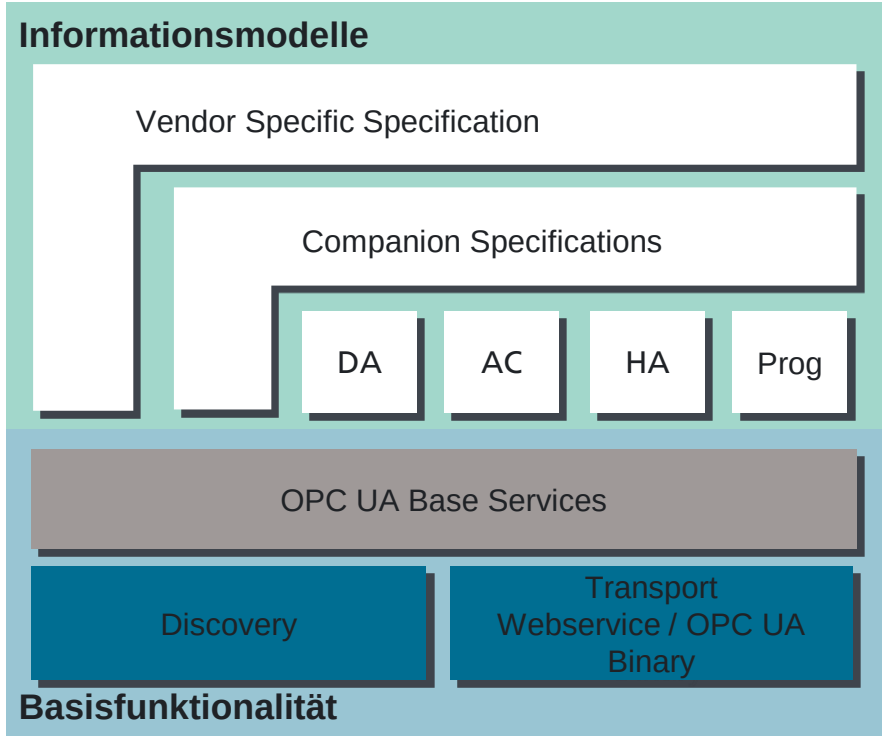
Information modeling

OPC UA Information and data models

- Extension of OPC UA specifications
- Basis are the OPC UA information models (DA, Ac, HA, Prog)
- > 40 Available/Planned Companion Specifications
  - PLCopen
  - MTConnectOpcUa
  - ISA95
  - DI, FDI, ADI, FDT
  - AutomationML
  - …



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Information modeling

Available Companion specifications (not exhaustive):

Name	Status	Datum
Analyzer Devices (ADI)	Release (1.1a)	09.01.2015
AutoID	Release	14.04.2016
AutomationML	Release	22.02.2016
CNC Systems (VDW)	Release	07.07.2017
FDI (Field Device Integration)	Release Candidate	
FDT (Field Device Tool)	Release	22.11.2016
ISA-95 Common Object Model	Release	30.10.2013
MDIS	Release	18.10.2017
OPC Unified Architecture for Devices (DI)	Release	25.07.2013
PLCopen	Release	
Powerlink	Release	15.11.2017
Sercos Devices	Release (1.2)	11.04.2017
…		

Quelle: OPC Foundation

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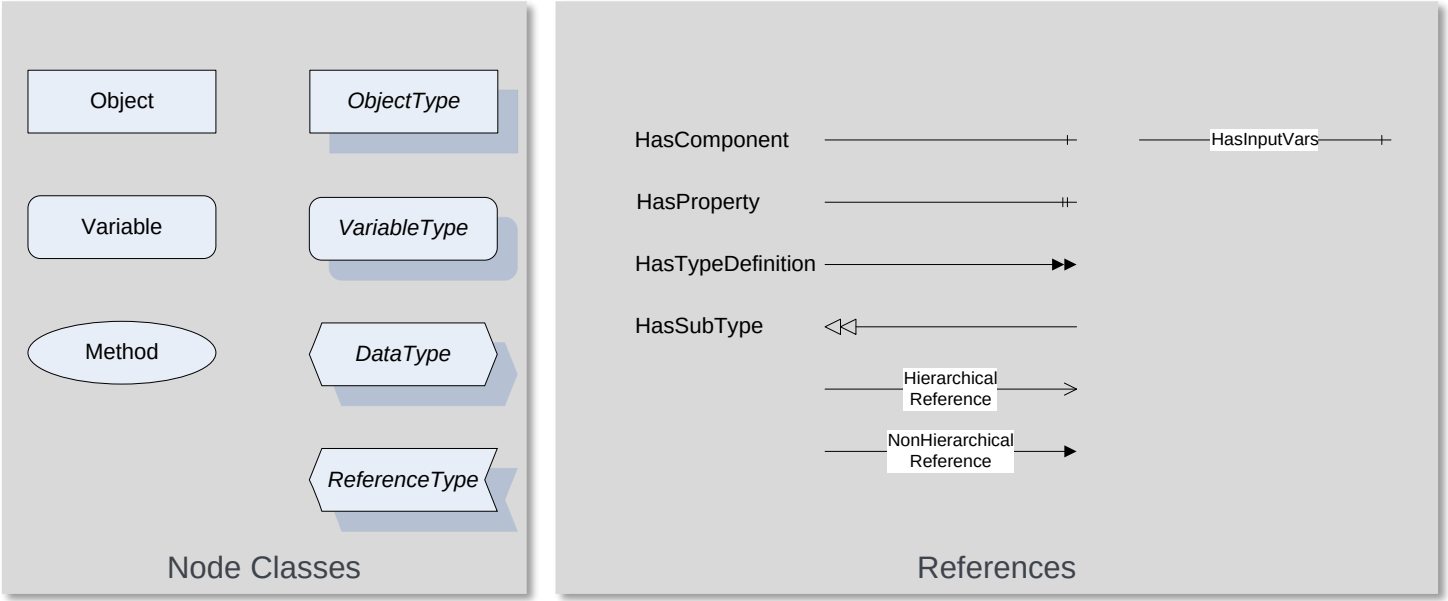
Information modeling

Notation



- modeling tools(UaModeler, Free OPC-UA-Modeler u.a.)
- NodeSet-Export (als XML)
- (Automatic code generation)

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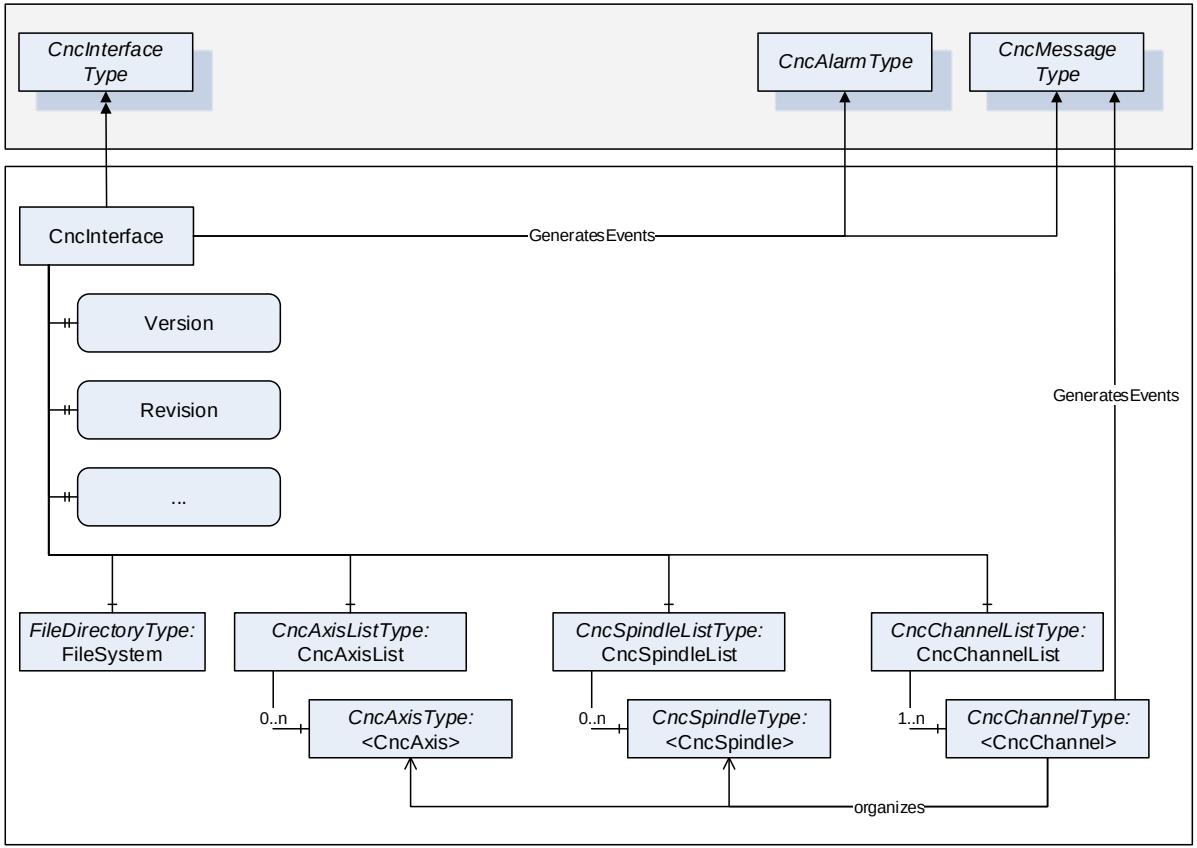
Information modeling

Example: Overview of the CNC Companion Specification



Quelle: OPC UA Companion Specification for CNC Systems

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SeRoNet

Eine Plattform zur arbeitsteiligen Entwicklung von Serviceroboter-Lösungen

Bundesministerium für Wirtschaft und Energie

Zielsetzung

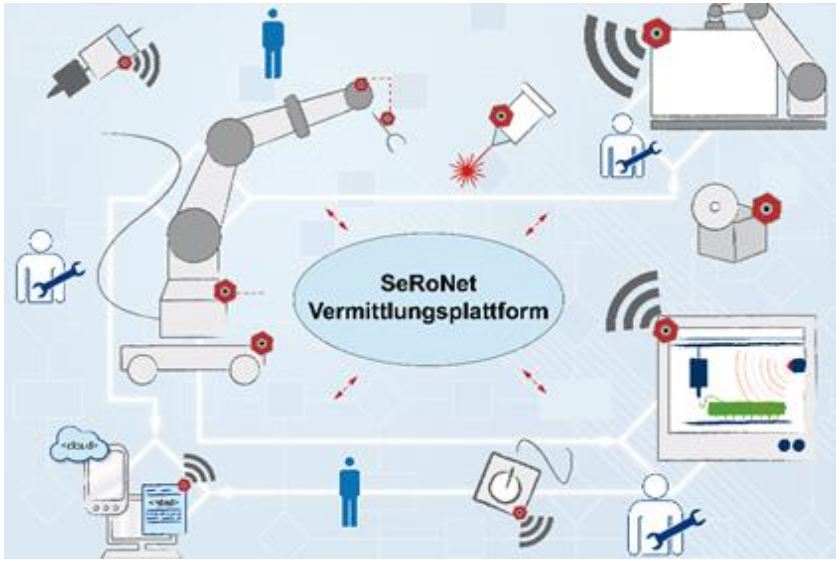
- Erschließung effizientere Wege in der Entwicklung von (Service-) Roboterlösungen
- Entwicklung einer offenen B2B-Vermittlungsplattform

Vorgehensweise

- Modellgetriebene Entwicklungswerkzeuge und semantische Beschreibung von Komponenten
- Kommunikation zwischen den Modulen mittels OPC UA
- Integrierte Plattform-Fonds

(Erwartete) Ergebnisse

- Eine offene Plattform zur Reduktion des Integrations- und Anpassungsaufwands für Service-Robotik-Lösungen



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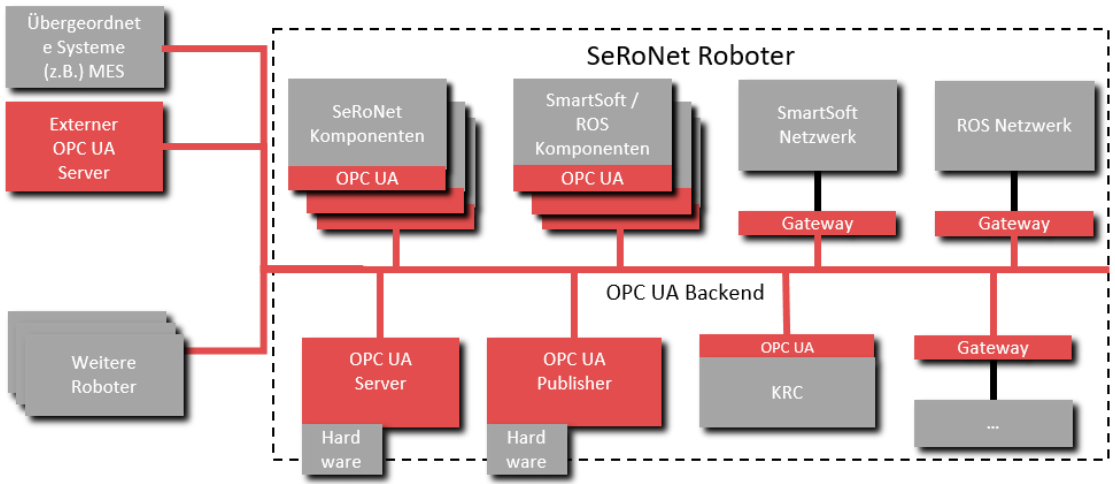
Introduction SeRoNet

Using OPC UA as Communcation Backend



- Connect different Frameworks like ROS, SmartSoft over OPC UA
- Connection Hardware Device directly over OPC UA
- Use Gateways to connect between Backend and other Components

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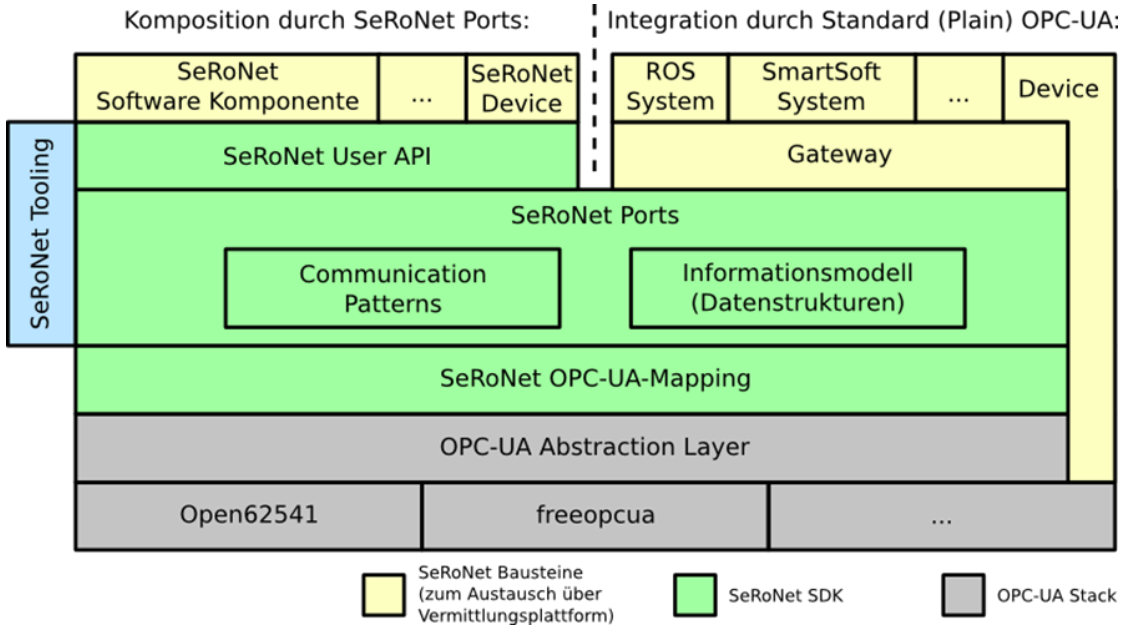
Introduction SeRoNet

Using OPC UA as Communcation Backend

- Define only a few communication Patterns
  - Publish/Subscription
  - Asynchron Methods
  - Events
- Enables composition
- Code generation for OPC UA Client and OPC UA Server



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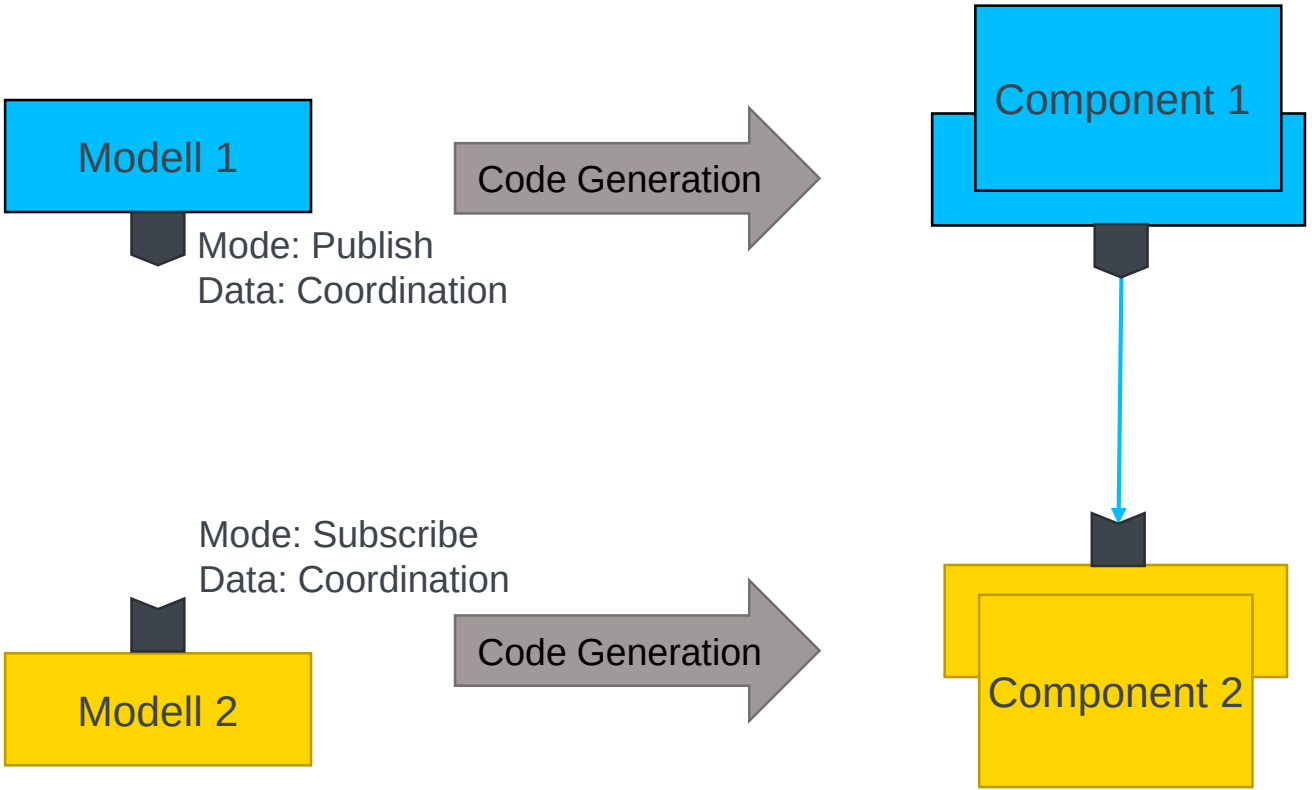
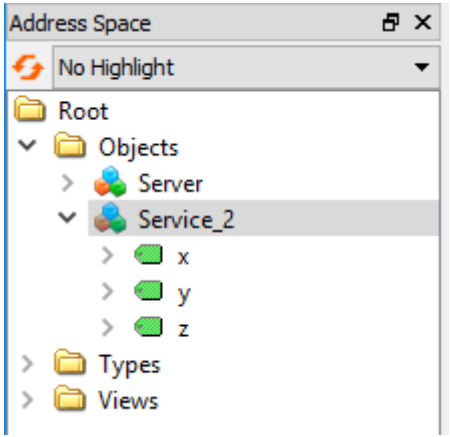
Introduction SeRoNet

Code generation for OPC UA Server and Client





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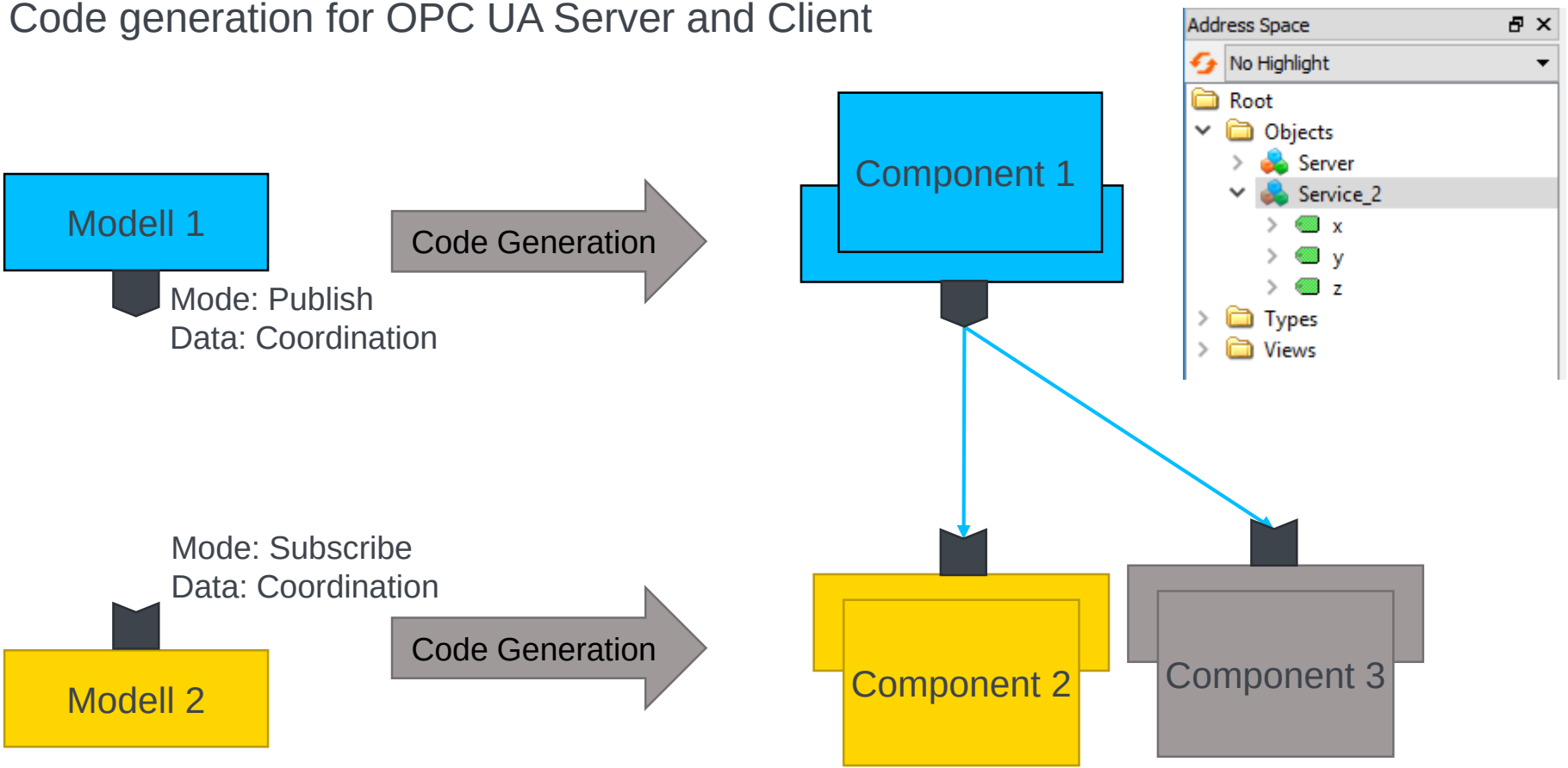

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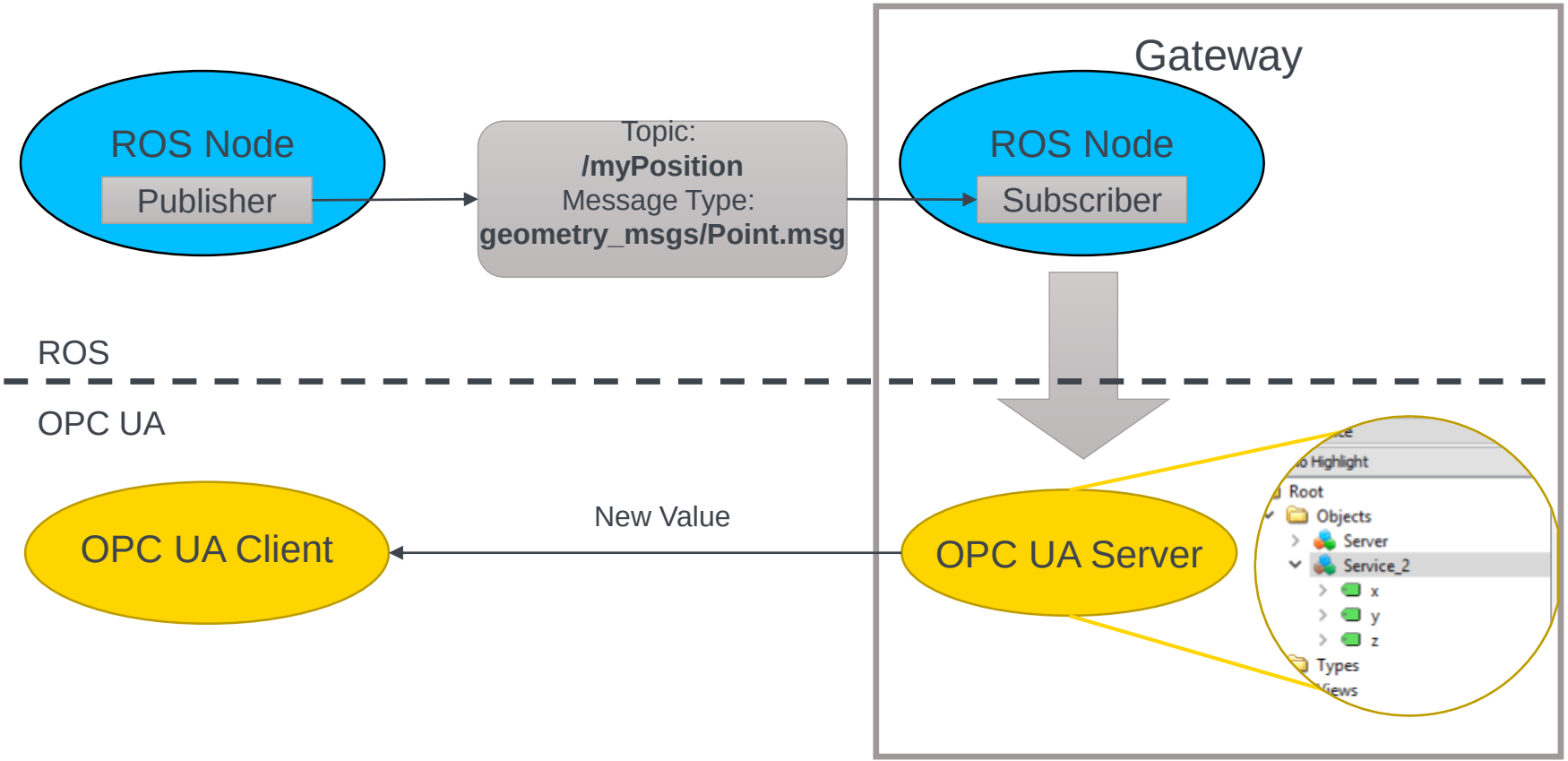
Introduction SeRoNet

Connect ROS and SeRoNet over a Gateway



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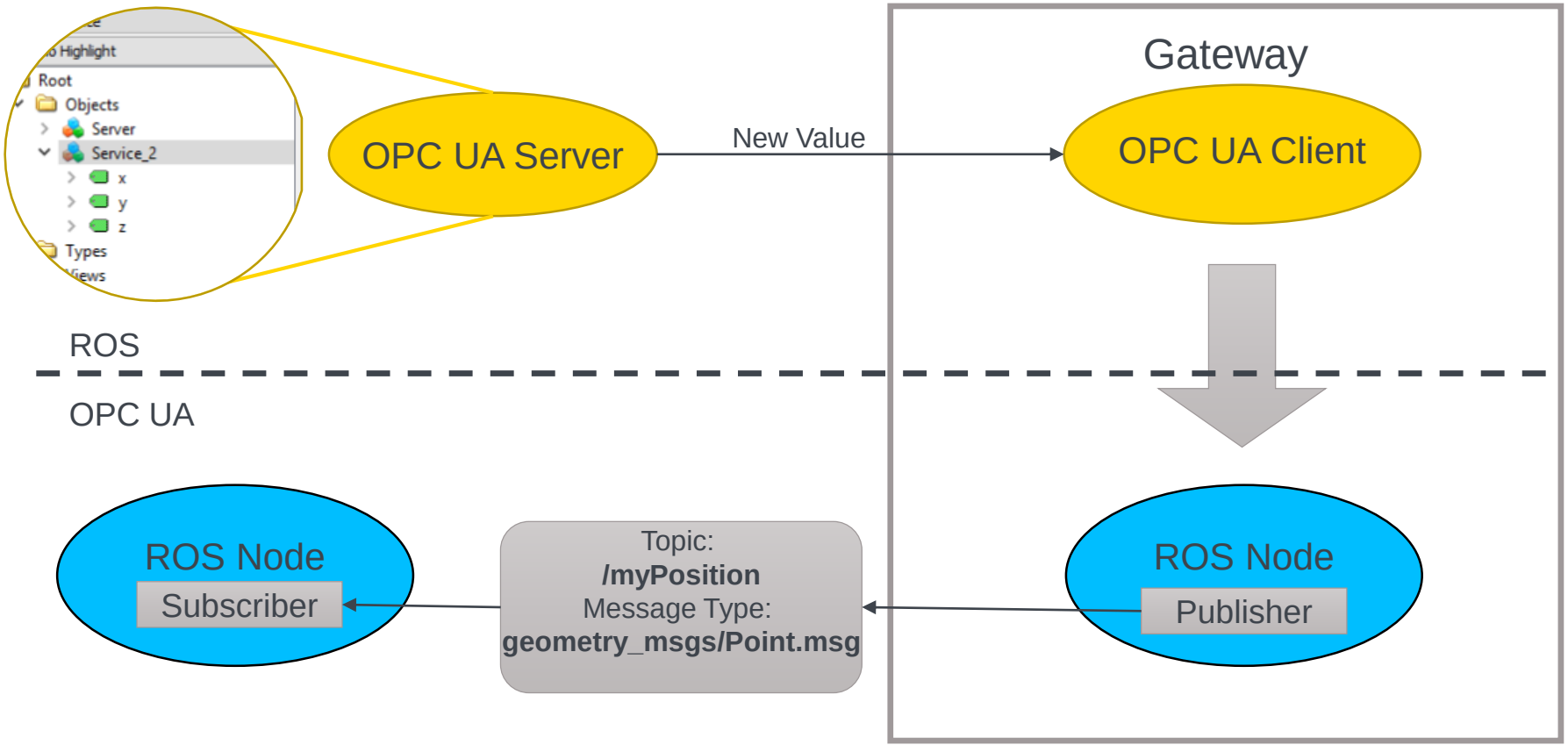

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Thank you!

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Backup: New Agenda

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