



OPC UA for S7-1500 and S7-1200

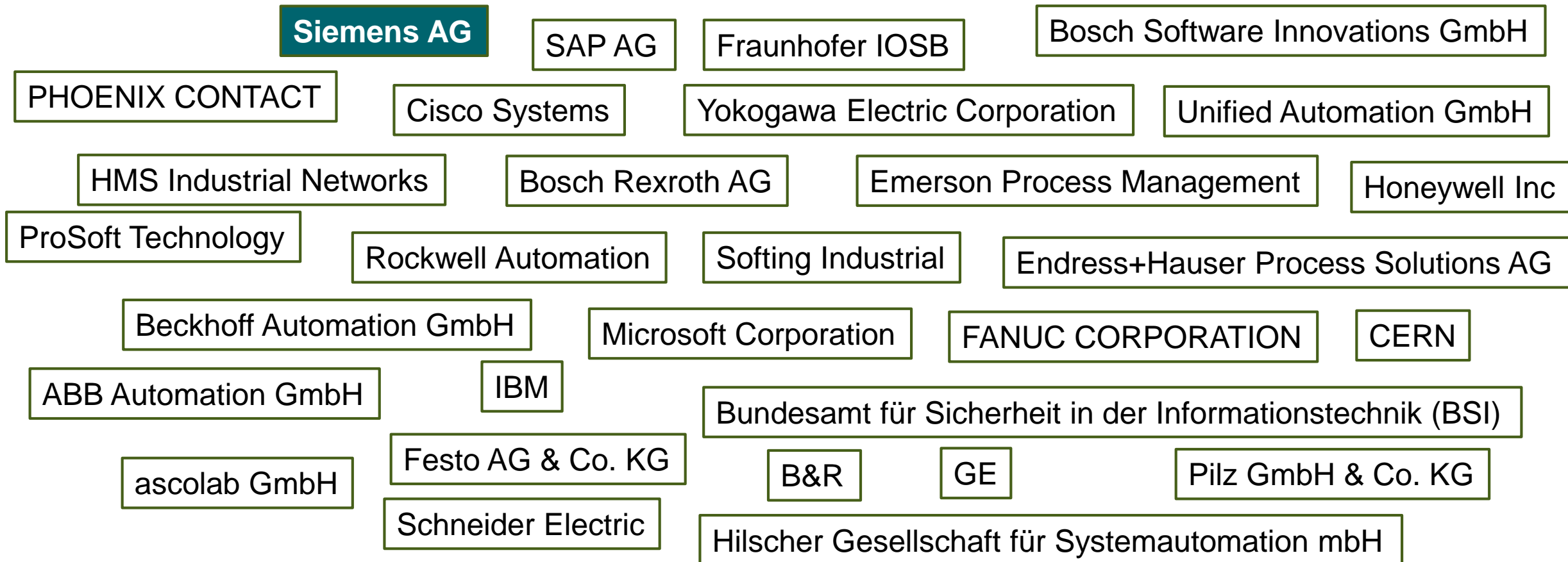
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[siemens.com/simatic-s7-opcua](https://www.siemens.com/simatic-s7-opcua)

OPC UA at a glance

OPC Foundation

- Founded 1996 (OPC Classic specification) ,OPC UA specification release 2009
- More than 450 members from all areas



Collaborations

The OPC Foundation closely cooperates with organizations and associations from various branches. Specific information models of other standardization organizations are mapped onto OPC-UA and thus become portable.

PLCopen
for efficiency in automation

BACnet
INTEREST GROUP EUROPE

m2m
alliance

AVM
Verband für Automatische
Datenerfassung, Identifikation und Mobilität

MES DACH
VERBAND

ISA

FIELD COMM GROUP
Connecting the World of
Process Automation

FDT
Group

OMAC
The Organization for Machine
Automation and Control

OpenFog

MDIS

VDW

energistics
Energy Standards

MT Connect

OPC UA

EUROMAP
European Plastics and Rubber Machinery

VDMA

<AutomationML/>

W3C

CiA

CLPA
CC-Link

EtherCAT
Technology Group

IO-Link

**INDUSTRIAL
DATA SPACE e.v.**

ODVA

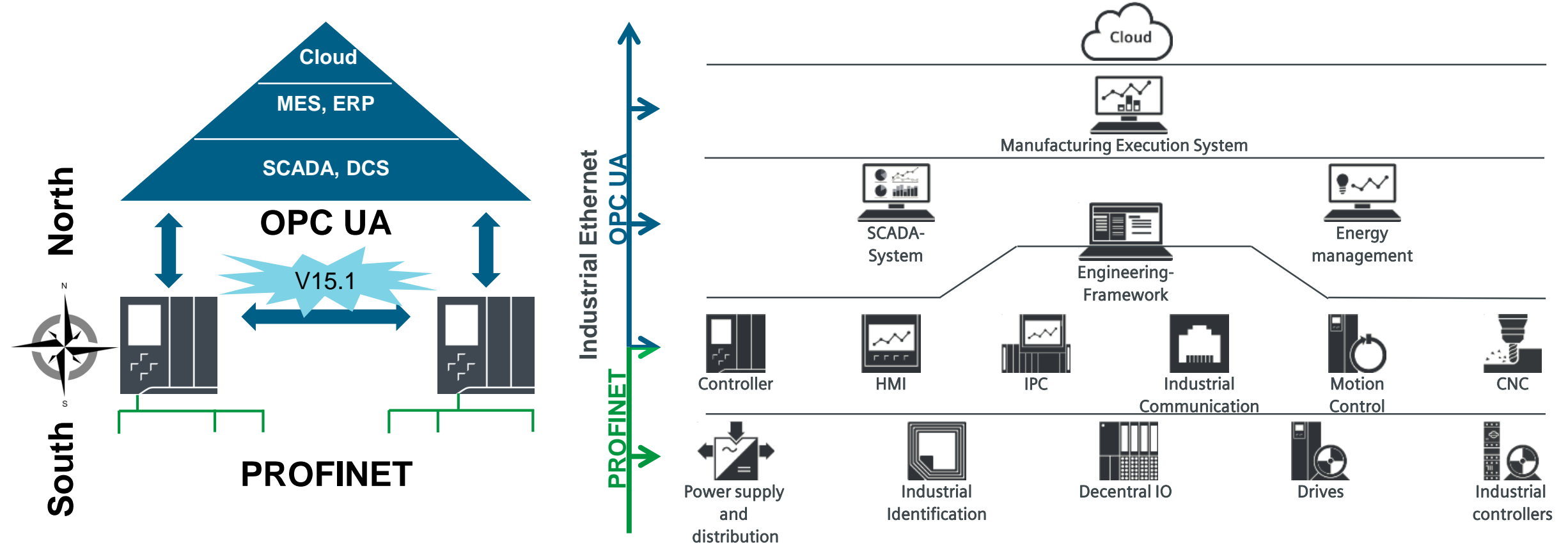
PI
PROFIBUS • PROFINET

**ETHERNET
POWERLINK**
Standardization Group

**SERCOS
international**

North-South Alignment

Strategic alignment of OPC UA and PROFINET

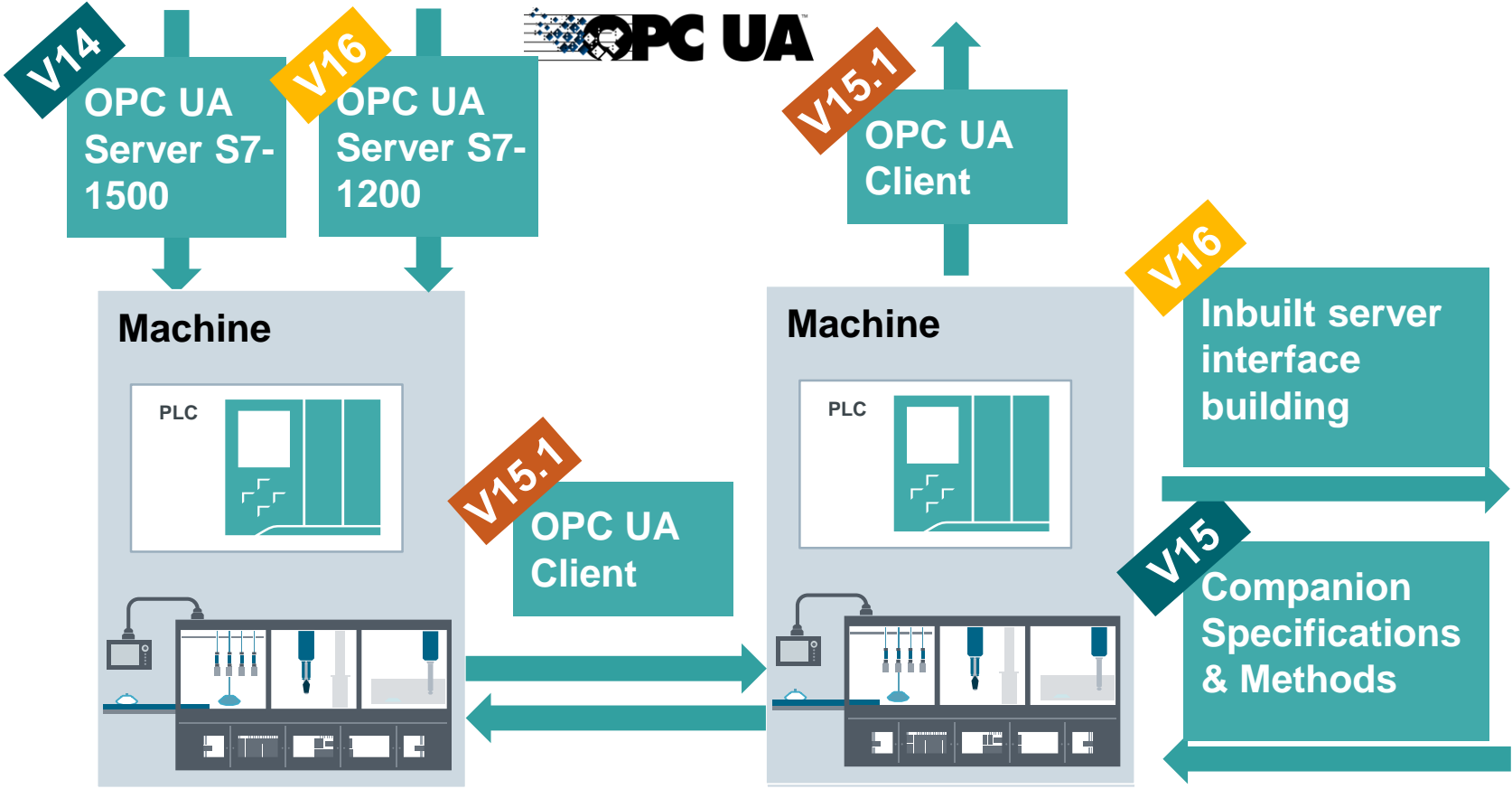


OPC UA Data Access Client (SIMATIC S7-1500)

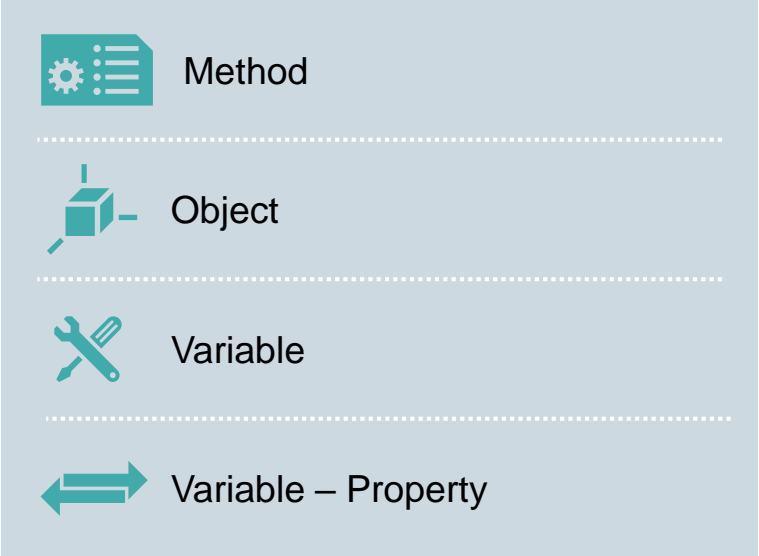
Customer use cases



Vertical Line Integration: e.g. MES, SCADA

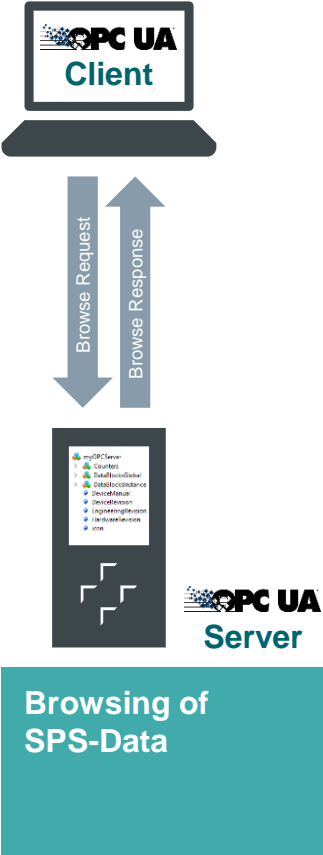


Industry Standard Support



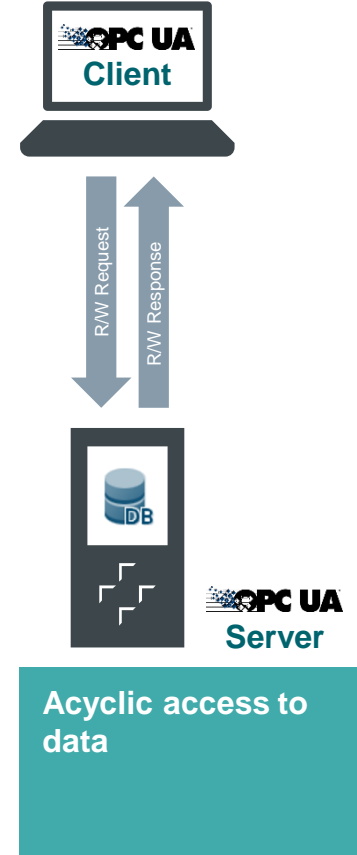
S7-1500 OPC UA Server

Browsing



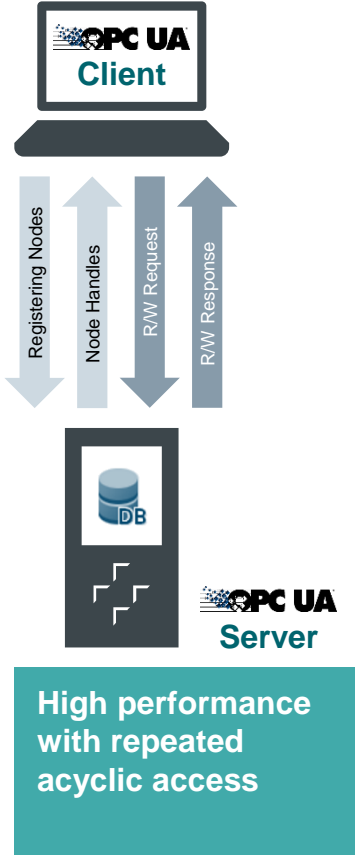
S7-1500 ✓ S7-1200 ✓

Read/Write



S7-1500 ✓ S7-1200 ✓

Registered Read/Write



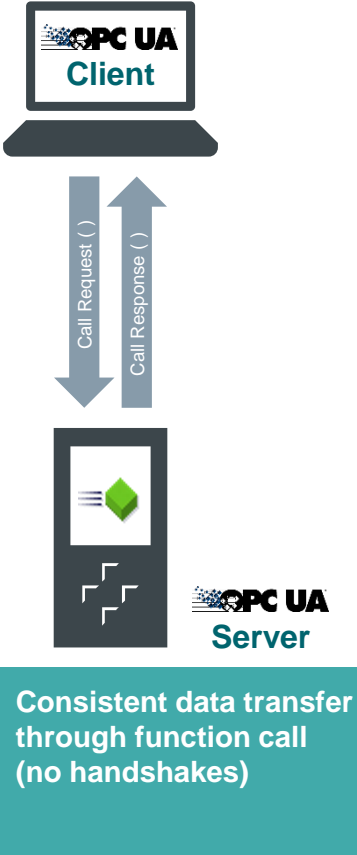
S7-1500 ✓ S7-1200 ✗

Subscription



S7-1500 ✓ S7-1200 ✓

Methods

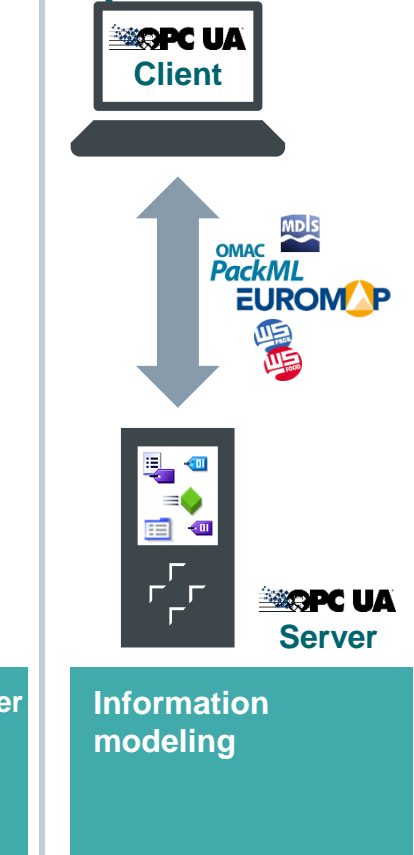


S7-1500 ✓ S7-1200 ✗

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Companion Specifications



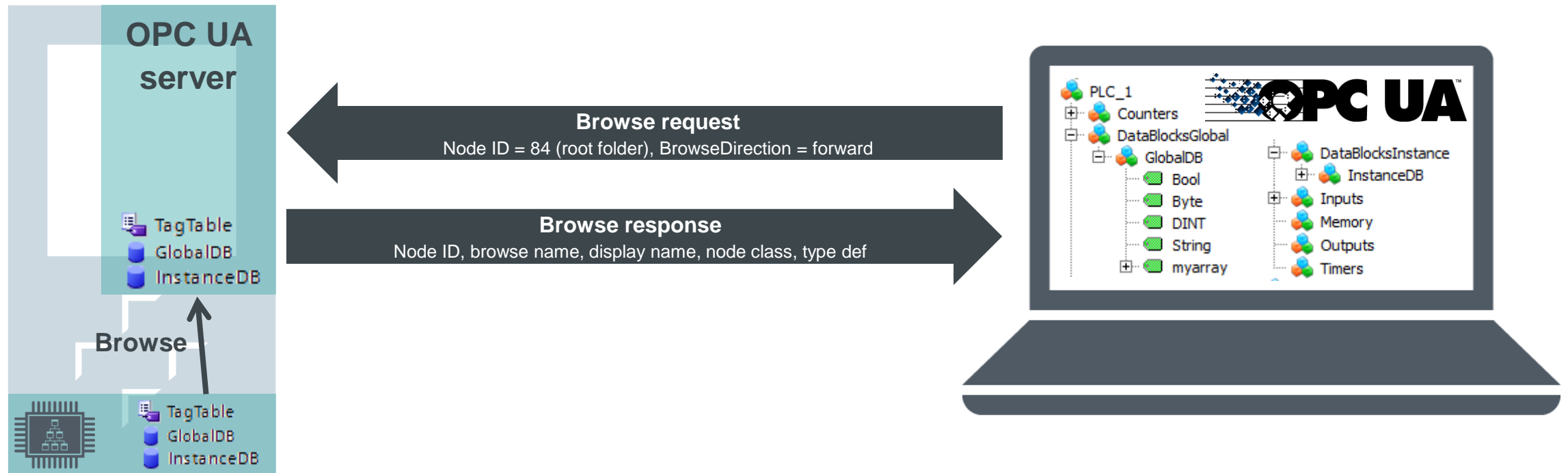
S7-1500 ✓ S7-1200 ✓

*: Only for user modelled interfaces

OPC UA Server for SIMATIC S7-1500 based CPUs

Functional scope

Browse

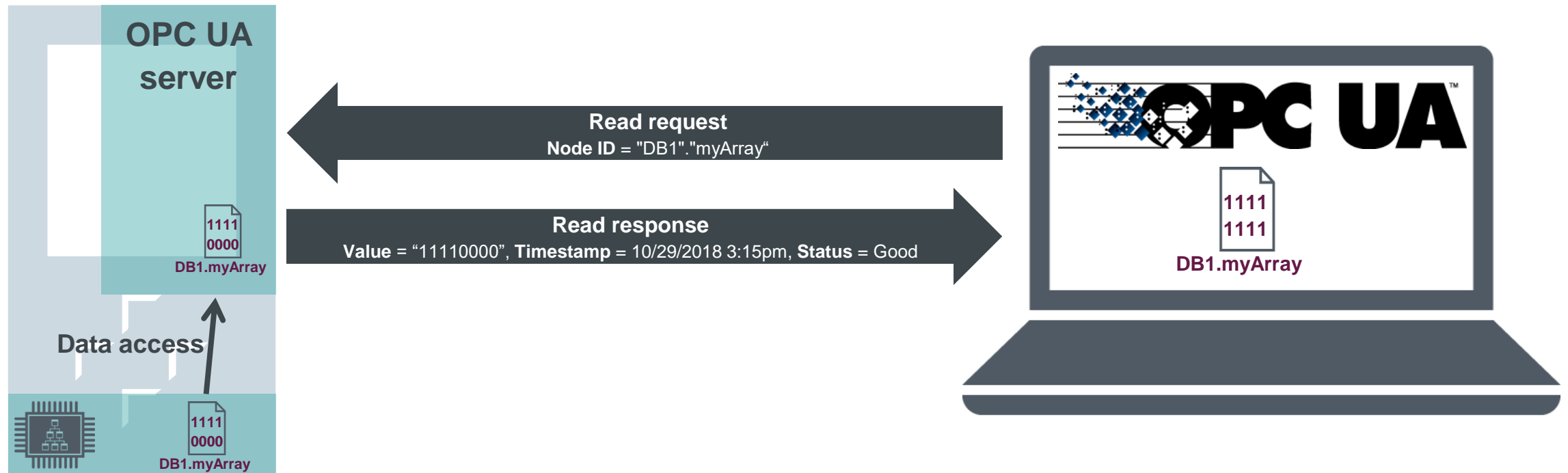


- Browsing of PLC Data • Dynamic adaptation of the client configuration to the data provided by a server

OPC UA Server for SIMATIC S7-1500 based CPUs

Functional scope

Read

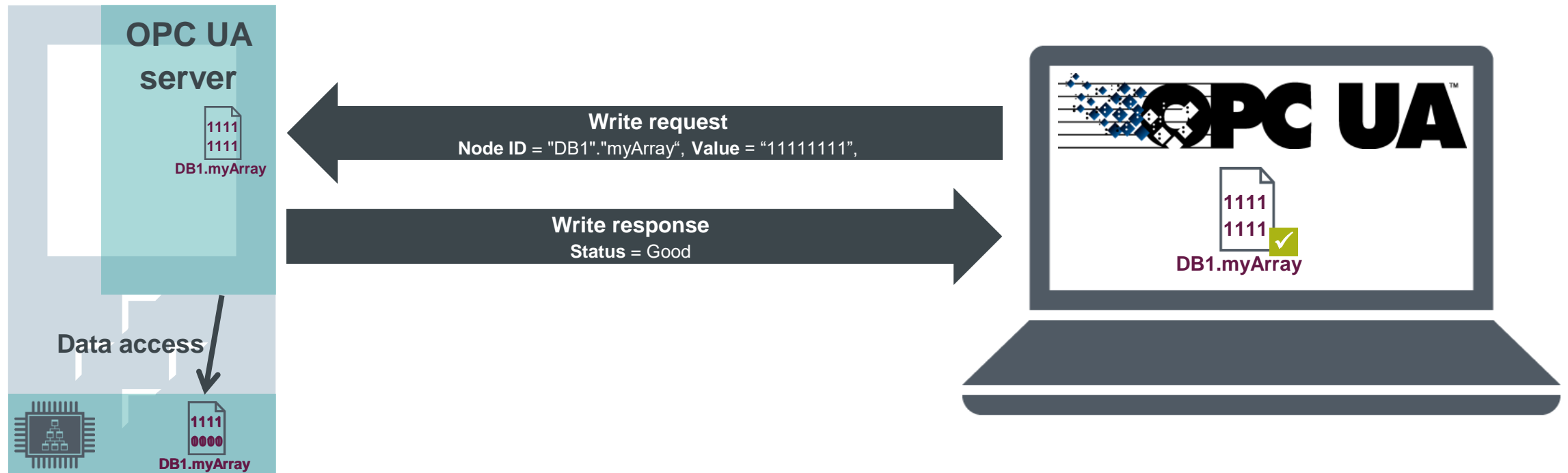


- Symbolic read access to PLC data

OPC UA Server for SIMATIC S7-1500 based CPUs

Functional scope

Write

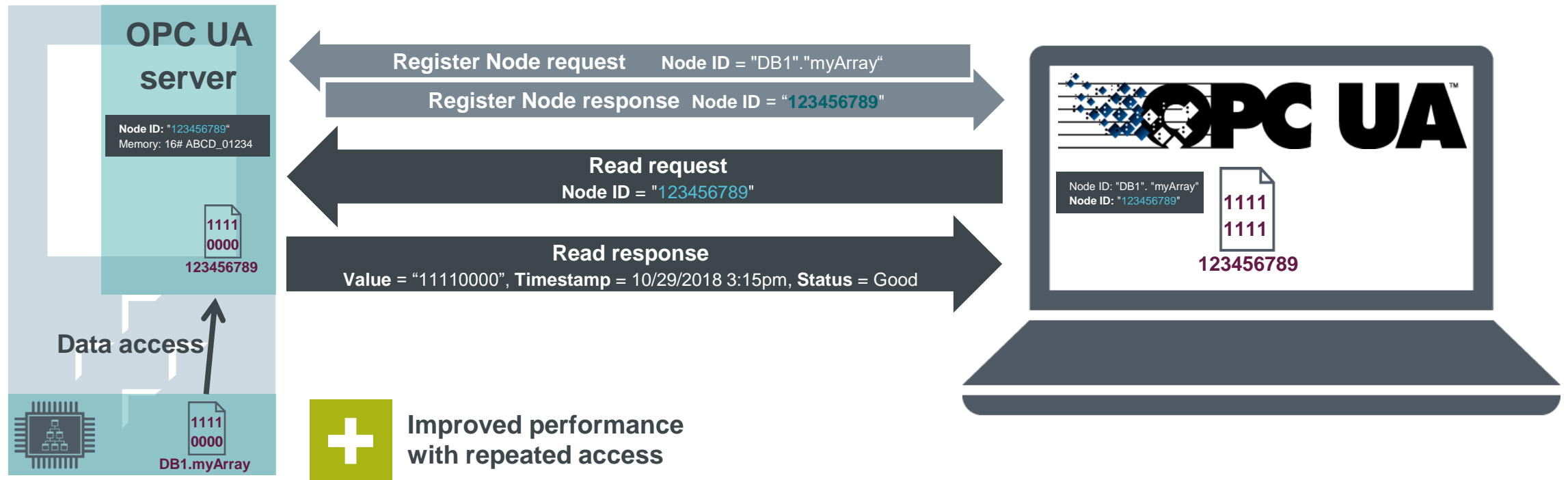


- Symbolic write access to PLC data

OPC UA Server for SIMATIC S7-1500 based CPUs

Functional scope

Registered Read

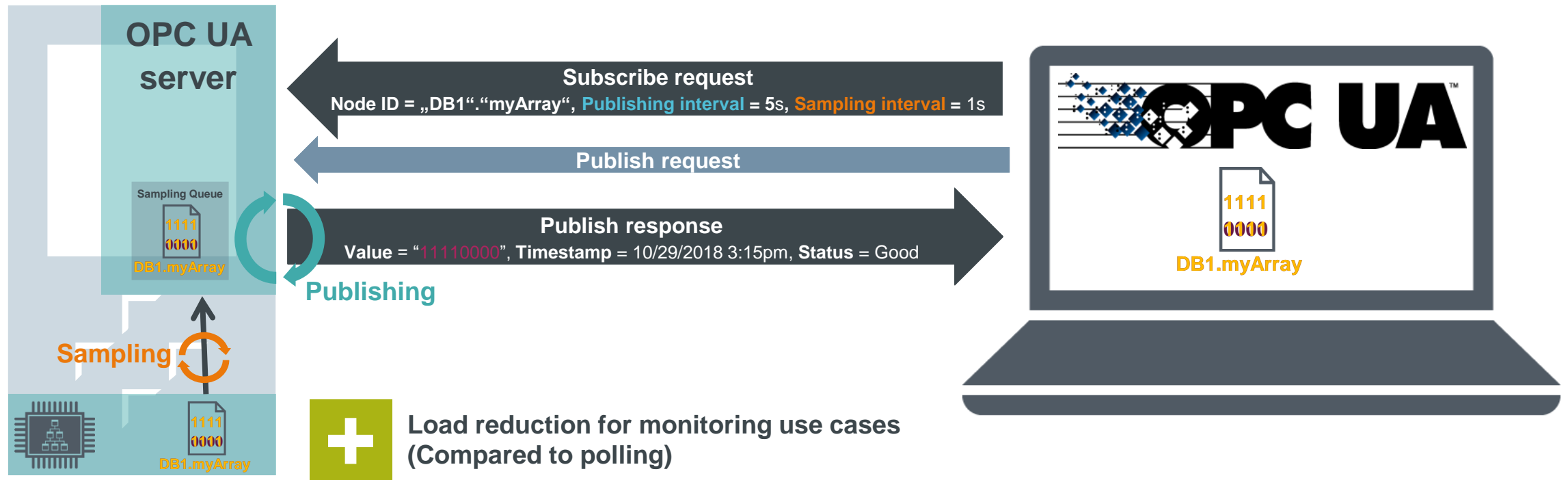


- Repeated access to PLC data

OPC UA Server for SIMATIC S7-1500 based CPUs

Functional scope

Subscribe



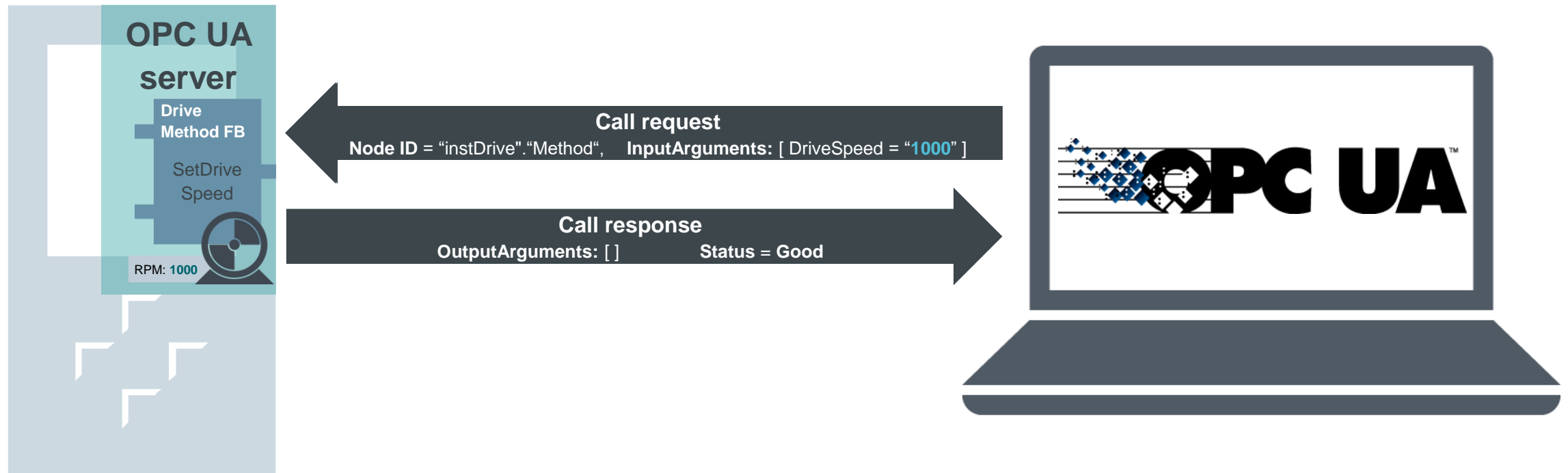
- Load reduction for monitoring use cases

- Absolute filters possible

OPC UA Server for SIMATIC S7-1500 based CPUs

Functional scope

Methods



- Consistent data transmission

- Request based interaction with the user program

OPC UA with SIMATIC CPUs

Access type recommendations

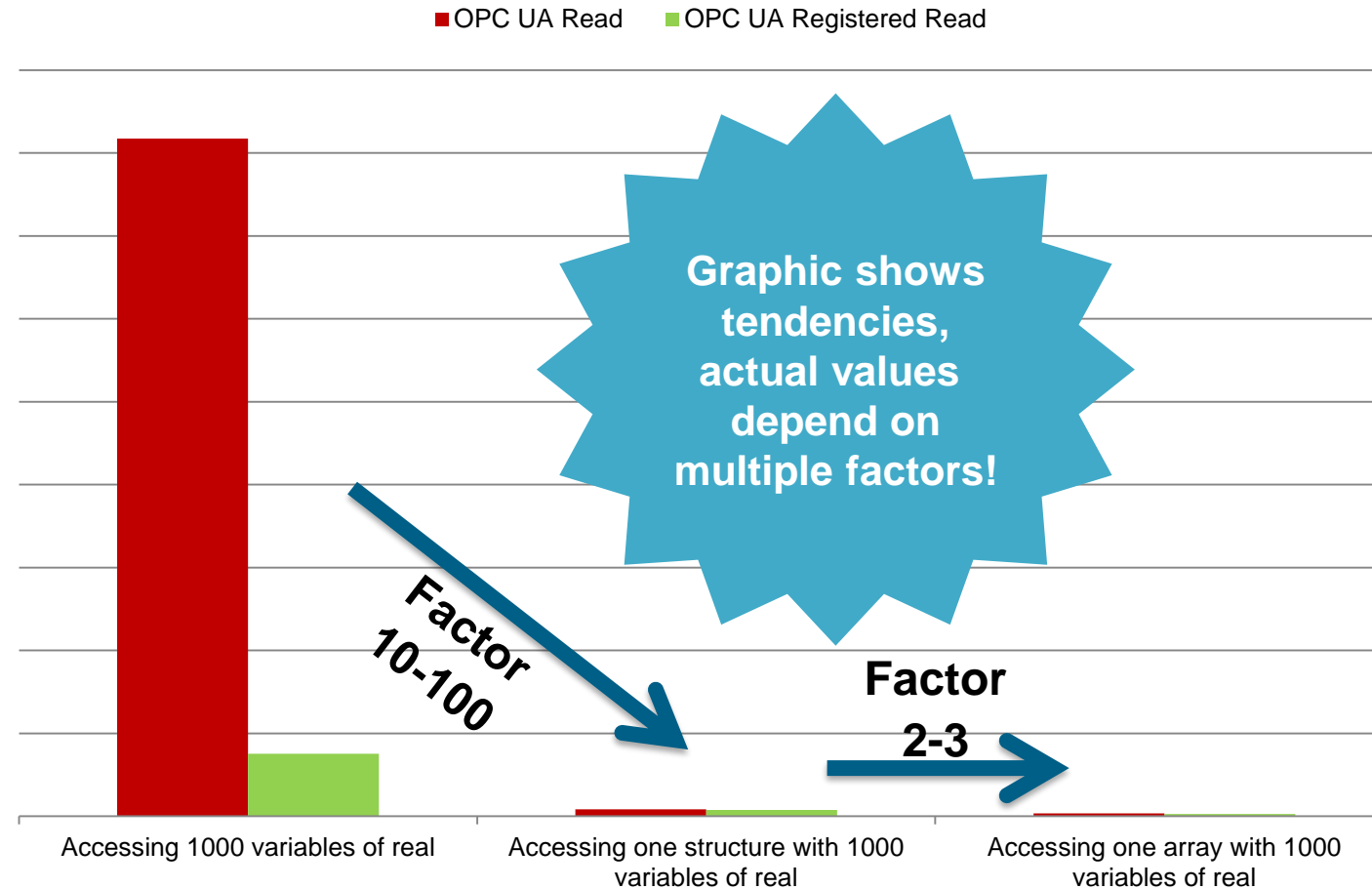
| Use case | | Recommended type of access |
|--|---|----------------------------|
| <ul style="list-style-type: none">Single or rare access of data | ▶ | Read / Write |
| <ul style="list-style-type: none">Cyclic read of data (≤ 10s)Monitor data | ▶ | Subscription |
| <ul style="list-style-type: none">High performance data access to predefined nodes | ▶ | Registered Read / Write |
| <ul style="list-style-type: none">Consistent data transferNo manual Handshake | ▶ | Methods |

Performance – Usage of arrays and structures whenever possible

PLC programmer

Always structure your data:

1. Arrays
2. Structures
3. Individual Variables



OPC UA Client programmer

Read arrays and
structures as a whole!

User OPC UA
“Registered Read” when
accessing the same
data recurrently

SIMATIC S7-1500 OPC UA Server

Functional scope - SiOME

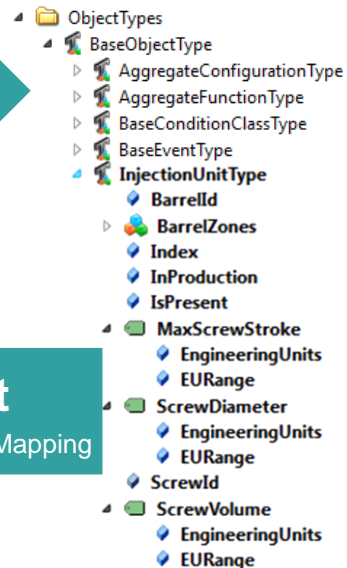
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Companion Specifications

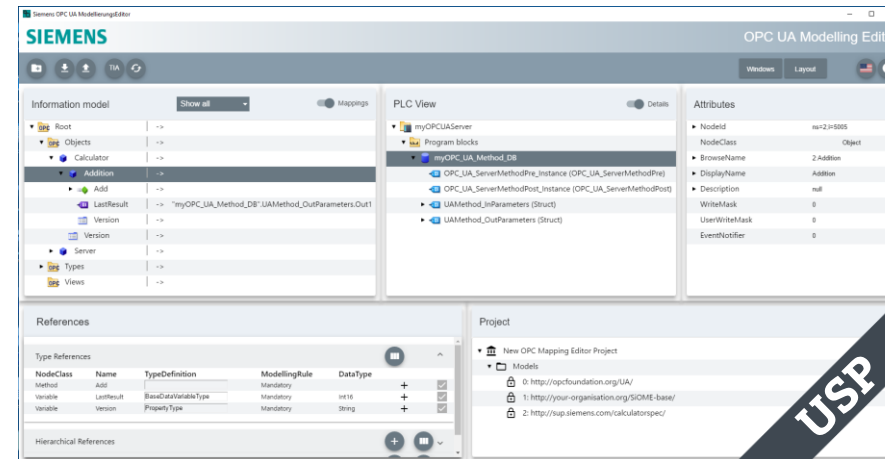


Import
Types according to
specification

Instances / models
> according to specification

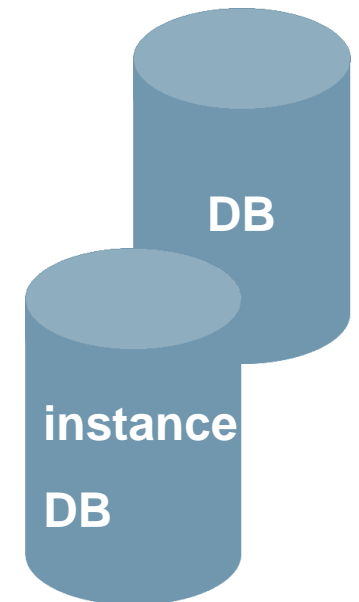


Export
Types, Instances, Mapping



<https://support.industry.siemens.com/cs/us/en/view/109755133>

Link



• Standardized OPC UA interfaces

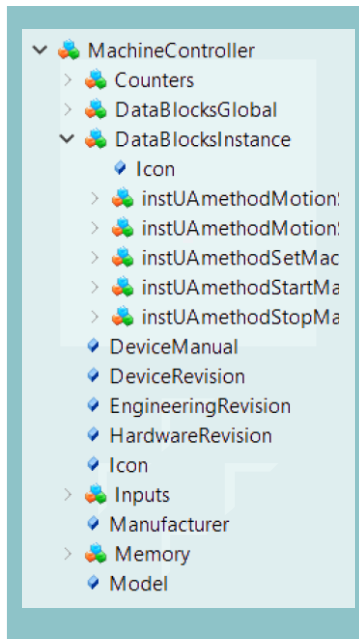
• Information modelling

OPC UA Server for SIMATIC S7-1500 based CPUs

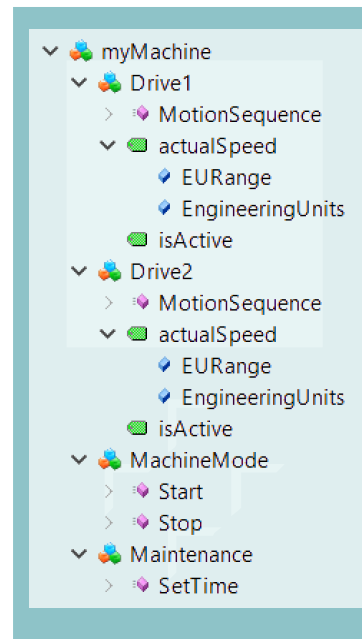
Functional scope

Companion Specifications

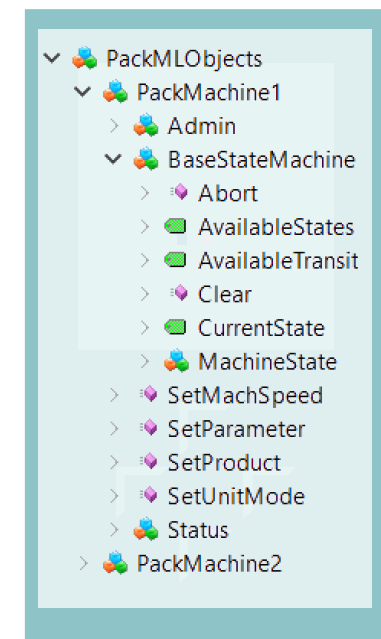
Standard SIMATIC interface



Additional interfaces



Companion specifications



OMAC
PackML



EUROMAP



• Standardized OPC UA interfaces

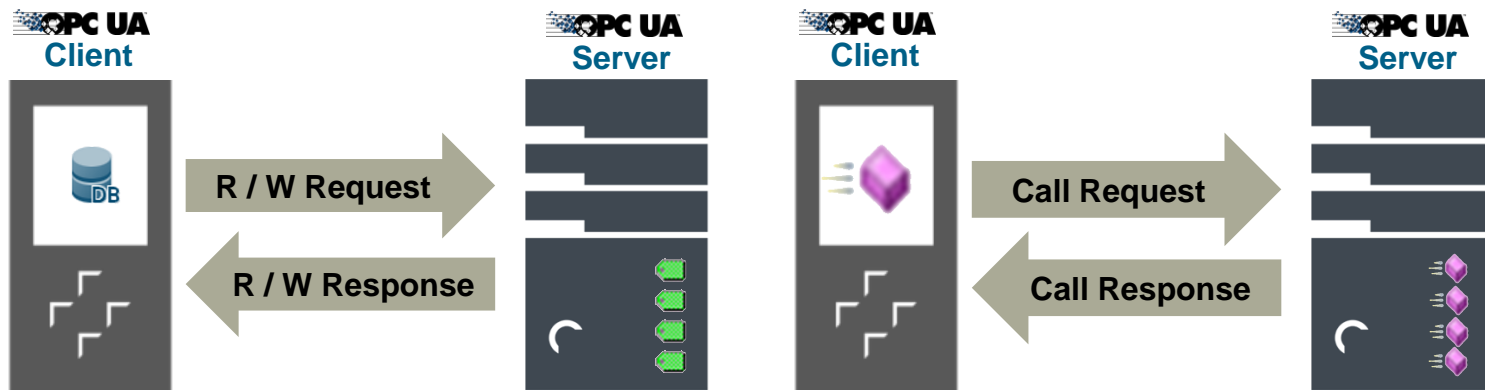
• Information modelling

OPC UA Data Access Client (SIMATIC S7-1500 based CPUs)

Functional scope from TIA V15.1 and FW 2.6

Read / Write

Method Call



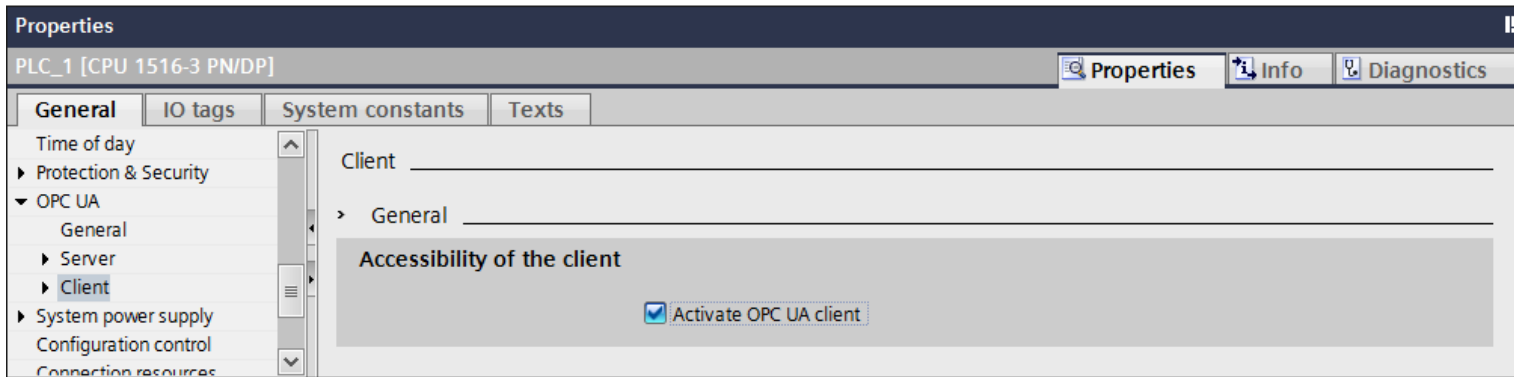
Asynchronous data access



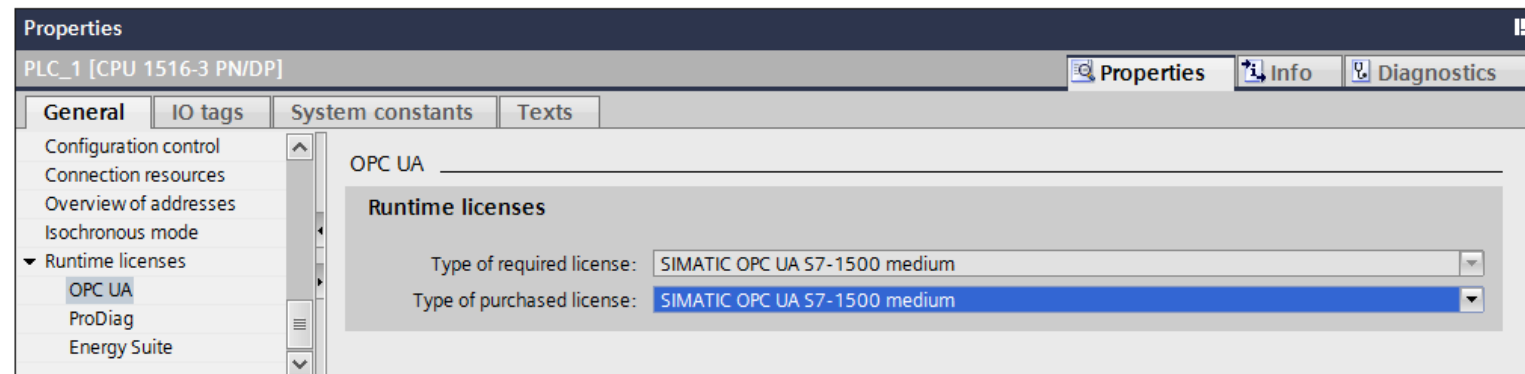
Consistent data transmission

OPC UA Data Access Client (SIMATIC S7-1500 based CPUs) Configuration

- The client must be activated in the device configuration



- OPC UA runtime license is necessary
(Server license includes client license)

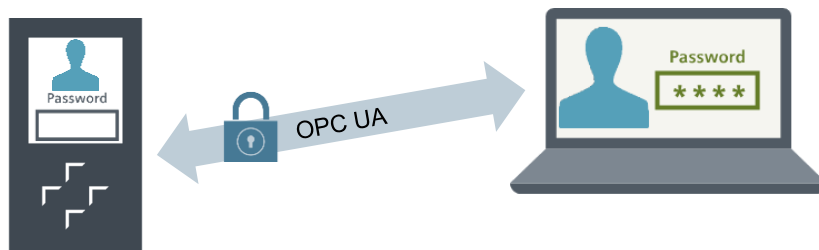


General

- OPC UA security actions are based on the following IT standards:
 - Encryption
 - Signing
 - Authentication via certificate and user accounts
- **Note:**
Security mechanisms have a negative effect on performance, especially when establishing a connection. While operating, performance is reduced by approx. 10%.

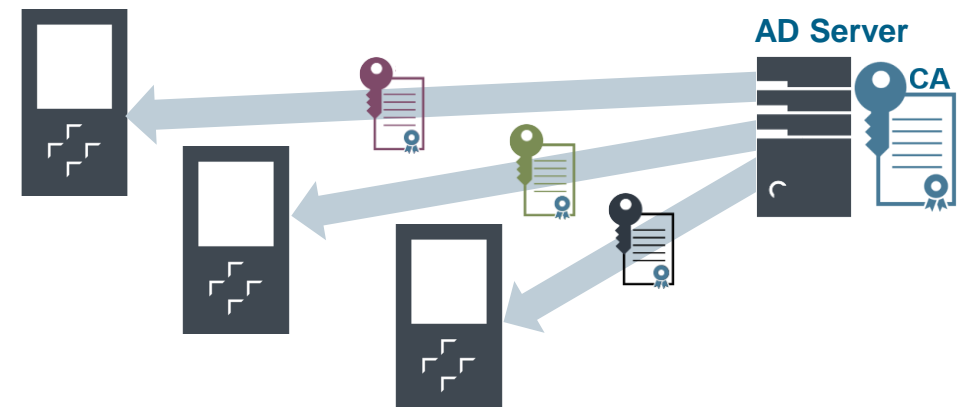
User Accounts

- The configuration of user accounts is analogue to the web server.
- The configuration is mostly self-explanatory



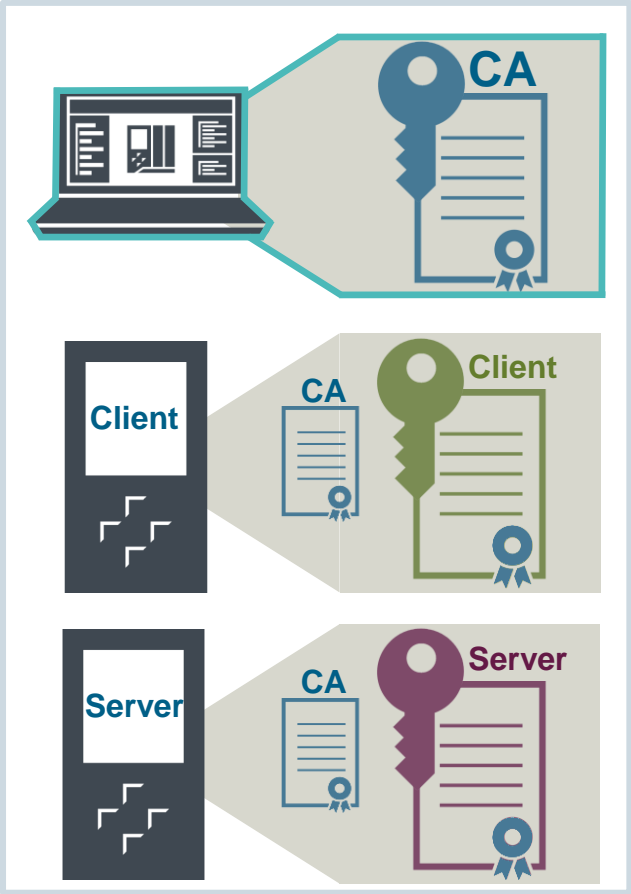
Certificates

- The management of the certificates must be coordinated in detail with the IT department of the user / customer.
- In many cases, certificates are managed centrally by the IT department, which increases the consulting effort massively.
- **Simple example:**
S7-1500 and Third Party Client with self-signed certificates
(<https://support.industry.siemens.com/cs/au/en/view/109737901>, chapter 2.1.4)
- **Consulting intensive example:**
Integration into existing IT infrastructure with certificate generation by Microsoft Active Directory

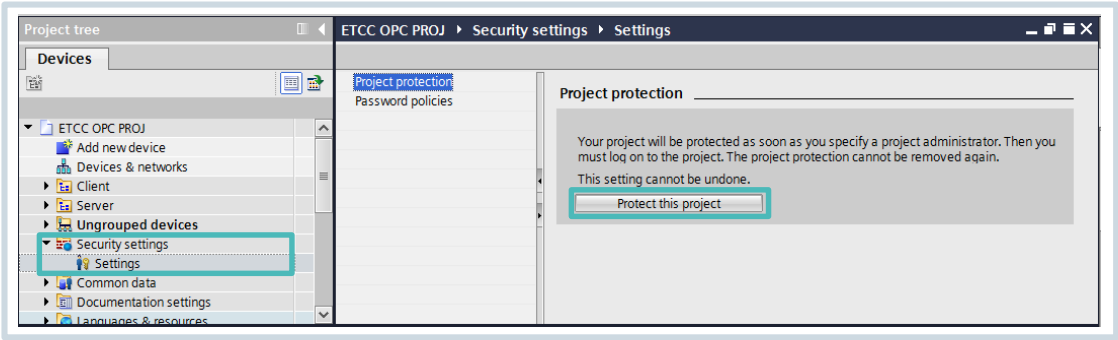


OPC UA Security

Certificate based authentication

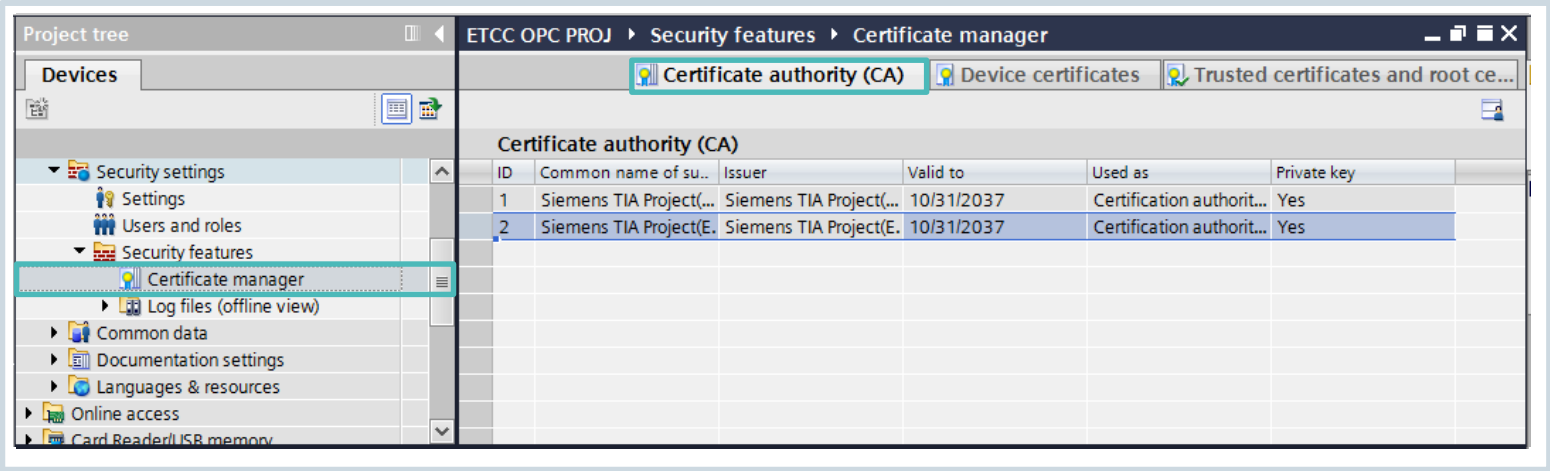


TIA Portal provides a project wide certification authority (CA)



Project protection is necessary to activate centralized certificate management

This enables the global certificate manager which includes the certification authority



OPC UA with SIMATIC S7 CPUs

Licensing



| CPU-Type | S7-1200 | ET 200SP CPU up to CPU 1513 | CPU 1515 / 1515SP PC CPU 1516 / 1516pro CPU 1507S | CPU 1517 / CPU 1518 / CPU 1508S (New) |
|------------------|-----------|-----------------------------------|---|---|
| Required License | Basic | small | medium | large |

OPC UA System limits S7-1200 & S7-1500

| | S7-1200 | CPU 1510...13 | CPU 1515/16 | CPU 1517/18 |
|---|---|---------------|-------------|-------------|
| No. of sessions, max. | 5 | 32 | 48 | 64 |
| No. of accessible variables, max. | 1,000 | 50,000 | 100,000 | 200,000 |
| No. of registerable nodes, max. | - | 10,000 | 20,000 | 50,000 |
| No. of subscriptions per session, max. | 5 | 20 | 20 | 20 |
| Sampling interval, min. | 100 ms | 100 ms | 100 ms | 10 ms |
| Publishing interval, min. | 200 ms | 500 ms | 200 ms | 10 ms |
| No. of server methods, max. | - | 20 | 50 | 100 |
| No. of in/outputs per server method, max. | - | 20 | 20 | 20 |
| No. of monitored items, recommended. | 500 (max.) | 1,000 | 2,000 | 10,000 |
| | for 1 s sampling interval and 1 s publishing interval | | | |
| No. of server interfaces, max. (SIMATIC, Information m., Reference m.) | 2/2/x | 10/10/20 | 10/10/20 | 10/10/20 |
| No. of nodes for server interfaces, max. | 1,000 | 1,000 | 5,000 | 30,000 |

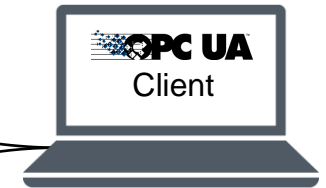
Guideline 1: Requirement for good performance

Structuring and registering data

- **Structuring of data budget required**
(e.g. Transfer oriented storage of data in UDTs)
→ The Client has to support access to UDTs
- Alternative: Using registered Read / Write
→ The Client has to support registered access

Example: Modeling of system components in UDTs

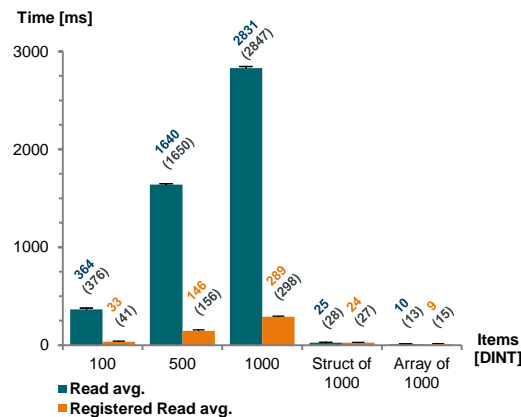
| | Name | Data type |
|----|----------------|----------------------|
| 1 | Static | |
| 2 | LeftConveyor | "typeConveyor" |
| 3 | LeftDrive | "typeConvDrive" |
| 4 | RPM | Real |
| 5 | Current | Real |
| 6 | Voltage | Real |
| 7 | Temperature | Real |
| 8 | LeftSensor | "typeConvSensor" |
| 9 | Signal | Bool |
| 10 | SignalQuality | Int |
| 11 | RightDrive | "typeConvDrive" |
| 12 | RPM | Real |
| 13 | Current | Real |
| 14 | Voltage | Real |
| 15 | Temperature | Real |
| 16 | RightSensor | "typeConvSensor" |
| 17 | Signal | Bool |
| 18 | SignalQuality | Int |
| 19 | ProductionUnit | "typeProductionUnit" |
| 20 | Position | Real |
| 21 | RPM | Real |
| 22 | Status | Int |
| 23 | RightConveyor | "typeConveyor" |
| 24 | <Add new> | |



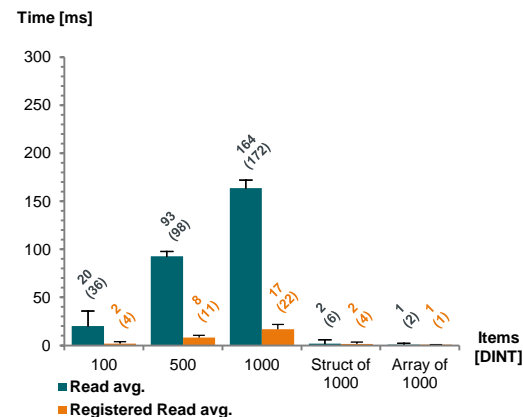
**Full access to UDTs
(Conveyor and ProductionUnit)**
→ High performance access to only three elements



Measuring (CPU 1516)



Measuring (CPU 1518)



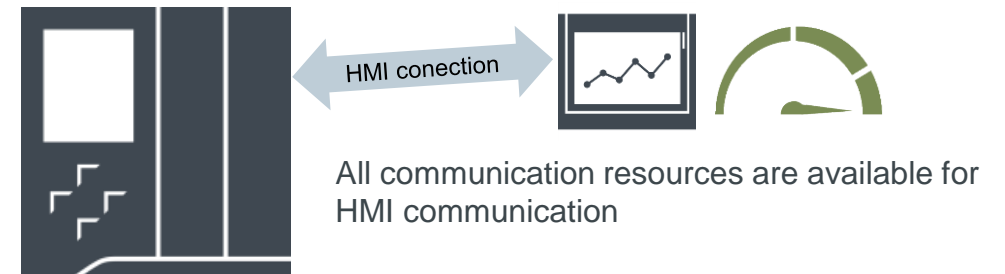
- Registered access is approx. 10 times faster
- Structured access is approx. 100 times faster
- The CPU 1517/18 is up to 18 times faster compared to smaller CPUs

Guideline 2: Influence on other types of communication

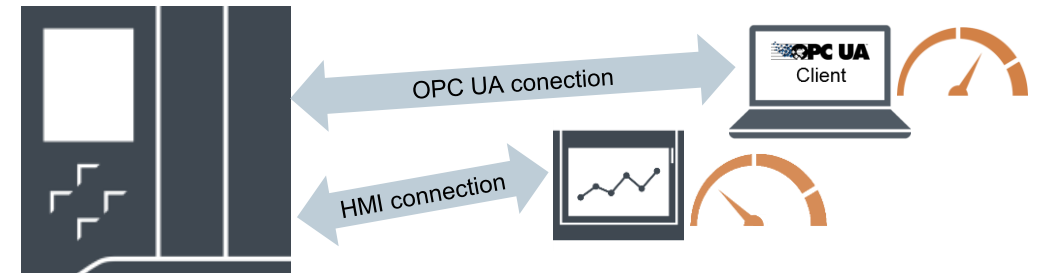
Resource pool for communication

- **Note:** Within the S7-1500 exists **only one resource pool** for all non real-time communication types. (Webserver, alarms, HMI, TCP, UDP, S7, etc.)
- The size of this resource pool can be influenced by the setting „maximum cycle load by communication“ and „minimum cycle time“.
- Due to its own resource pool, cyclic real-time communication (e.g. PROFINET) has no influence on / through OPC UA.
- The load due to OPC UA may fluctuate greatly under certain circumstances (login processes of OPC UA clients, for example, create a temporarily high communication load).

Example: HMI communication without influence of OPC UA



Example: HMI communication with influence of OPC UA

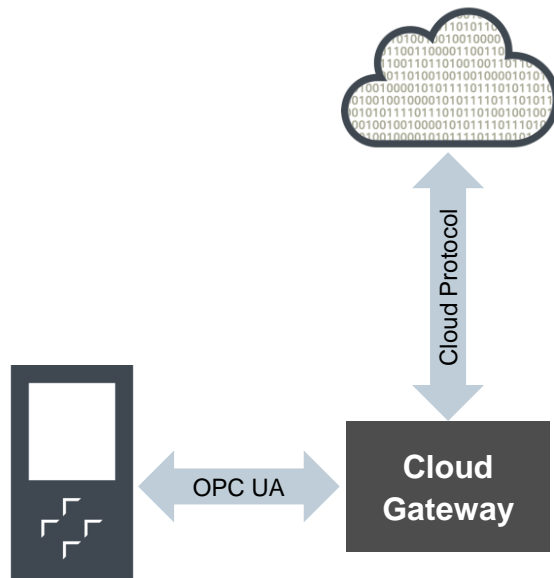


The HMI communication is slowed down depending on the OPC UA client.
(HMI and OPC UA client share the PLC communication resources)

Guideline 3: Quantity structures

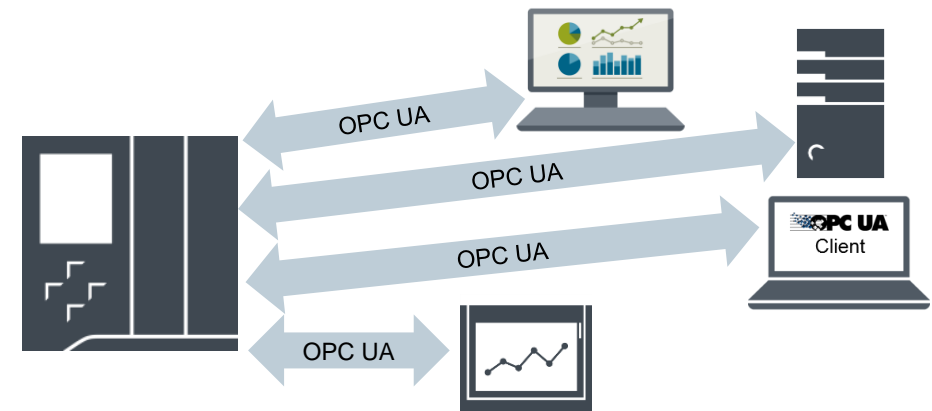
Small quantity structures

- **Small quantity structures** without strict time requirements are usually not critical
- **Example:**
Transfer of machine status and energy data (approx. 100 data points per second) to a cloud gateway



Large quantity structures

- **Large quantity structures** should be coordinated with the technical advisor (the possible quantity structures depend strongly on the client).
- **Example:**
Use of OPC UA as an integrated communication standard for HMI, SCADA, MES with more than 1000 data points per second.
- **General:**
The maximum quantity structures of the CPU 1517 and 1518 are up to a factor of 10 higher compared to smaller CPUs (e.g. 1510).



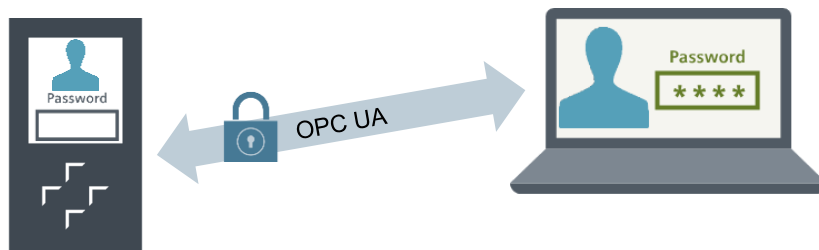
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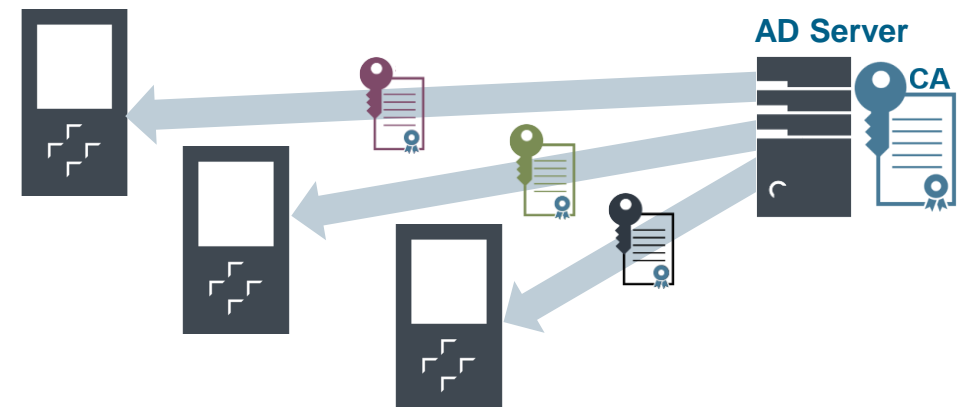
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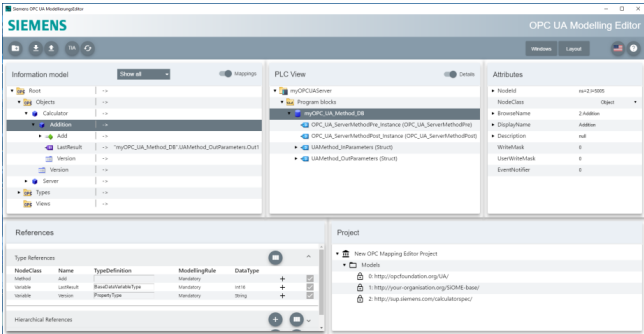
Guideline 5: Standards via information models (Companion Specifications)



Predefined and simple customized models

- The integration of predefined models (e.g. Euromap 77) can be done with SiOME according to the application example.
- Simple interfaces can also be created with SiOME by following the instructions.

Application example for SiOME:
<https://support.industry.siemens.com/cs/au/en/view/109755133>



Creating companion specifications and customer-specific standards

- Creating full Companion Specifications requires in-depth knowledge of the OPC UA standard.

Cross-industry Companion Specifications (e.g. PackML or Euromap77) are therefore created in respective expert circles.

- Furthermore, each specification must be checked for compatibility with the S7-1500.
- For major standardizations, discuss with Siemens

Table 3 – PackMLBaseObjectType Definition

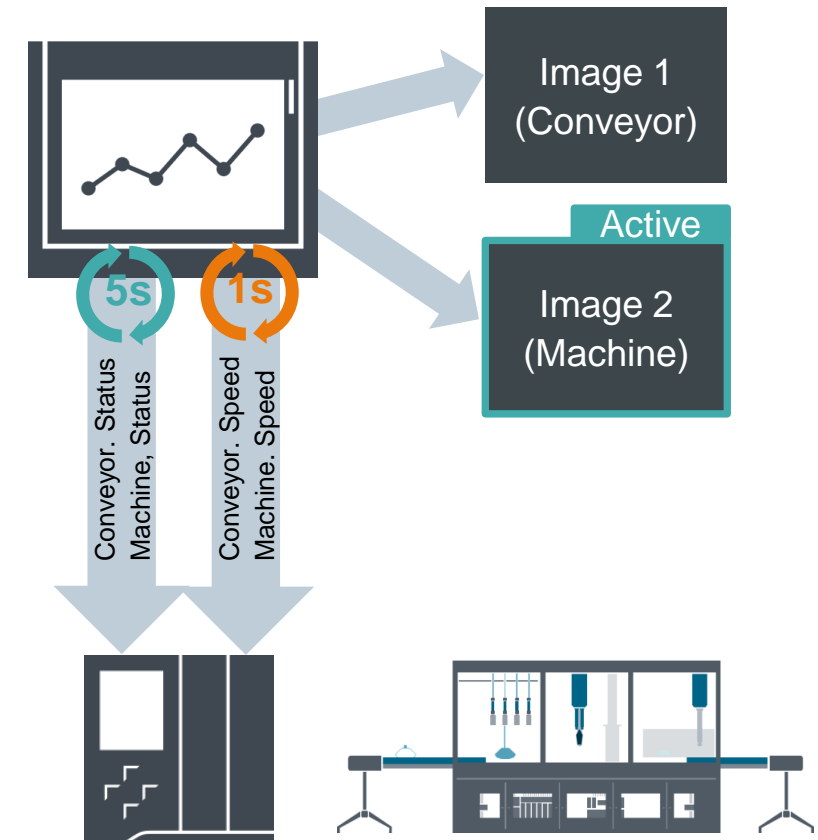
| Attribute | Value | | | | | |
|--|----------------------|------------------|---------------------------|----------------------------|----------------|----|
| BrowseName | PackMLBaseObjectType | | | | | |
| IsAbstract | False | | | | | |
| Reference | Node Class | BrowseName | Data Type | Type Definition | Modelling Rule | RW |
| Subtype of the <i>BaseObjectType</i> from OPC UA Part 5. | | | | | | |
| HasProperty | Variable | TagID | String | PropertyType | Optional | |
| HasProperty | Variable | PackMLVersion | String | PropertyType | Optional | |
| HasComponent | Object | Admin | | PackMLAdminObjectType | Mandatory | |
| HasComponent | Object | Status | | PackMLStatusObjectType | Mandatory | |
| HasComponent | Object | BaseStateMachine | | PackMLBaseStateMachineType | Mandatory | |
| HasComponent | Method | SetUnitMode | Defined in section 6.7.2 | | Mandatory | |
| HasComponent | Method | SetMachSpeed | Defined in section 6.7.3 | | Mandatory | |
| HasComponent | Method | SetProduct | Defined in section 6.7.4 | | Mandatory | |
| HasComponent | Method | SetParameter | Defined in section 6.7.17 | | Mandatory | |
| HasComponent | Method | RemoteCommand | Defined in section 6.7.15 | | Optional | |
| HasComponent | Method | SetInterlock | Defined in section 6.7.16 | | Optional | |


Guideline 6: Use Case: Monitoring via HMI

Monitoring via OPC UA Subscriptions

- The definition of the subscriptions should be aligned with the display mechanisms.
(Avoiding unnecessary communication)
- Only variables that are displayed should be activated.
(Switching between modes „Disabled“ and „Reporting“)
- Subscriptions should be created during connection setup and changed as little as possible during runtime.
(communication load due to log-on procedures)
- Data should be divided into different update cycles(e.g. 1s and 5s)
(Each cycle then represents a subscription with one or more monitored items)

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 Optimizing through structured data storage is essential
(Especially for larger quantity structures, see guideline 1)

Guideline 7: Use Case: Connection to overlaid systems

Usage of OPC UA client functions

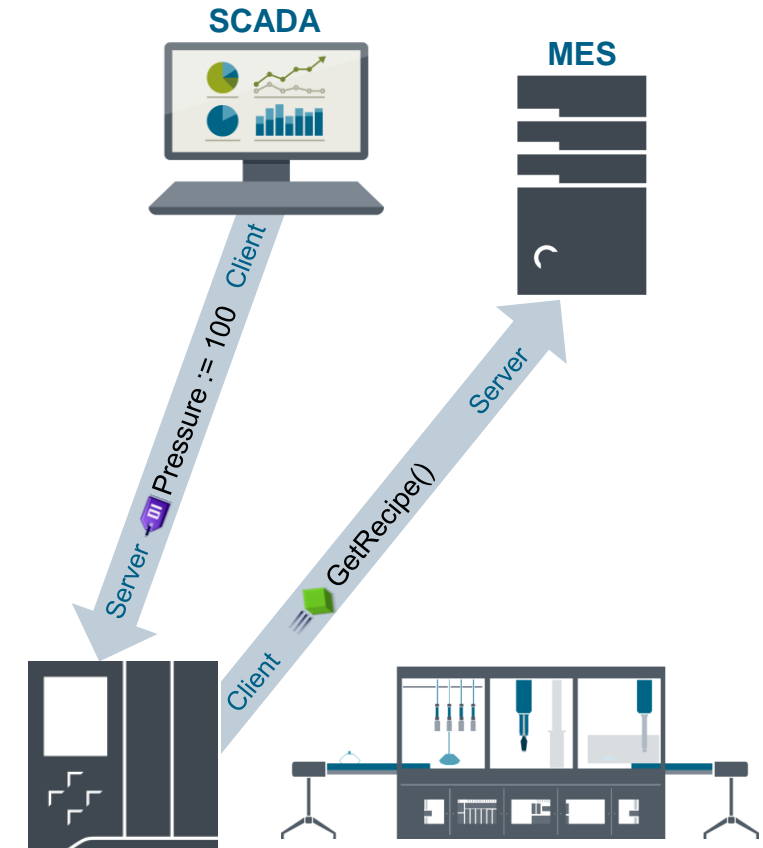
- Data transfer is initiated by PLC
(e.g. machine actively requests order at MES)

Usage of OPC UA server functions

- Data transfer is initiated by the overlaid system
(e.g. operator changes a parameter on SCADA)

Usage of OPC UA methods

- Data consistency is required (e.g. recipes, quality data)
- The overlaid system starts a program sequence in the PLC.
(e.g. controlled start or stop of the machine)



Feature set of server and client have to be aligned

Guideline 8:

Use Case: Communication between several S7-1500

Read / Write access

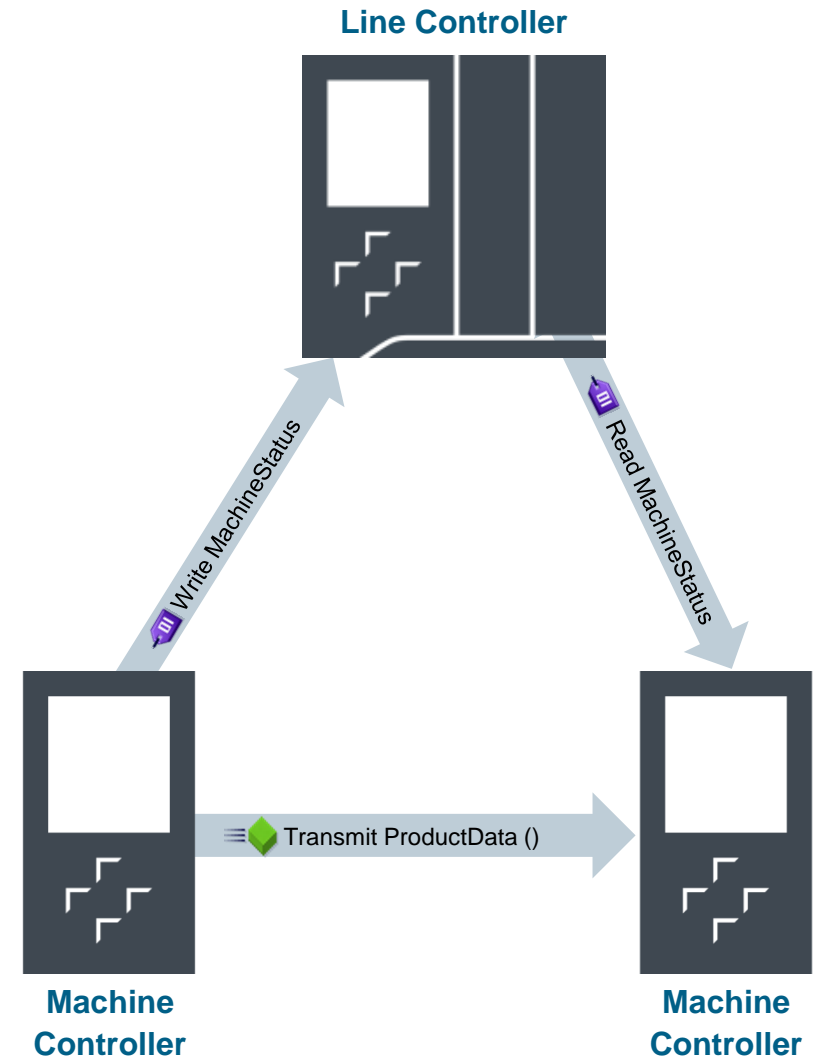


- If data consistency is not required, read/write mechanisms are sufficient.
(e.g. monitoring of machine status at the line controller)
- Access by the S7-1500 OPC UA Client is always registered according to PLC open specification.
(Third Party Clients can also access the S7-1500 OPC UA Server unregistered)

Methods



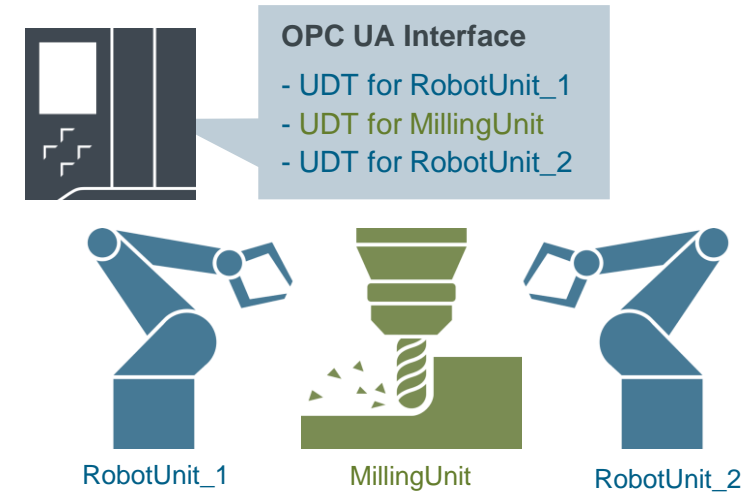
- For consistent data transfer it is recommended to use OPC UA methods
(e.g. transfer of production data between two machines)



Practical example 1: Using OPC UA as communication standard to Third Party SCADA

Requirements

- OPC UA is designed to be used as communication standard between PLC and SCADA
- The number of single variables significantly exceeds the subscription quantity structure of 10000 monitored elements (see data sheet SIMATIC CPU 1518)



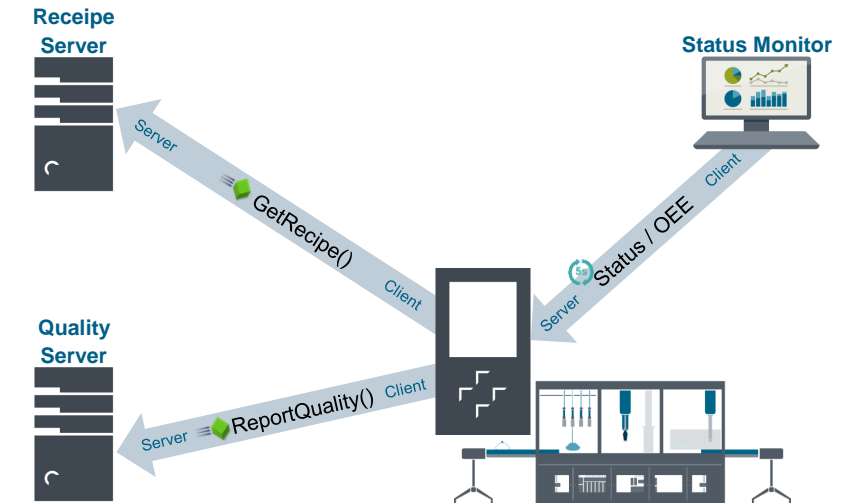
Suggested solution

- a. Synchronization of the data budget between HMI and PLC → [Guideline 1, Performance](#)
 - Definition of PLC data in UDTs (e.g. UDT for robots incl. sensors)
 - Use of this data structure in the HMI (e.g. faceplate based on robot UDT, subscription to entire UDT)
→ Reduction of the quantity structure to a small fraction of the original requirement (using the same data volume)
- b. Classification of data by different sampling and publishing intervals (e.g. 100ms, 1s, 5s) → [Guideline 6, Subscriptions](#)
- c. Deactivating unused data points to avoid unnecessary communication → [Guideline 6, Subscriptions](#)
(e.g. activating data points for faceplate call)

Practical example 2: Production control and collection of OEE data

Requirements

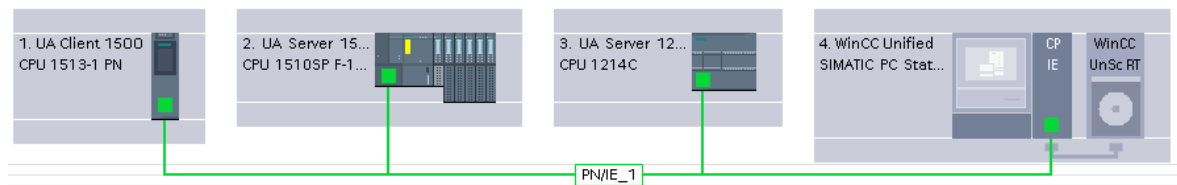
- OPC UA is designed to be used for the following data transfers to connect to plant systems:
 - Recipe requests from the PLC to plant systems (approx. 300 elements)
 - Monitoring of the machine status (approx. 50 variables)
 - Transfer of data after completing a production step (approx. 200 elements)
 - Time requirement: 250ms Transfer time before and after production of a component



Suggested solution

- a. Definition of a standardized format for data about recipe and quality as UDT for all machines → [Guideline 1, Performance](#)
- b. Using the S7-1500 OPC UA Client to consistently transfer data about recipe and quality → [Guideline 7, Methods](#)
(PLC knows first when a new recipe is needed / when data about quality is available)
- c. Usage of a subscription to transfer status and OEE data → [Guideline 6, Subscriptions](#)
(No consistency required, data rarely changes, subscription with 5s intervals is sufficient)

LIVE DEMO



| OPC UA server interface | | | | OPC UA elements | |
|-------------------------|---------------------------------|------------|--|-----------------------|-------------------------|
| Browse name | Node type | Local data | | Project data | Data type |
| 1. Server interface_1 | Interface | | | 1. Program blocks | |
| 2. Machine Data | Object | | | 2. Machine Data [DB9] | Machine Data |
| 3. Machine 1 | Production Data | | | 3. Machine 1 | Production Data |
| 4. Machine 2 | Production Data | | | 4. Machine 2 | Production Data |
| 5. Machine 3 | Production Data | | | 5. Machine 3 | Production Data |
| 6. Machine 4 | Production Data | | | 6. Machine 4 | Production Data |
| 7. Line 1 | ARRAY[0..99] of Production Data | | | 7. Line 1 | Array[1..100] of Pro... |
| 8. <Add new> | | | | 8. Technology objects | |
| | | | | 9. PLC tags | |
| | | | | 10. Default tag table | |

- TIA Tips & Tricks
- OPC UA Server Interface setup 1200/1500
- OPC UA Client setup & testing
- OPC UA Performance monitoring & influences



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