OPC UA for S7-1500 and S7-1200
OPC UA at a glance
OPC Foundation

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

Siemens AG
SAP AG
Fraunhofer IOSB
Bosch Software Innovations GmbH

PHOENIX CONTACT
Cisco Systems
Yokogawa Electric Corporation
Unified Automation GmbH

ABB Automation GmbH
Bosch Rexroth AG
Emerson Process Management
Honeywell Inc

HMS Industrial Networks
Rockwell Automation
Softing Industrial
Endress+Hauser Process Solutions AG

Bundesamt für Sicherheit in der Informationstechnik (BSI)

ProSoft Technology
Microsoft Corporation
FANUC CORPORATION
CERN

ABB Automation GmbH
IBM

Festo AG & Co. KG
Schneider Electric

B&R
B&R

GE
Pilz GmbH & Co. KG

Hilscher Gesellschaft für Systemautomation mbH
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.
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

OPC UA Server S7-1500
OPC UA Server S7-1200
OPC UA Client
OPC UA Client
Inbuilt server interface building
Companion Specifications & Methods

Method
Object
Variable
Variable – Property
S7-1500 OPC UA Server

Browsing

- Browsing of SPS-Data
- Acyclic access to data

Read/Write

- High performance with repeated acyclic access
- Load reduction for HMI / monitoring applications

Registered Read/Write

- Node Handles
- Sampling

Subscription

- Publishing
- Consistent data transfer through function call (no handshakes)

Methods

- Information modeling

* Only for user modelled interfaces
OPC UA Server for SIMATIC S7-1500 based CPUs

Functional scope

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

**Browse**

**Browse request**
Node ID = 84 (root folder), BrowseDirection = forward

**Browse response**
Node ID, browse name, display name, node class, type def

OPC UA server

- TagTable
- GlobalDB
- InstanceDB

Browse
OPC UA Server for SIMATIC S7-1500 based CPUs

Functional scope

Read

• Symbolic read access to PLC data

Read request
Node ID = "DB1.myArray"

Read response
Value = "11110000", Timestamp = 10/29/2018 3:15pm, Status = Good
OPC UA Server for SIMATIC S7-1500 based CPUs

Functional scope

- Symbolic write access to PLC data

Write request
Node ID = "DB1.myArray", Value = "11111111".

Write response
Status = Good

1111 1111
DB1.myArray

✓
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

- Load reduction for monitoring use cases
- Absolute filters possible

Subscribe

OPC UA server

Subscribe request
- Node ID = "DB1.myArray"
- Publishing interval = 5s
- Sampling interval = 1s

Publish request

Publish response
- Value = "11110000"
- Timestamp = 10/29/2018 3:15pm
- Status = Good

Load reduction for monitoring use cases (Compared to polling)
OPC UA Server for SIMATIC S7-1500 based CPUs

Functional scope

**Methods**

Call request
- **Node ID**: "instDrive"."Method",
- **InputArguments**: [DriveSpeed = "1000"]

Call response
- **OutputArguments**: []
- **Status**: Good

• Consistent data transmission
• Request based interaction with the user program
## OPC UA with SIMATIC CPUs
### Access type recommendations

<table>
<thead>
<tr>
<th>Use case</th>
<th>Recommended type of access</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Single or rare access of data</td>
<td>Read / Write</td>
</tr>
<tr>
<td>• Cyclic read of data (≤ 10s)</td>
<td>Subscription</td>
</tr>
<tr>
<td>• Monitor data</td>
<td>Registered Read / Write</td>
</tr>
<tr>
<td>• High performance data access to predefined nodes</td>
<td>Methods</td>
</tr>
<tr>
<td>• Consistent data transfer</td>
<td></td>
</tr>
<tr>
<td>• No manual Handshake</td>
<td></td>
</tr>
</tbody>
</table>
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

Graphic shows tendencies, actual values depend on multiple factors!

Factor 10-100
Factor 2-3

- OPC UA Read
- OPC UA Registered Read

- Accessing 1000 variables of real
- Accessing one structure with 1000 variables of real
- Accessing one array with 1000 variables of real
SIMATIC S7-1500 OPC UA Server
Functional scope - SiOME

Companion Specifications

- Standardized OPC UA interfaces
- Information modelling

Instances / models
> according to specification

Import
Types according to specification

Export
Types, Instances, Mapping

Link

Instances / models according to specification

DB instance

OPC UA Server for SIMATIC S7-1500 based CPUs

Functional scope

Companion Specifications

Standard SIMATIC interface

Additional interfaces

Companion specifications

- 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)
OPC UA Security

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

Project protection is necessary to activate centralized certificate management

This enables the global certificate manager which includes the certification authority

TIA Portal provides a project wide certification authority (CA)
## OPC UA with SIMATIC S7 CPUs
### Licensing

<table>
<thead>
<tr>
<th>CPU-Type</th>
<th>S7-1200</th>
<th>ET 200SP CPU up to CPU 1513</th>
<th>CPU 1515 / 1515SP PC CPU 1516 / 1516pro CPU 1507S</th>
<th>CPU 1517 / CPU 1518 / CPU 1508S (New)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required License</td>
<td>Basic</td>
<td>small</td>
<td>medium</td>
<td>large</td>
</tr>
</tbody>
</table>

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## OPC UA System limits
### S7-1200 & S7-1500

<table>
<thead>
<tr>
<th></th>
<th>S7-1200</th>
<th>CPU 1510...13</th>
<th>CPU 1515/16</th>
<th>CPU 1517/18</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of sessions, max.</td>
<td>5</td>
<td>32</td>
<td>48</td>
<td>64</td>
</tr>
<tr>
<td>No. of accessible variables, max.</td>
<td>1,000</td>
<td>50,000</td>
<td>100,000</td>
<td>200,000</td>
</tr>
<tr>
<td>No. of registerable nodes, max.</td>
<td>-</td>
<td>10,000</td>
<td>20,000</td>
<td>50,000</td>
</tr>
<tr>
<td>No. of subscriptions per session, max.</td>
<td>5</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Sampling interval, min.</td>
<td>100 ms</td>
<td>100 ms</td>
<td>100 ms</td>
<td>10 ms</td>
</tr>
<tr>
<td>Publishing interval, min.</td>
<td>200 ms</td>
<td>500 ms</td>
<td>200 ms</td>
<td>10 ms</td>
</tr>
<tr>
<td>No. of server methods, max.</td>
<td>-</td>
<td>20</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>No. of in/outputs per server method, max.</td>
<td>-</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>No. of monitored items, recommended.</td>
<td>500 (max.)</td>
<td>1,000</td>
<td>2,000</td>
<td>10,000</td>
</tr>
</tbody>
</table>

*for 1 s sampling interval and 1 s publishing interval*

<table>
<thead>
<tr>
<th>No. of server interfaces, max. (SIMATIC, Information m., Reference m.)</th>
<th>2/2/x</th>
<th>10/10/20</th>
<th>10/10/20</th>
<th>10/10/20</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of nodes for server interfaces, max.</td>
<td>1,000</td>
<td>1,000</td>
<td>5,000</td>
<td>30,000</td>
</tr>
</tbody>
</table>

**Further information about system limits**
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

- 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 (logon processes of OPC UA clients, for example, create a temporarily high communication load).

Example:
**HMI communication without influence of OPC UA**

All communication resources are available for HMI communication.

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).
Guideline 4: Security

General

• OPC UA security actions are based on the following IT standards:
  - Encryption
  - Signing
  - Authentication via certificate and user accounts

• Note:
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• Simple example:
  S7-1500 and Third Party Client with self-signed certificates

• Consulting intensive example:
  Integration into existing IT infrastructure with certificate generation by Microsoft Active Directory
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>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BrowseName</td>
<td>PackMLBaseObjectType</td>
</tr>
<tr>
<td>ObjectType</td>
<td>String</td>
</tr>
<tr>
<td>BaseObject</td>
<td>PackMLBaseObjectType</td>
</tr>
<tr>
<td>HasProperty</td>
<td>TagID</td>
</tr>
<tr>
<td>HasProperty</td>
<td>PackMLVersion</td>
</tr>
<tr>
<td>HasComponent</td>
<td>Admin</td>
</tr>
<tr>
<td>HasComponent</td>
<td>Status</td>
</tr>
<tr>
<td>HasComponent</td>
<td>BaseState Machine</td>
</tr>
<tr>
<td>HasComponent</td>
<td>SetUnitMode</td>
</tr>
<tr>
<td>HasComponent</td>
<td>SetMachSpeed</td>
</tr>
<tr>
<td>HasComponent</td>
<td>SetProjAct</td>
</tr>
<tr>
<td>HasComponent</td>
<td>SetParameter</td>
</tr>
<tr>
<td>HasComponent</td>
<td>GetMotorCommand</td>
</tr>
</tbody>
</table>

Table 3 – PackMLBaseObjectType Definition
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)

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