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OPC UA methods for the SIMATIC S7-1500 OPC UA server

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1 Introduction

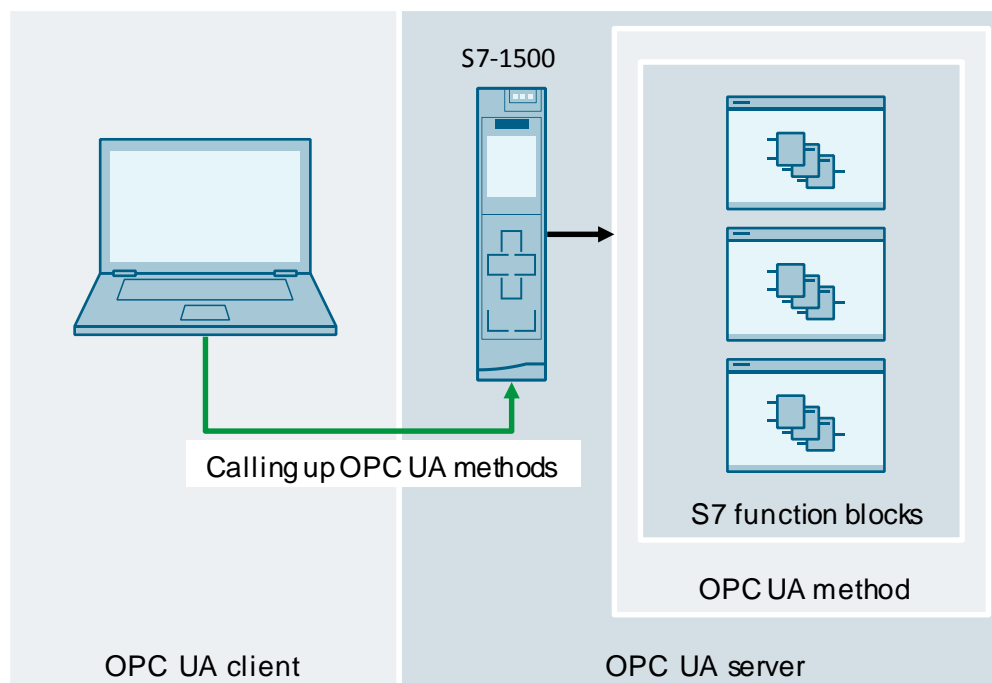
1.1 Overview

For standardized, communication of an S7 control system that applies to all platforms and manufacturers, Siemens offers you the communication protocol OPC UA.

As of firmware version V2.5 and TIA Portal V15, the SIMATIC S7-1500 control system can also offer OPC UA methods for the clients via its integrated OPC UA server. With this addition to the functions, you not only have the option of reading or writing OPC UA variables of the control system, you can now also start complex functional sequences via OPC UA. This enables almost complete M2M communication via OPC UA, for the networking of plants or for the control of plants from an ERP / MES level.

In this application example, we explain how to program an S7 function block so that it can be called up as an OPC UA method on the server of an S7-1500.

Figure 1-1 Pictorial schematic



1.2 Mode of operation

From a PLC programmer's point of view, OPC UA methods on a SIMATIC S7 controller are just conventional S7 function blocks. In addition to the normal program code, you must call up two system function blocks in the S7 function block in order to implement the OPC UA functionality. This does not restrict the program logic within the S7 function module compared to normal function blocks.

If you have created and programmed an S7 function block correctly, the method appears in the OPC UA address space of the OPC UA server of the S7-1500 and can be called up by an OPC UA client.

The example project supplied with this application example contains four fully programmed OPC UA methods for you:

- "OpcMethodAllowedDataTypes"
- "OpcMethodBubbleSort"
- "OpcMethodSetPlcTime"
- "OpcMethodStateMachine"

You can extend the methods or use them as a template for your own implementation.

1.3 Components used

This application example was created with the following hardware and software components:

Table 1-1

Component	Number	Article number	Note
SIMATIC S7-1500 CPU 1513-1 PN	1	6ES7 513-1AL01-0AB0	Firmware V2.5 or later
STEP 7 Professional	1	6ES7822-1AA05-0YA5	TIA Portal V15 or later

This application example consists of the following components:

Table 1-2

Component	File name	Note
Documentation	109756885_OpcUa_ServerMethods_DOC_V10_de.pdf	This document.
Example project	109756885_OpcUa_ServerMethods_PROJ_V10.zip	TIA Portal project
OPC UA Status-Codes	109756885_OpcUa_ServerMethods_XML_V10.zip	Status codes for import into TIA Portal.

2 Engineering

2.1 Creation of OPC UA methods

In this chapter, we explain the procedure and basis for creating an OPC UA method. The system function blocks "OPC_UA_ServerMethodPre" and "OPC_UA_ServerMethodPost", which implement the OPC UA method, are the central component of an OPC UA method.

2.1.1 Explanation of the system function blocks

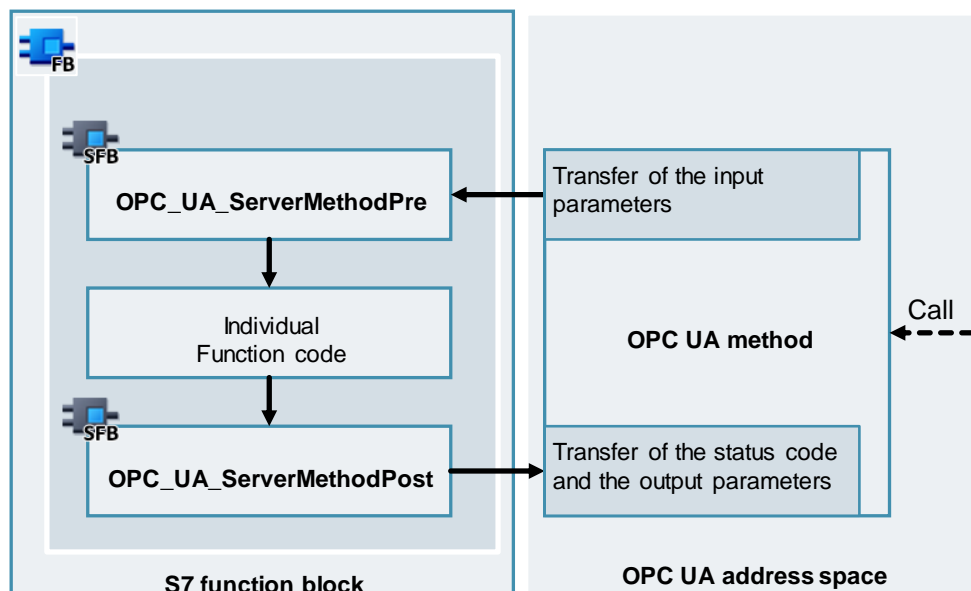
The creation of OPC UA methods requires calling the system function blocks "OPC_UA_ServerMethodPre" and "OPC_UA_ServerMethodPost". Call these system functions in an S7 function block to implement the functionality of the S7 function block as an OPC UA method. You will find the system function blocks in the instruction list of the TIA Portal under "Communication> OPC UA> OPC UA Server" ("Communication> OPC UA> OPC UA server").

Functional sequence

When calling an OPC UA method, the input parameters are transferred to the system function "OPC_UA_ServerMethodPre". The system function then provides these in the user program. Additionally, an interface parameter on the function block indicates that the method was called by an OPC UA client. Run your custom function code after the parameter is set.

After processing the function code, you must transfer the output parameters and the status code to the "OPC_UA_ServerMethodPost" system function and also set an interface parameter to indicate to the function that the code has been executed. This system function then transmits the output parameters and the status code to the OPC UA client.

Figure 2-1 Sequence of functions



Interface description of the system function blocks

The following figure and table explain the interface of the "OPC-UA_ServerMethodPre" system function:

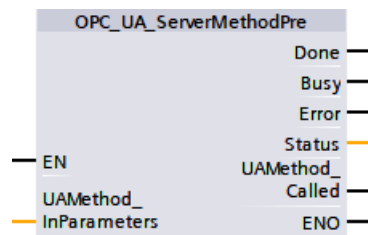


Table 2-1

Name	Data type	Description
UAMethod_InParameters	Version	Input parameters of the method; Transferred by the client
Done	Bool	True if the system function was called up successfully
Busy	Bool	True if the system function is in progress
Error	Bool	True if an error occurred while calling up the system function
Status	DWord	Cause of the error, see TIA Help ("F1")
UAMethod_Called	Bool	True, if the method was called up by a client

The following figure and table explain the interface of the "OPC-UA_ServerMethodPost" system function:

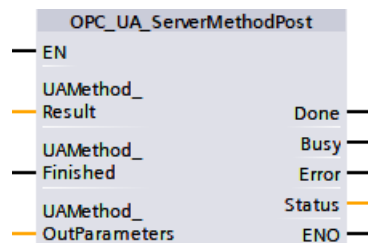


Table 2-2

Name	Data type	Description
UAMethod_Result	DWord	OPC UA status code; Will be transferred to the client
UAMethod_Finished	Bool	Set to True when function code is complete; The method is hereby terminated.
UAMethod_Out parameters	Version	Output parameter of the method; transferred to the client
Done	Bool	True if the system function was called up successfully
Busy	Bool	True if the system function is in progress
Error	Bool	True if an error occurred while calling up the system function
Status	Status	Cause of the error, see TIA Help ("F1")

2.1.2 Preparation

You must make the following preparations to create a functional OPC UA method for a SIMATIC S7-1500:

- Create a STEP 7 V15 project.
- Configure a SIMATIC S7-1500 with firmware 2.5 or higher.
- Activate the OPC UA server of the S7-1500 so that the methods can be accessed via OPC UA. For instructions, see the appendix at [4](#).
- Create a block of the "function block" type. The programming language used in the module is irrelevant. This example uses the scripting language "SCL".
- (Optional) Import the XML file "OpcUaMethodStatusCodes.xml" provided with this entry to use standardized OPC UA status codes. Instructions on this can be found in the chapter [3.2 OPC UA Status Codes](#).

2.1.3 Creation of the basic framework

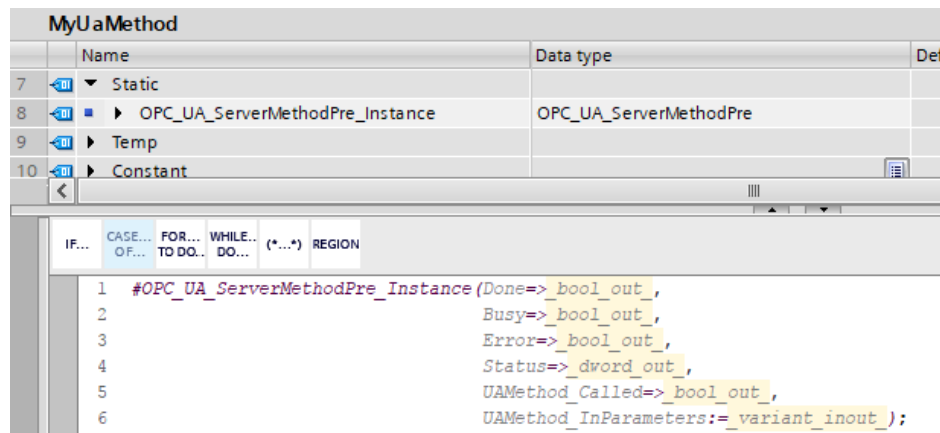
To create OPC UA methods, always create a basic framework in the module that is mandatory for the function of the method.

Perform steps 1 through 4 of the following procedure for each OPC UA method.

Follow steps 5 through 8 only if your method requires input or output parameters.

Proceed as follows:

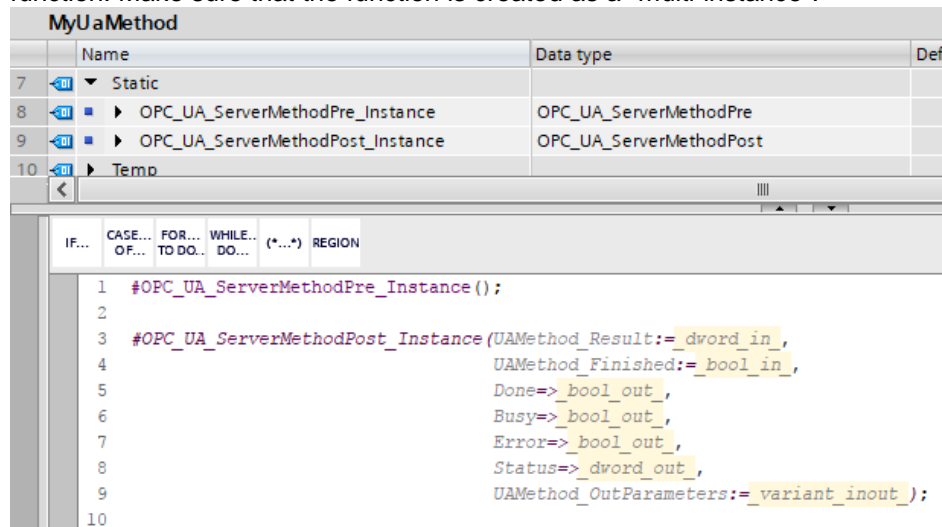
1. Open the function block created in advance.
2. Call the "OPC_UA_ServerMethodPre" function in the block. Make sure that the function is created as a "multi-instance".



Note

The name of the multi-instance must be "OPC_UA_ServerMethodPre_Instance" for the method to be created in the address space.

3. In the block, call the "OPC-UA_ServerMethodPost" function under the pre-function. Make sure that the function is created as a "multi-instance".



Note The name of the multi-instance must be "OPC-UA_ServerMethodPost_Instance" for the method to be created in the address space.

4. Assign suitable variables to the block interfaces of the pre- and post-function. We recommend that you define the variables in the static area of the block so that they can be observed during operation for diagnostic purposes. Information about the block interfaces can be found in chapter [2.1.1 Explanation of the system function blocks](#).

```

1 #OPC-UA_ServerMethodPre_Instance(Done=>#statPreDone,
2                                   Busy=>#statPreBusy,
3                                   Error=>#statPreError,
4                                   Status=>#statPreStatus,
5                                   UAMethod_Called=>#statPreCalled);
6
7 #OPC-UA_ServerMethodPost_Instance(UAMethod_Result:=#statPostResult,
8                                   UAMethod_Finished:=#statPostFinished,
9                                   Done=>#statPostDone,
10                                  Busy=>#statPostBusy,
11                                  Error=>#statPostError,
12                                  Status=>#statPostStatus);

```

5. To define input parameters for the OPC UA method, create a variable with the name "UAMethod_InParameters" of the data type "Struct" or UDT in the static area of the block. Within the structure you define the individual transfer parameters (example: "myInt1" and "myInt2" of the data type "Int").

21	UAMethod_InParameters	Struct
22	myInt1	Int
23	myInt2	Int

Note The name of the variable must be "UAMethod_InParameters" to display the input parameters of the method.

6. Assign the variable "UAMethod_InParameters" to the block interface "UAMethod_InParameters" of the pre-function.

```

1 //Call pre
2 #OPC-UA_ServerMethodPre_Instance (Done=>#statPreDone,
3                                     Busy=>#statPreBusy,
4                                     Error=>#statPreError,
5                                     Status=>#statPreStatus,
6                                     UAMethod_Called=>#statPreCalled,
7                                     UAMethod_InParameters:=#UAMethod_InParameters);
8

```

7. To define output parameters for the OPC UA method, create a variable with the name "UAMethod_OutParameters" of the data type "Struct" or UDT in the static area of the block. Within the structure, you define the individual transfer parameters (example: "myIntResult" of the data type "DInt").

24	UAMethod_OutParameters	Struct
25	myIntResult	DInt

Note

The name of the variable must be "UAMethod_OutParameters" to display the output parameters of the method.

8. Assign the variable "UAMethod_OutParameters" to the block interface "UAMethod_OutParameters" of the post function.

```

13 //Call post
14 #OPC-UA_ServerMethodPost_Instance (UAMethod_Result:=#statPostResult,
15                                     UAMethod_Finished:=#statPostFinished,
16                                     Done=>#statPostDone,
17                                     Busy=>#statPostBusy,
18                                     Error=>#statPostError,
19                                     Status=>#statPostStatus,
20                                     UAMethod_OutParameters:=#UAMethod_OutParameters);
--

```

9. Make sure that the "Accessible from HMI / OPC UA" check boxes are set in the declaration of the pre- and post-function as well as in the input and output parameters.

	Name	Data type	Accessible from HMI/OPC UA	Writa...	Visible in ...
7	Static		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8	UAMethod_InParameters	Struct	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
9	UAMethod_OutParameters	Struct	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
10	OPC-UA_ServerMethodPre_Instance	OPC-UA_ServerMethodPre	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
11	OPC-UA_ServerMethodPost_Instance	OPC-UA_ServerMethodPost	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

2.1.4 Programming the functionality

The following instructions explain the basic procedure for programming the function of the OPC UA method:

1. Create a basic framework as described in chapter [2.1.3 Creation of the basic framework](#).
2. Create an IF query on the variable of the "UAMethod_Called" interface of the pre-function. If the function is to be run through for several cycles, define the variable as "Static". If processing is possible in just one cycle, define the variable as "Temp". Program the functionality of the method within this IF loop so that the code is only executed when the method is called by a client.

```

1 //Call pre
2 #OPC-UA_ServerMethodPre_Instance(Done=>#statPreDone,
3     Busy=>#statPreBusy,
4     Error=>#statPreError,
5     Status=>#statPreStatus,
6     UAMethod_Called=>#statPreCalled,
7     UAMethod_InParameters:=#UAMethod_InParameters);
8
9
10 IF #statPreCalled THEN
11     ;
12 END_IF;
13
14
15 //Call post
16 #OPC-UA_ServerMethodPost_Instance(UAMethod_Result:=#statPostResult,
17     UAMethod_Finished:=#statPostFinished,
18     Done=>#statPostDone,
19     Busy=>#statPostBusy,
20     Error=>#statPostError,
21     Status=>#statPostStatus,
22     UAMethod_OutParameters:=#UAMethod_OutParameters);

```

3. Program the functionality. In this example, the two input parameters "myInt1" and "myInt2" are added together and the result is assigned to the output parameter "myIntResult".

```

1 //Call pre
2 #OPC-UA_ServerMethodPre_Instance(Done=>#statPreDone,
3     Busy=>#statPreBusy,
4     Error=>#statPreError,
5     Status=>#statPreStatus,
6     UAMethod_Called=>#statPreCalled,
7     UAMethod_InParameters:=#UAMethod_InParameters);
8
9
10 IF #statPreCalled THEN
11     #UAMethod_OutParameters.myIntResult :=
12     #UAMethod_InParameters.myInt1 + #UAMethod_InParameters.myInt2; //Function
13 END_IF;
14
15 //Call post
16 #OPC-UA_ServerMethodPost_Instance(UAMethod_Result:=#statPostResult,
17     UAMethod_Finished:=#statPostFinished,
18     Done=>#statPostDone,
19     Busy=>#statPostBusy,
20     Error=>#statPostError,
21     Status=>#statPostStatus,
22     UAMethod_OutParameters:=#UAMethod_OutParameters);

```

Note

You can use the input and output interface of the function block for the functionality in order to interact with the rest of the user program.

- Set the interface variable "UAMethod_Finished" of the post function to "True" when your function code is completed. Define a "Temp" variable for this. Additionally, assign an appropriate status code to the interface variable "UAMethod_Result". Please note the chapter [3.2 OPC UA Status Codes](#). (If you have defined the variable "UAMethod_Called" as "Static", reset it.)

```

4 //Call pre
5 #OPC-UA_ServerMethodPre_Instance(Done=>#statPreDone,
6     Busy=>#statPreBusy,
7     Error=>#statPreError,
8     Status=>#statPreStatus,
9     UAMethod_Called=>#statPreCalled,
10    UAMethod_InParameters:=#UAMethod_InParameters);
11
12
13 IF #statPreCalled THEN
14     #UAMethod_OutParameters.myIntResult :=
15     #UAMethod_InParameters.myInt1 + #UAMethod_InParameters.myInt2; //Function
16     #statPostResult := "OpcUa_Good"; //Provide status code (e.g. from user constants)
17     #statPostFinished := true; //Provide finished flag
18 END_IF;
19
20 //C: #tempPostFinished := true;
21 #OPC-UA_ServerMethodPost_Instance(UAMethod_Result:=#statPostResult,
22     UAMethod_Finished:=#statPostFinished,
23     Done=>#statPostDone,
24     Busy=>#statPostBusy,
25     Error=>#statPostError,
26     Status=>#statPostStatus,
27     UAMethod_OutParameters:=#UAMethod_OutParameters);

```

- You have created your OPC UA method. Call the function block in the user program so that the method appears in the OPC UA address space of your SIMATIC S7-1500. Please note the explanations on this in chapter [2.1.5 Call in the user program](#).

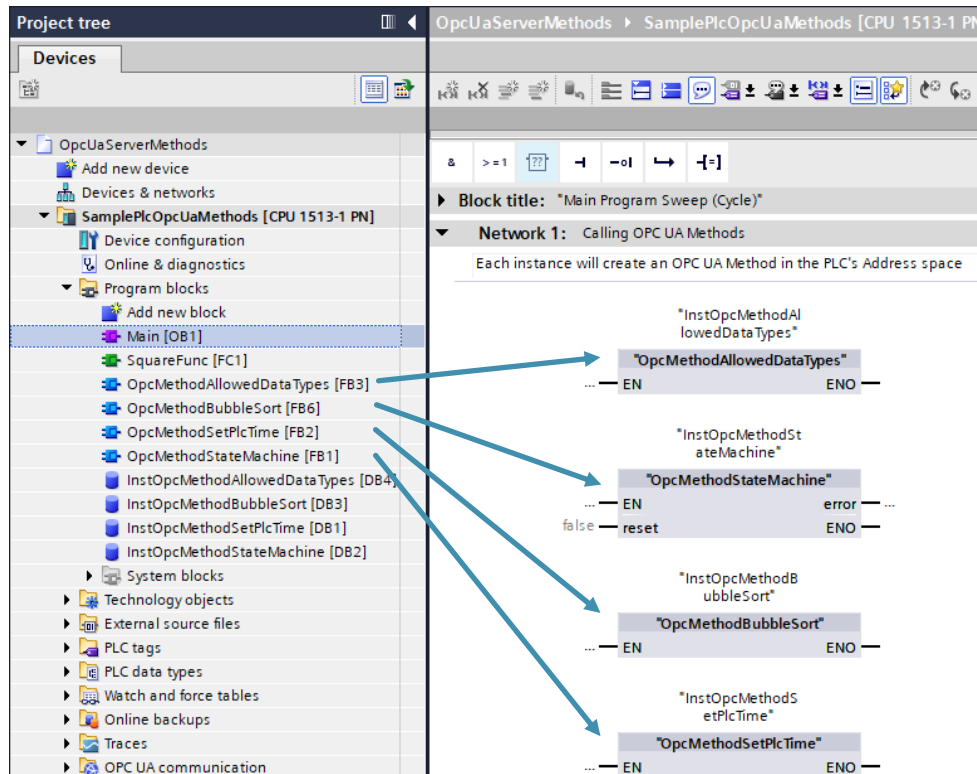
2.1.5 Call in the user program

To implement the OPC UA functionality of an S7 function block created for this purpose, call the block in the user program. Call the block in a cyclic OB ("program cycle") or in a cyclic interrupt OB ("cyclic interrupt").

Alternatively, you can call the block in a higher-level function block. However, you must also call the higher-level function block in one of the two permitted OB types.

The following figure shows an example of calling S7 function blocks in OB1 ("Main"). The individual instances of the blocks implement the OPC UA methods.

Figure 2-2



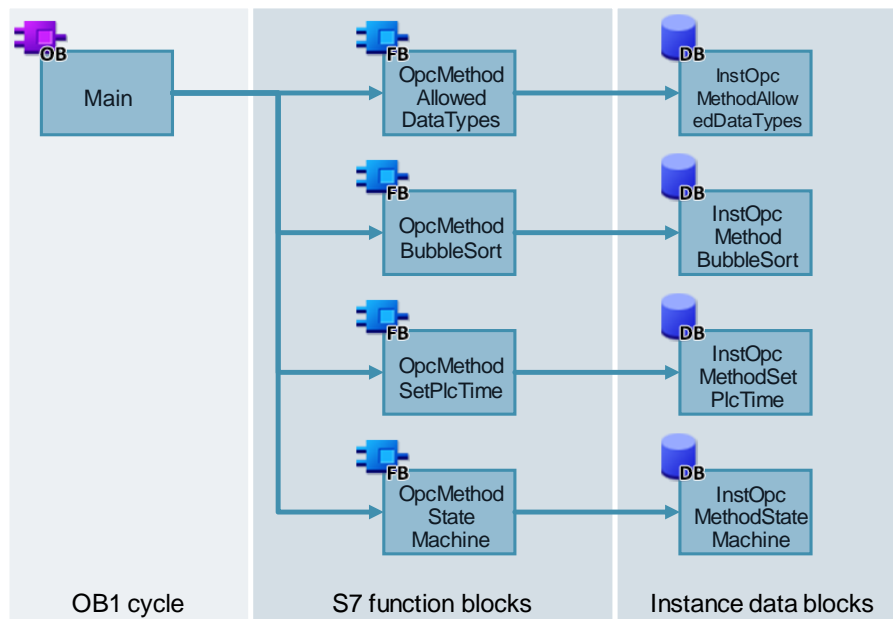
2.2 Explanations to the example project.

In this chapter, we will explain the example project provided with this.

2.2.1 Call structure

The following figure shows you the call hierarchy of the blocks of the example project:

Figure 2-3



All S7 function blocks are called directly in the OB1 cycle of the user program. Here, the instance data blocks of the individual function blocks implement the OPC UA methods.

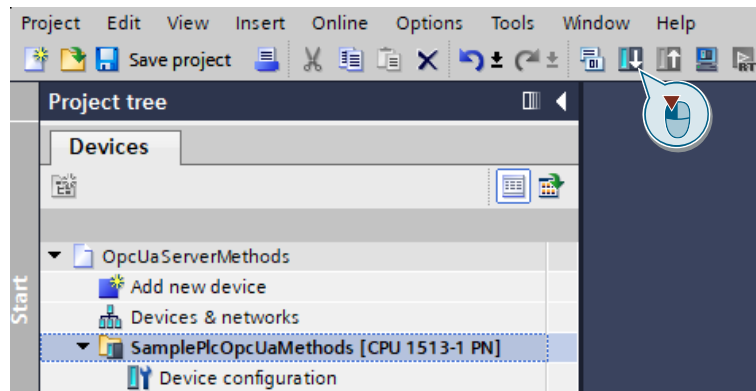
The following methods can be called by an OPC UA client in this example:

- "OpcMethodAllowedDataTypes":
This method contains all permitted data types as input parameters of the method. During execution, the transferred values are provided as output parameters of the method.
- "OpcMethodBubbleSort":
This method offers an array of type "Int" as input parameter. The transferred values are sorted by value size and the result is provided as an output parameter.
- "OpcMethodSetPlcTime":
You can use this method to set the PLC time.
- "OpcMethodStateMachine":
This method contains a step sequence that is started when the method is called. The method has no input or output parameters. While the step sequence is being processed, you receive a negative response when calling again.

2.2.2 Commissioning the example project

In order to commission the sample project, proceed as follows:

1. Download the project "109756885_OpcUa_ServerMethods_PROJ_V10.zip" to your hard disk. The download can be found on the HTML page of this article ([2](#)).
2. Unzip the ZIP archive to any location.
3. In the unpacked archive, navigate to the folder "OpcUaServerMethods". This folder contains the TIA Portal project.
4. Open the project by double-clicking on the file "OpcUaServerMethods.ap15".
5. Select the CPU in the project navigation and click on "Download to device".



2.2.3 Operation of the example project

To test the OPC UA methods of the sample project, you can use any OPC UA client that controls the method functionality. This example uses the "UaExpert" tool from Unified Automation. The free download can be found in the appendix (5).

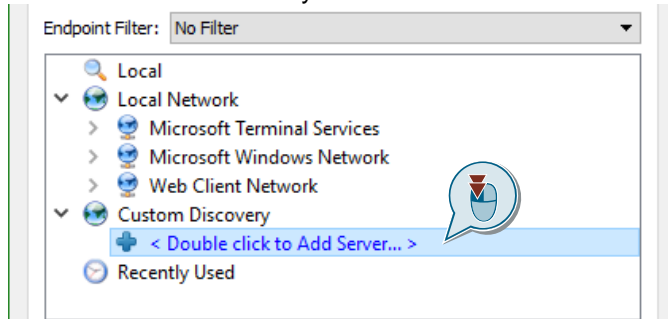
Establish the connection to the server

First, connect UaExpert to the server of the PLC:

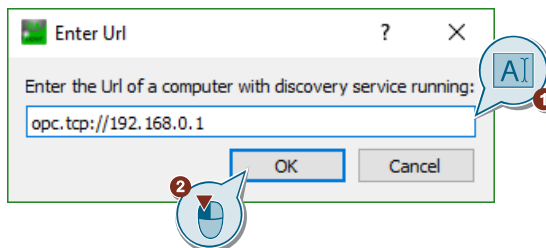
1. Start the tool "UaExpert".
2. Click on the "Add server" button.



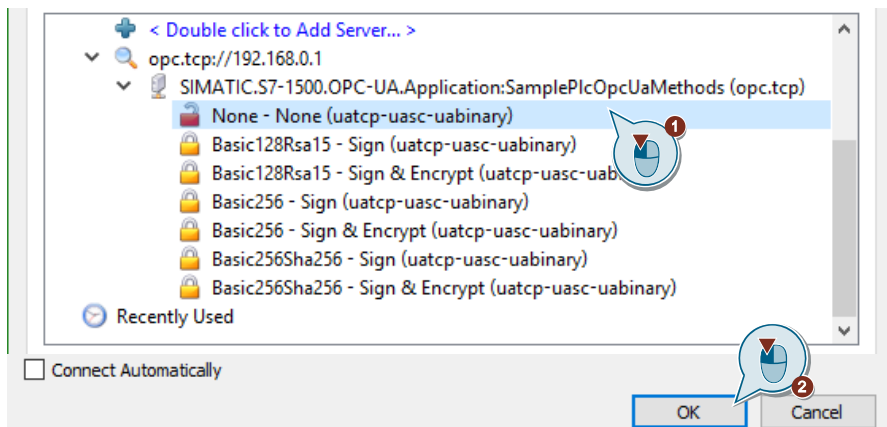
3. Under "Custom Discovery" double click on "Double click to Add Server"



4. Enter the IP address of the PLC in the text field of the dialog that appears and then confirm with "OK".



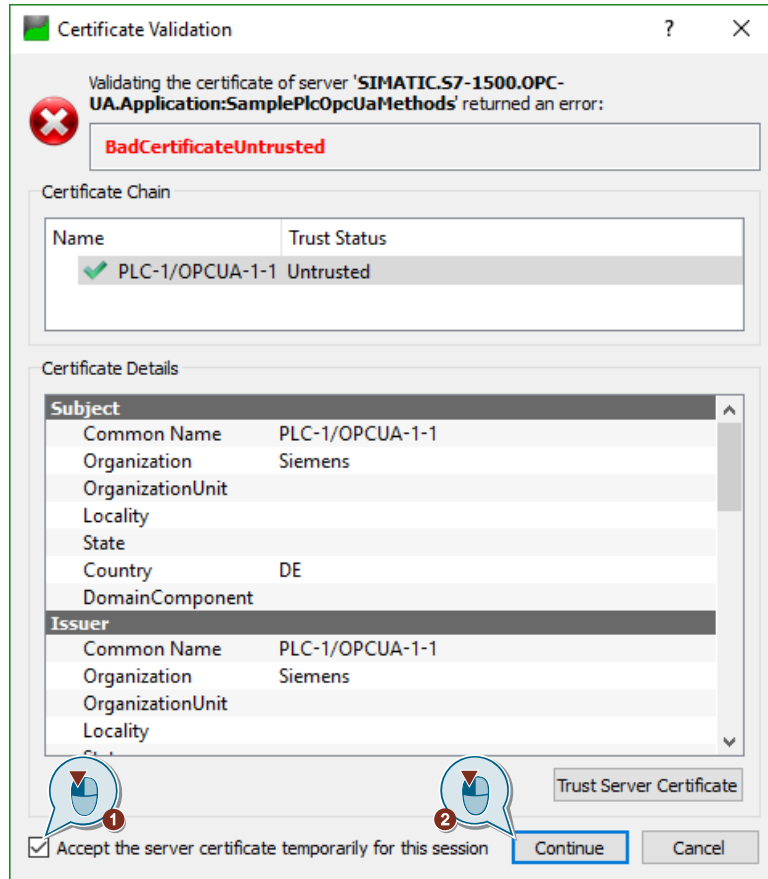
5. Select an end point ("None" in this example) and then confirm with "OK".



6. Select the selected endpoint in the project navigation and click on the "Connect Server" button.



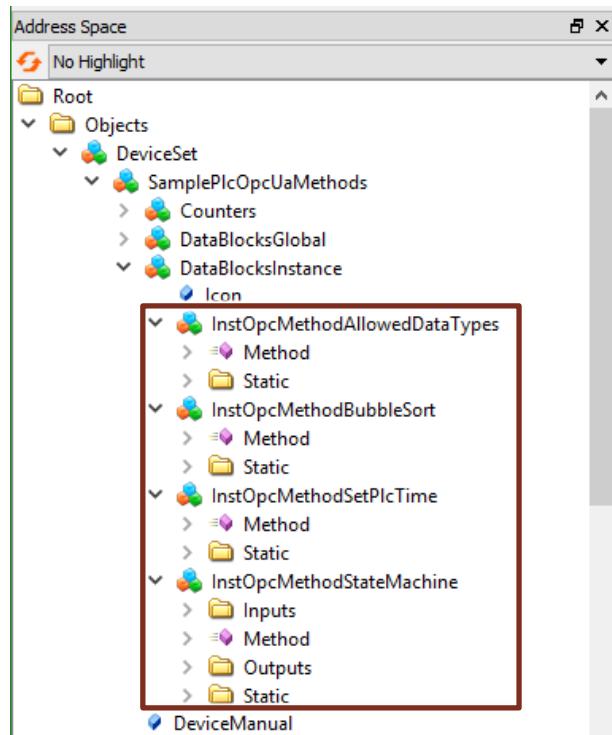
7. Confirm the certificate of the PLC. For this purpose, activate the checkbox "Accept the server certificate for this session" and confirm with "Continue". Alternatively, you can permanently accept the certificate by clicking the "Trust Server Certificate" button.



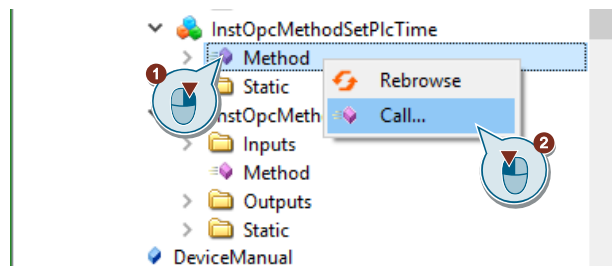
Call methods

Once you have established a connection to the server of the PLC, you can call up the methods created in advance:

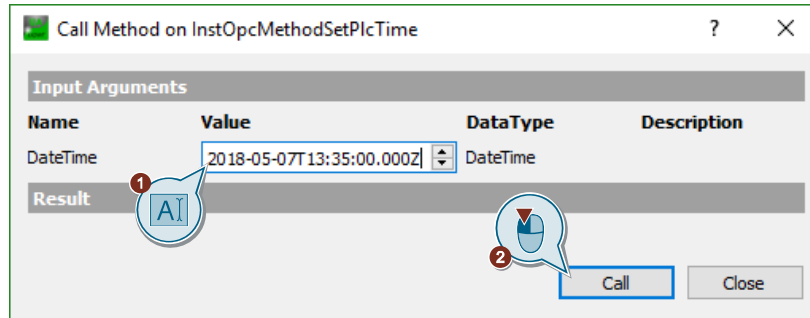
1. In the “Address Space” area, navigate to “Root> Objects> DeviceSet> SamplePlcOpcUaMethods> DataBlockInstance”. Within the objects of the block instances, you will find the OPC UA methods created in advance.



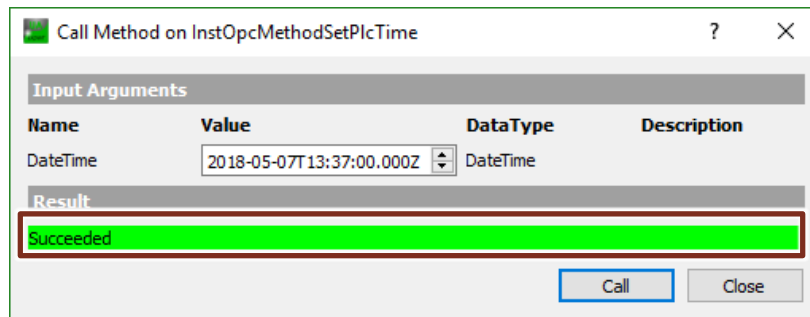
2. Right-click on a method (for example, within the instance of “InstOpcMethodSetPlcTime”), and then click “Call...”



3. In the dialog that appears, enter an input parameter of the method (in the example: The PLC time) and then click on "Call" to execute the method.



4. After the successful execution of the method, you will receive a message in the dialog. In case of a faulty execution, the error code will be displayed there. If the method has output parameters, these are also displayed in the dialog.



3 Useful information

In this chapter, we provide you with valuable information regarding the implementation of OPC UA methods on an S7-PLC.

3.1 Allowed data types as interface parameters

You can define the following PLC data types as input and output parameters ("UAMethod_InParameters" and "UAMethod_OutParameters") of your OPC UA methods:

Table 3-1

Approved data types	
Bool	ULint
SInt (also for Byte)	Real
Int (also for Word)	LReal
DInt (also for DWord)	LDT
LInt	WString
USInt	Struct/Array
UInt	OPC_UA_NodeId
UDInt	OPC_UA_QualifiedName

Note

You can declare a maximum of 20 input and output parameters. A structure or array is interpreted as just one parameter here.

3.2 OPC UA Status Codes

The OPC Foundation has defined a multitude of status codes for OPC UA. We recommend that you use these status codes for the OPC UA methods created in the TIA Portal.

In this application example, we provide you with an XML file with the most important status codes. Proceed as follows to import the file into the TIA Portal:

1. Download the archive "109756885_OpcUa_ServerMethods_XML_V10.zip" to your hard disk. The download can be found on the HTML page of this article ([V2](#)).
2. Unzip the ZIP archive to any location.
3. Open your TIA Portal project and create a ("variable table") ("tag table").
4. Click the "Import" button in the workspace.
5. In the dialog that appears, navigate to the location of the unpacked archive and select the file "OpcUaStatusCodes.xml". Activate the check box "Constants" and confirm with "OK".

4 Appendix

4.1 Service and Support

Industry Online Support

Do you have any questions or need assistance?

Siemens Industry Online Support offers round the clock access to our entire service and support know-how and portfolio.

The Industry Online Support is the central address for information about our products, solutions and services.

Product information, manuals, downloads, FAQs, application examples and videos – all information is accessible with just a few mouse clicks:

<https://support.industry.siemens.com>

Technical Support

The Technical Support of Siemens Industry provides you fast and competent support regarding all technical queries with numerous tailor-made offers – ranging from basic support to individual support contracts. Please send queries to Technical Support via Web form:

www.siemens.com/industry/supportrequest

SITRAIN – Training for Industry

We support you with our globally available training courses for industry with practical experience, innovative learning methods and a concept that's tailored to the customer's specific needs.

For more information on our offered trainings and courses, as well as their locations and dates, refer to our web page:

www.siemens.com/sitrain

Service offer

Our range of services includes the following:

- Plant data services
- Spare parts services
- Repair services
- On-site and maintenance services
- Retrofitting and modernization services
- Service programs and contracts

You can find detailed information on our range of services in the service catalog web page:

<https://support.industry.siemens.com/cs/sc>

Industry Online Support app

You will receive optimum support wherever you are with the "Siemens Industry Online Support" app. The app is available for Apple iOS, Android and Windows Phone:

<https://support.industry.siemens.com/cs/ww/en/sc/2067>

4.2 Links and Literature

Table 4-1

No.	Topic
\1\	Siemens Industry Online Support https://support.industry.siemens.com
\2\	Link to the entry page for the application example https://support.industry.siemens.com/cs/ww/en/view/109756885
\3\	SIMATIC S7-1500, ET 200MP, ET 200SP, ET 200AL, ET 200pro Communication https://support.industry.siemens.com/cs/ww/en/view/59192925
\4\	OPC UA .NET client for the SIMATIC S7-1500 OPC UA server https://support.industry.siemens.com/cs/ww/en/view/109737901
\5\	Link to the download of the UaExpert tool https://www.unified-automation.com/products/development-tools/uaexpert.html

4.3 Change documentation

Table 4-2

Version	Date	Change
V1.0	05/2018	First edition