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TwinCAT PLC to Unity

Communication research

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# Introduction

In this file you will find the done research on the best communication protocol for between Unity and TwinCAT and how to use and install our final choice. We will use the DOT framework for our research and we will answer a few main questions we had to answer, in order to set up the communication between our Digital-twin (Unity) and our PLC (TwinCAT).

# Questions

## Main questions

* Which communication protocol is best to use for the communication between Unity and TwinCAT?
* How do you implement the protocol?

## Sub questions

* Can Unity and TwinCAT communicate with each other?
* Is the protocol easy to implement?

# Why do we need to conduct this research?

We need to find out how to communicate between the digital twin and PLC that will control the robot arm. We are all new to working with a PLC and a digital twin, so we will have to find a way to make a connection between those two systems. To prove we are using the best protocol available and to find out how to work with that protocol, we will do some research. In this document we provide you with the information we have collected on this subject.

# How do we research the protocols?

To implement the [DOT framework](#_Sources) in the correct way, this is why we used the ‘library method’ to do research. After learning about the desired topics, we checked it, wrote it down and with our final solution, we tested it was indeed the wright choice. When is clear that we will indeed work with one final protocol, we will do further research and make a demo with explanation on how to implement the chosen protocol.

# TwinCAT ADS protocol

TwinCAT ADS is a protocol written by the makers of TwinCAT (Beckhoff), this means that it is fully included within core system of TwinCAT. The protocol is also supported by the visualization software we are going to use, Unity. To answer the question if the communication is possible, yes, it is definitely possible. The only remaining question is then if it is easy to research, implement and is good for our use cases.

The group before us used TwinCAT ADS as a protocol for communication, this alone would not be enough for us to conclude that ADS is indeed a good and easy protocol. [Some other sources and videos](#_Sources) showed us that ADS is indeed very easy to use.

The requirements for this protocol are:

* An internet connection.
* Port 851 open.
* Software like Visual Studio and Unity that support the TwinCAT.ADS library.
* The AMS Net id of the PLC.

# OPC UA client SDK protocol

We found out that the protocol OPC UA client SDK is a second good protocol, also widely used in the industry. The problem is that finding good documentation and examples on how to implement this code was much harder to find. We did find that the possibility’s where almost the same and the OPC UA client SDK protocol was mostly written as a general data transporter, while the ADS is just used for TwinCAT. We had a hard Time finding concrete examples and facts on OPC UA client SDK, so we figured this protocol was not worth so much trouble if we already had a good and more than sufficient solution.

# Implementing The TwinCAT ADS protocol

## Installing the adsClient library in Visual Studio

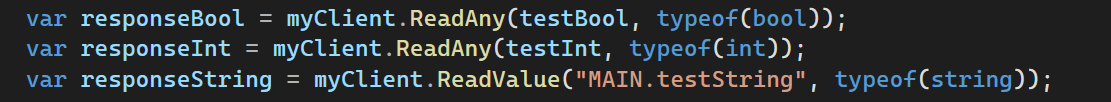
* Tools
* NuGet Package Manager
* Manage NuGet Package for Solutions
* Browse
* beckhoff.ads (not the server one but the Beckhoff.TwinCAT.Ads one)

## POC program in Visual Studio

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the first thing we do is we create a client. We do this by using (AdsClient “clientname” = new AdsClient()). In this namespace we can then write all of our client code as show above. We then use myClient.Connect to connect the client to the plc. In this case it is my local laptop we are connecting to so we use AmsNetId.Local and we use the default port of 851. Port 851 is used in twincat 3. Port 850 is used in twincat 2, but since we use twincat 3, we will probably only use port 851.



ReadAny reads the value of the current variable it then places it in the var. the first parameter is used for where the variable can be found. The string for example can be found in MAIN and the name of the string is testString (MAIN.testString). The second parameter is used to tell the client what type of variable it is that it is going to read. For using bool and int we can use ReadAny. For strings we have to use readValue because otherwise we do not know how long the string is we want to read. By using Readvalue we avoid this issue.

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For writing values we use WriteAny or WriteValue. WriteAny can be used for bools. WirteValue is used for writing the other variables. It will again first need the location of the variable and then the type it is going to write.

## The Results of the example project:

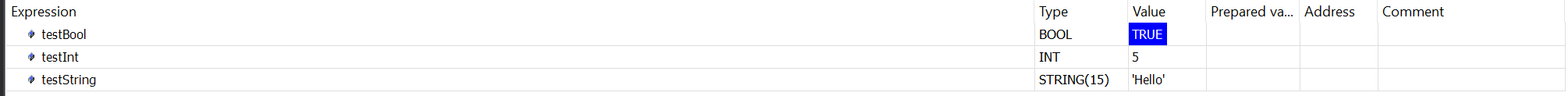


Figure 1 : The variables before ADS contact



Figure 2 : The variable after ADS contact

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The Visual Studio terminal displays the actions and variables correctly.

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If we send a ADS contact request but send the values it already has, the values stay the same and it will display it correctly.

# Sources

* The DOT Framework, explaining the DOT Framework, website: <https://ictresearchmethods.nl/The_DOT_Framework>.
* TwinCAT ADS, implementation and information, website: <http://dronefactory.co.uk/?p=43>.
* TwinCAT ADS, implementation video, video: <https://www.youtube.com/watch?v=JQ1PdZGCyOE&ab_channel=Maxwell%27sProgrammingJourney>
* TwinCAT ADS, implementation video, video: <https://www.youtube.com/watch?v=JZChSdU2LMc&t=1370s&ab_channel=JakobSagatowski>
* OPC UA client SDK, information on the protocol, website: <https://opcfoundation.org/about/opc-technologies/opc-ua/>
* OPC UA client SDK, information and implementation video, video: <https://www.youtube.com/watch?v=KCW23eq4auw&t=940&ab_channel=IndustrialITandAutomation>

# Final result in unity

For the final application we wanted to control the speed and the position of the roboticArm using ADS. To achieve this we made a roboticArmController class to control the robotic arm.

A screen shot of a computer program

Description automatically generated with low confidenceA screenshot of a computer program

Description automatically generated with medium confidence

I started with making a RobotArmController where we can pass in the Ip address of the plc we want to connect to. It will make a new client and tries to connect to the plc. If it can’t connect it will throw an exception. If it can connect it will try to create the variable Handles of the variables we want to control.

A screen shot of a computer program

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I then made a MoveArmToPosition function where we can control the arm based on a given X,Y,Z position. It will then try to write the position over ADS.

A screen shot of a computer program

Description automatically generated with low confidence

We also have a function to control the arm speed named ChangeArmSpeed. This function works in the same way as the MoveArmToPosition function works. The only difference is we use the speed variable here and not the position variables.

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We then made a ReadDafaultPosition function. This function will talk to the twincat application and checks if the robotic arm is done moving. It will then return if the robotic arm is done moving. If it can not read the bool variable it will return false. This is to make sure the conveyer belt will stop moving if there is a problem with reading the variable.

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We made a function called SendHasNewData that will let the robotic arm know if it can pick up a new cube of, of the conveyer belt.

A screen shot of a computer program

Description automatically generated with low confidence

Lastly we made 2 function to disconnect and delete the ams client. The disconnect function can be used to disconnect the current ams client and connect it to a different IP address. The Dispose is used to completely delete the ams client.

## A picture containing text, line, number, plot Description automatically generatedTest

In the Twincat application we made a struct named robotData. This struct saves the values of the variables that can be changed with ADS

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The program starts of with the target X,Y,Z being 0 and the isAtDefaultPosition and hasNewData at false. The conveyer belt in unity is now moving.

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When the isAtDealautPosition variable is set at true that means the robot arm is ready to pick up a new cube. We then stop the conveyer belt en send the x,y,z locations to the arm en tell it it has new data. The values are then being set at false and the belt will start moving again.

[](https://www.youtube.com/embed/lymaP-yPP1A?feature=oembed)