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OPC UA with Visual Studio and C#

Using “OPC UA Server Simulator” and “OPC UA .NET SDK”

Hans-Petter Halvorsen

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OPC

Hans-Petter Halvorsen

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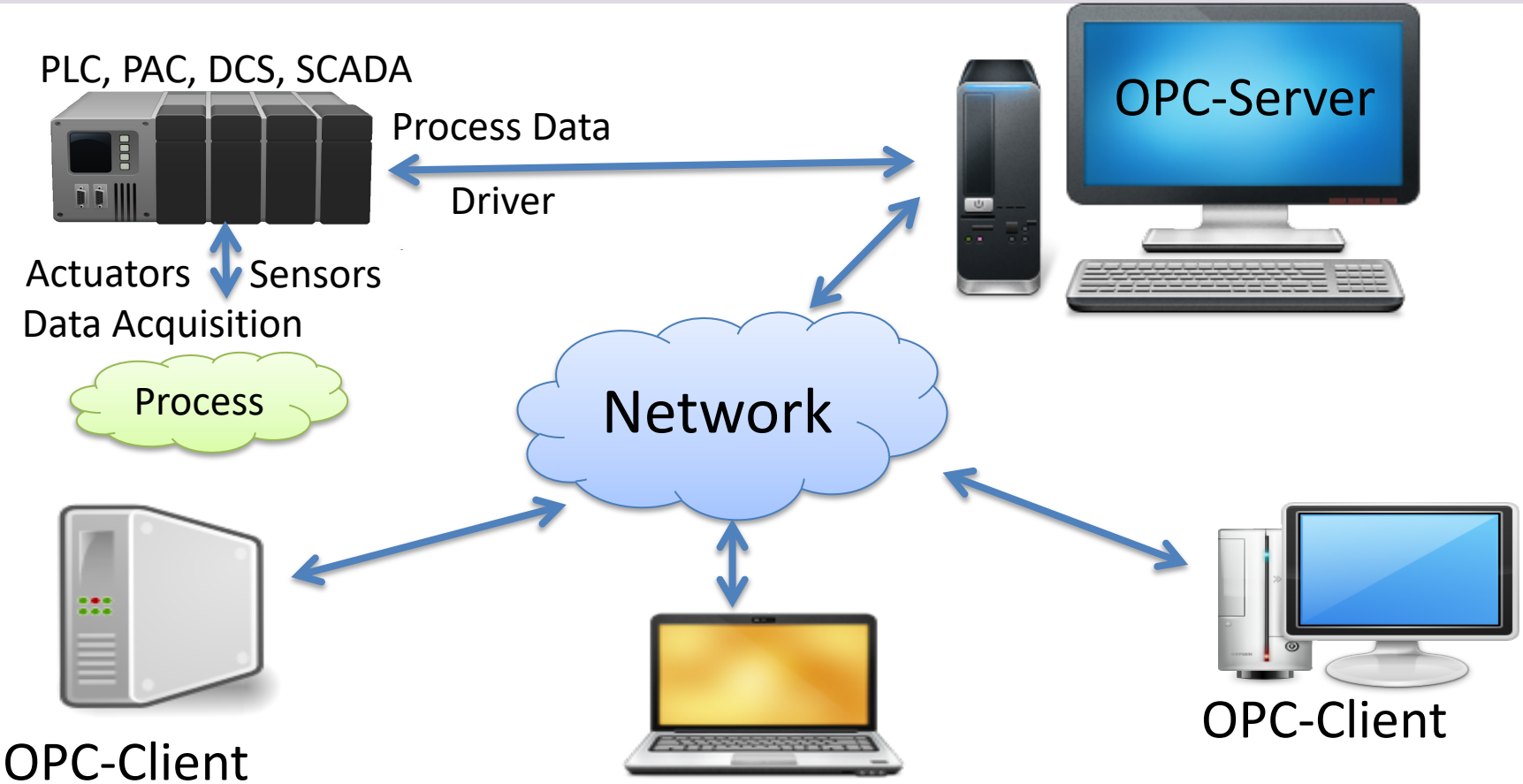
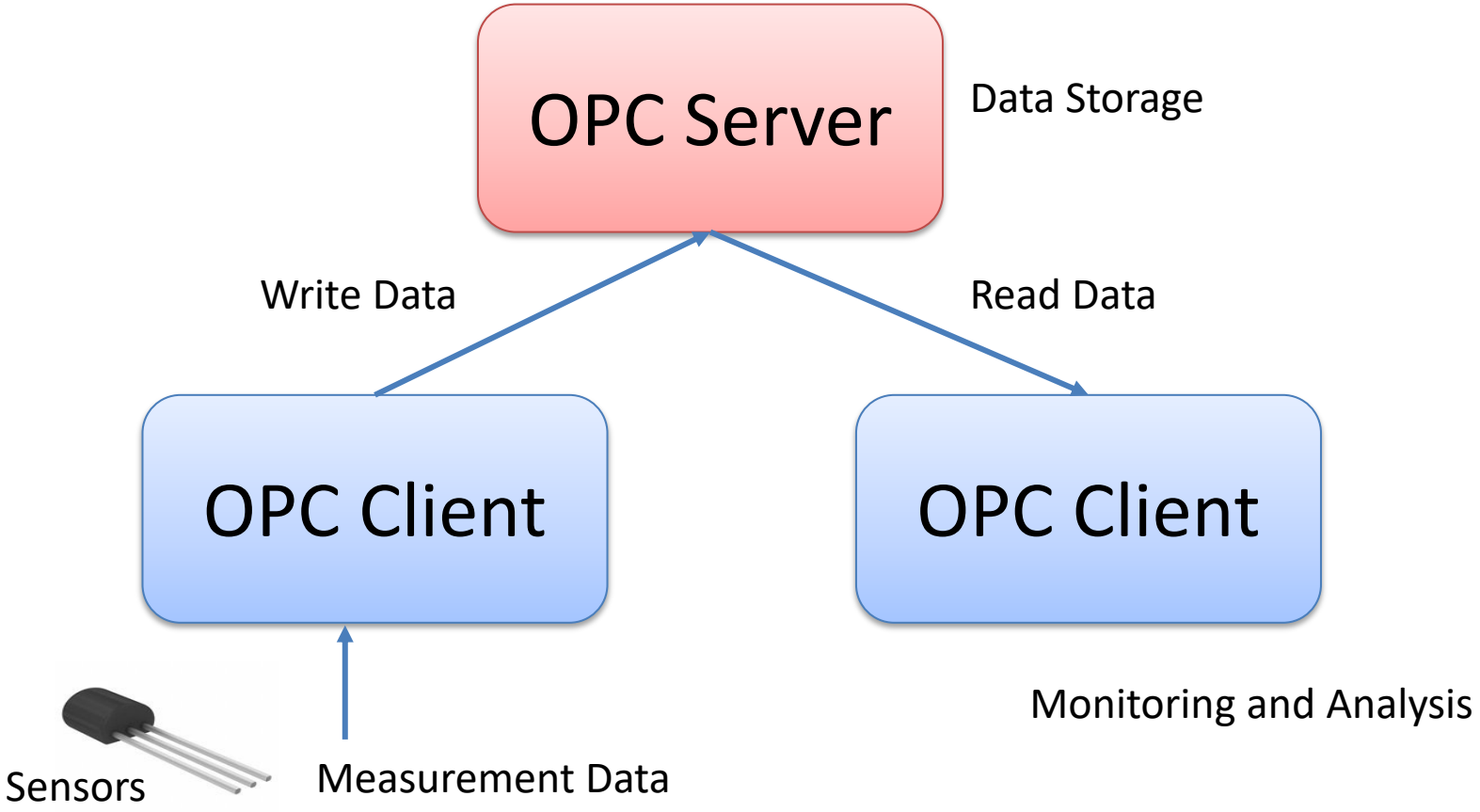
What is OPC?

- A standard that defines the communication of data between devices from different manufactures
- Requires an OPC server that communicates with the OPC clients
- OPC allows “plug-and-play”, gives benefits as reduces installation time and the opportunity to choose products from different manufactures
- Different standards: “Real-time” data (OPC DA), Historical data (OPC HDA), Alarm & Event data (OPC AE), etc.

Typical OPC Scenario



OPC Server and Client(s)



OPC UA

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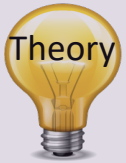
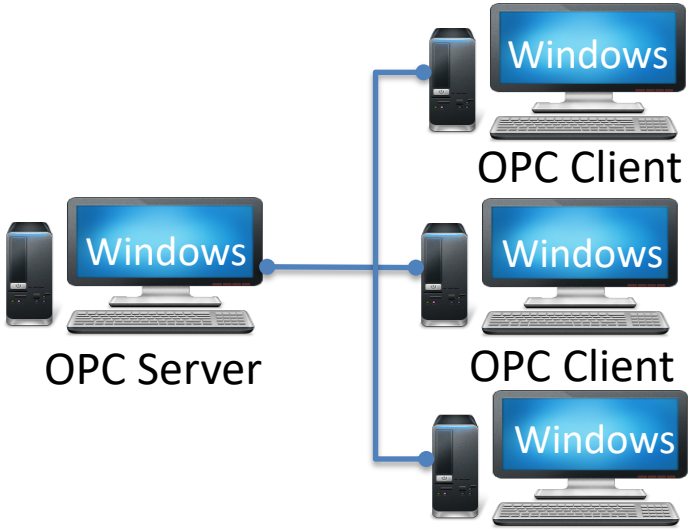
OPC UA

- UA – Unified Architecture
- The Next Generation OPC
- Cross Platform. “Classic“ OPC works only for Windows
- Based on Modern Software/Network Architecture (No DCOM problems!)
- It makes it easier to transmit and receive data in a modern data network/Internet

Classic OPC vs. OPC UA

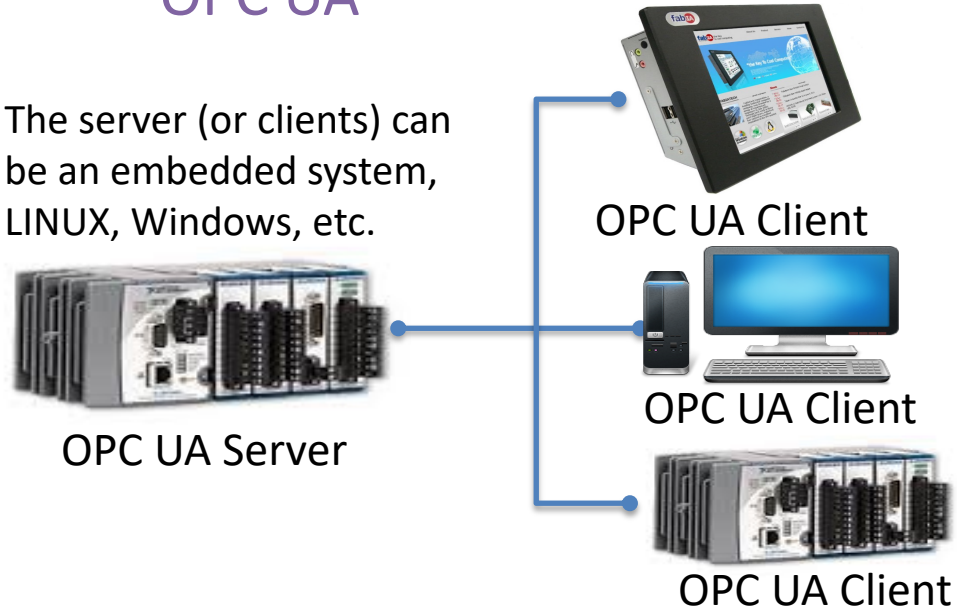


Classic OPC (DCOM)



OPC UA

The server (or clients) can be an embedded system, LINUX, Windows, etc.



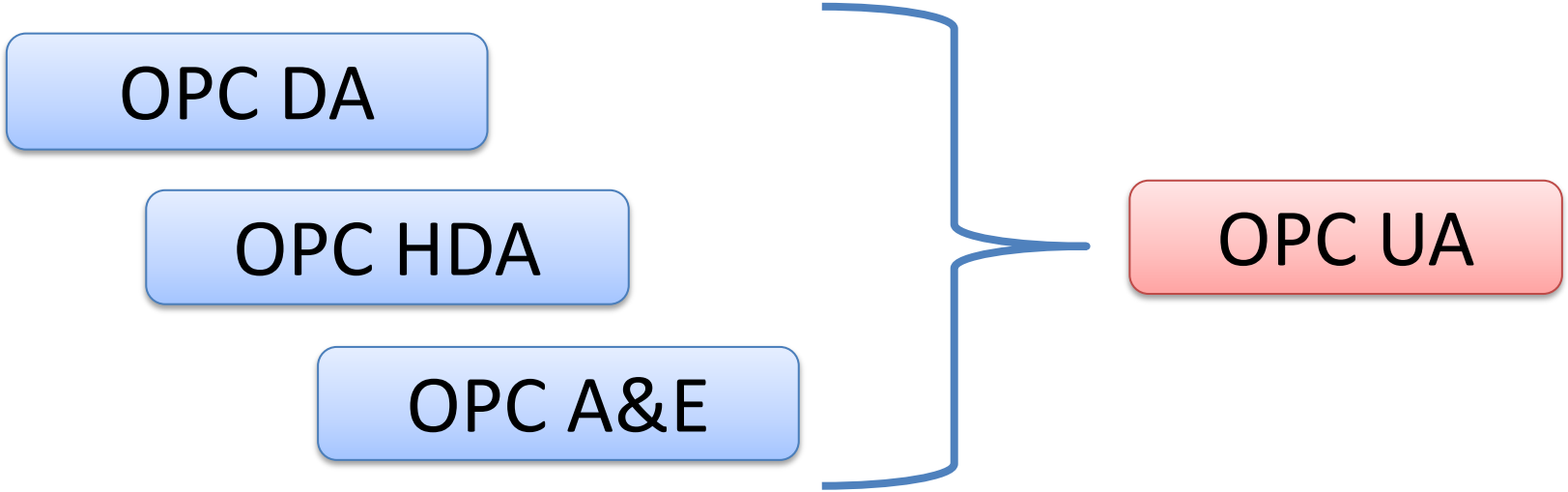
Classic OPC requires a Microsoft Windows operating system to implement COM/DCOM server functionality. By utilizing SOA and Web Services, OPC UA is a platform-independent system that eliminates the previous dependency on a Windows operating system. By utilizing SOAP/XML over HTTP, OPC UA can deploy on a variety of embedded systems regardless of whether the system is a general purpose operating system, such as Windows, or a deterministic real-time operating system.

http://www.ni.com/white-paper/13843/en/

OPC Specifications

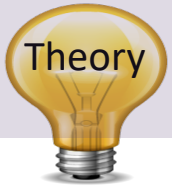
"Classic" OPC

"Next Generation" OPC



... (Many others)

Next Generation OPC



COM/DCOM

OPC Classic

Next Generation OPC

XML, HTTP, SOAP

OPC UA

OPC DA

OPC HDA

OPC A&E

Specifications

Windows only

Cross-platform

Windows, Linux, Mac, Embedded, VxWorks

All specifications collected in one (DA, HDA, A&E)

Protocols: “UA Binary” or “UA XML”

OPC DA Server

OPC HDA Server

OPC A&E Server

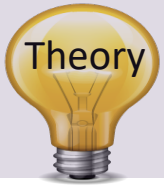
OPC Client (DCOM)

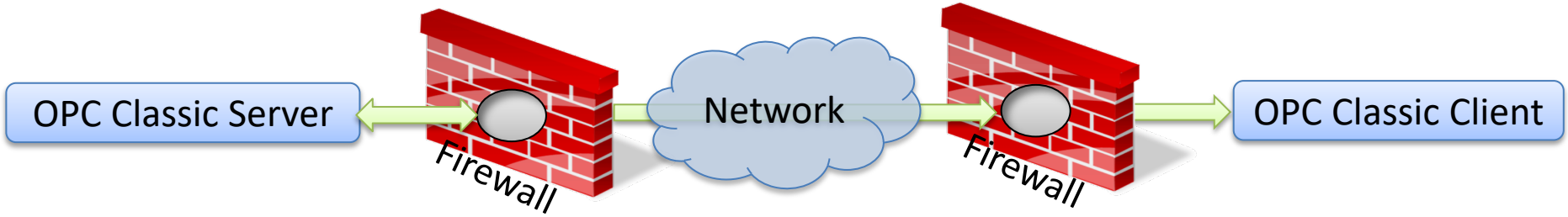
Simpler!!

OPC UA Server

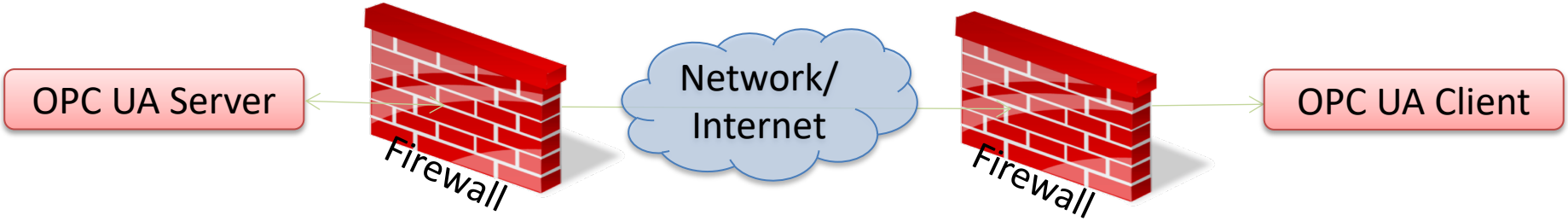
OPC UA Client

Next Generation OPC





To open DCOM through firewalls demanded a large hole in the firewall!
Impossible to route over Internet!



No hole in firewall (UA XML) or just a simple needle stick (UA Binary) is necessary
Easy to route over Internet!

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OPC UA Server Simulator

Hans-Petter Halvorsen

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OPC UA Server Simulator

- This free OPC UA Server tool supports data access and historical access information models of OPC UA.
- Consequently, it provides simulated real-time and historical data.
- It is possible to configure your own tags and the data simulation via CSV files.
- OPC UA clients can monitor real-time data and explore history data from this simulator.
- https://opcfoundation.org/products/view/opc-ua-server-simulator

OPC UA Server Simulator

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Products » OPC UA Server Simulator

OPC UA Server Simulator

Member: Integration Objects

Product website: integrationobjects.com/sioth-opc/sioth-opc-unified...

Integration Objects' **OPC UA Server Simulator** is a free to use and distribute OPC Unified Architecture server utility. Indeed, you can use this OPC UA simulator to play the role of OPC UA servers and test your OPC UA Client applications.

This free OPC UA Server tool supports data access and historical access information models of OPC UA. Consequently, it provides simulated real-time and historical data. Moreover, users can configure their own tags and the data simulation via CSV files. OPC UA clients can monitor real-time data and explore history data from this simulator.

Back

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https://opcfoundation.org

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- OPC UA Client Toolkit
- OPC UA Server Simulator
- OPC UA Proxy
- OPC UA Wrapper
- OPC UA Client

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OPC Servers
OPC Client Toolkits
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OPC Server Toolkits

OPC UA Server Simulator

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Watch Demo Videos

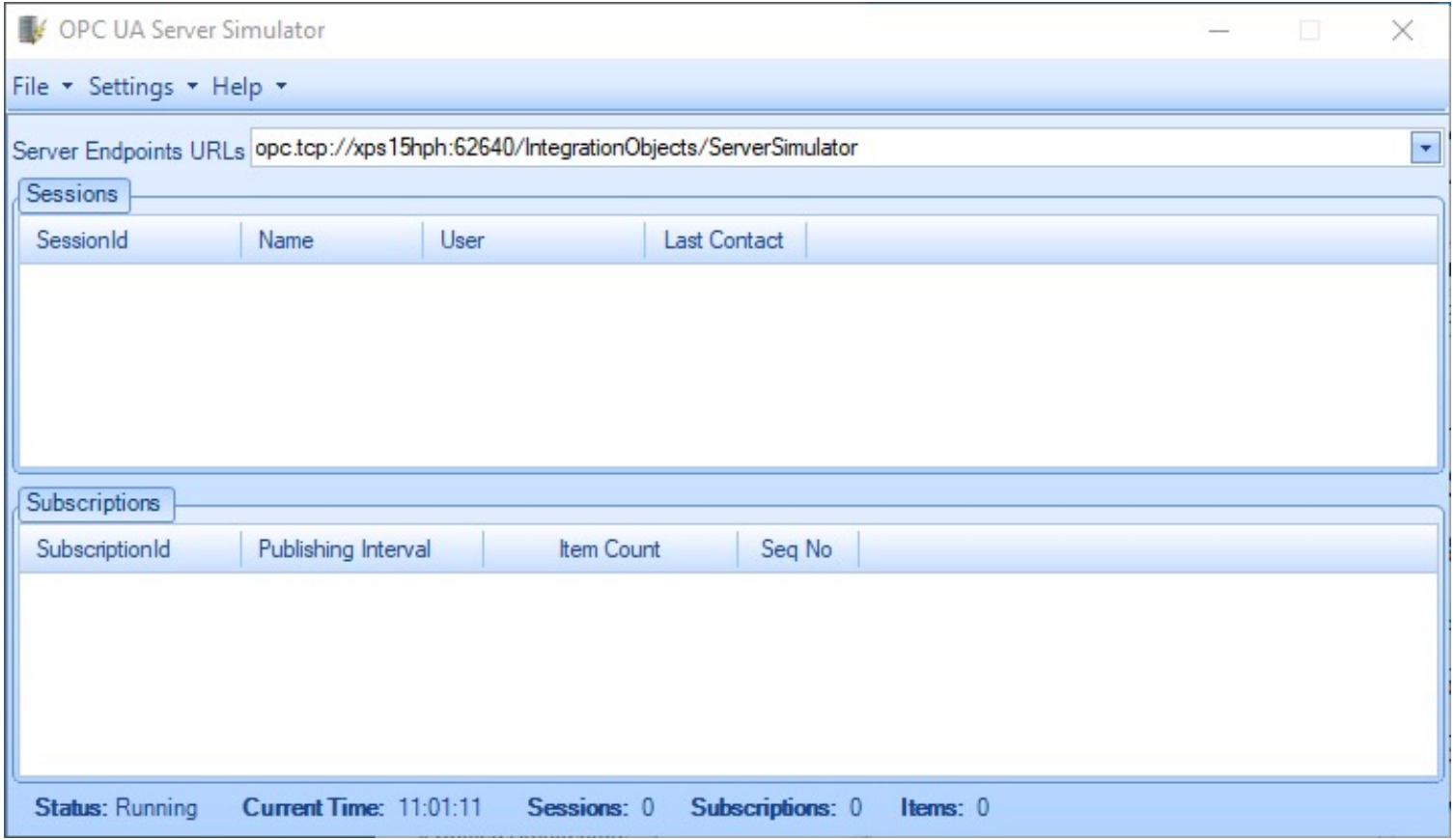
Simulate real-time and historical data using OPC UA Server Simulator!

Integration Objects' **OPC UA Server Simulator** is a free to use and distribute OPC Unified Architecture server utility. Indeed, you can use this OPC UA simulator to play the role of OPC UA servers and test your OPC UA Client applications.

This free OPC UA Server tool supports data access and historical access information models of OPC UA. Consequently, it provides simulated real-time and historical data. Moreover, users can configure their own tags and the data simulation via CSV files. OPC UA clients can monitor real-time data and explore history data from this simulator.

https://integrationobjects.com/sioth-opc/sioth-opc-unified-architecture/opc-ua-server-simulator/

OPC UA Server Simulator



OPC UA Server Simulator

The OPC UA Server Simulator uses 2 CSV simulation files:

- “**AddressSpace.csv**” used to build the address space of the OPC UA Server.
- “**ValueSpace.csv**” used to simulate the data values of the OPC UA items.
- Those two files are located at the following path: X:\Program Files (x86)\Integration Objects\Integration Objects' OPC UA Server Simulator\OPC UA Server Simulator\DATA

AddressSpace.csv

Tag Name	Data Type	AccessRights	Simulated
Tag1	IO_Int16	RW	FALSE
Tag2	IO_Int32	RW	FALSE
Tag3	IO_Int64	RW	FALSE
Tag4	IO_UInt16	RW	FALSE
Tag5	IO_UInt32	RW	FALSE
Tag6	IO_UInt64	RW	FALSE
Tag7	IO_Double	RW	FALSE
Tag8	IO_String	RW	FALSE
Tag9	IO_Byte	RW	FALSE
Tag10	IO_Boolean	RW	FALSE
Tag11	IO_Int16	R	TRUE
Tag12	IO_Int32	R	TRUE
Tag13	IO_Int64	R	TRUE
Tag14	IO_UInt16	R	TRUE
Tag15	IO_UInt32	R	TRUE
Tag16	IO_UInt64	R	TRUE
Tag17	IO_Double	R	TRUE
Tag18	IO_String	R	TRUE
Tag19	IO_Byte	R	TRUE
Tag20	IO_Boolean	R	TRUE

ValueSpace.csv

Tag11		Tag12		Tag13	
11	good	56	good	47	good
12	good	32	good	14	good
13	good	28	good	85	good
14	good	14	good	125	good
15	good	15	good	24	good
16	good	57	good	69	good
17	good	65	good	36	good
18	good	18	good	18	good
19	good	48	good	84	good
20	good	36	good	64	good

“OPC UA Client” Tool

Hans-Petter Halvorsen

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“OPC UA Client“ Tool

- “OPC UA Client” is a free client tool that supports the main OPC Unified Architecture information models.
- These models are Data Access, Alarms & Conditions, and Historical Data Access
- https://integrationobjects.com/sioth-opc/sioth-opc-unified-architecture/opc-ua-client/

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OPC UA
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- OPC UA Server Simulator
- OPC UA Proxy
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- OPC UA Client

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OPC UA Client

Download | User Guide | Quick User Guide

Download free OPC UA Client and start your OPC UA tests now!

OPC UA Client is a free client tool that supports the main OPC Unified Architecture information models. These models are Data Access, Alarms & Conditions, and Historical Data Access. In fact, it offers the capability to:

- Discover local and remote OPC UA servers
- Establish secure communication channels
- Browse the address space of any OPC UA compliant server
- Monitor real-time data and alarms & conditions
- Explore and update history data

Moreover, this OPC UA explorer allows you to generate its self-signed Application Instance Certificate in order to provide application level security and secure the connections with OPC UA servers.

View Tutorial Video of OPC UA Test Client & OPC UA Wrapper

Integration Objects' OPC UA Client

Home

New | Open | Save | Save as | Connect | Disconnect | Settings | UA Settings | Help | About | Define | Remove | Certificate Manager

File | Session | Configuration | Help

Sessions

Sessions

Address Space

Forward

Data View | Histo

Display Name | Subscription | Session

Attribute | Value

Message Type	Timestamp	Message
[Control]	2022-02-08 13:05:06	Disconnecting from session "
[Control]	2022-02-08 13:03:09	Read operation of the variab
[Control]	2022-02-08 13:01:03	A session "Session0" with the

3 Messages

Connection Settings

Session Information

Session Name: Session0

Server Information

Endpoint Url: opc.tcp://xps15hph:62640/IntegrationObjects/S

Discover

Transport Protocol

- (•) Opc.tcp
- ( ) Https

Message Encoding

- (•) Binary
- ( ) Xml

Security Mode

- (•) None
- ( ) Sign
- ( ) Sign _Encrypt

Security Policy

- (•) None
- ( ) Basic128RSA15
- ( ) Basic256
- ( ) Basic256Sha256

User Authentication Mode

- (•) Anonymous
- ( ) UserName
- ( ) Certificate

Certificate (.pfx)

Password

Apply | Cancel

Integration Objects' OPC UA Client

Home

New | Open | Save | Save as | Connect | Disconnect | Settings | UA Settings | Help | About | Define | Remove | Certificate Manager

File | Session | Configuration | Help | Default Configuration | Certificate

Sessions

- Sessions
  - Session0

Address Space

Forward

- Real Time Data
  - Tag1
  - Tag2
  - Tag3
  - Tag4
  - Tag5
  - Tag6
  - Tag7
  - Tag
  - Tag
  - Tag

References and Attributes
Read
Write
History Update
Monitor

Data View | History View | Event View

Display Name	Node Id	Value	Data Type	Server Timestamp	Source Timestamp	Status Code	Subscription	Session

Attribute	Value
NodeId	ns=2;s=Historical...
NodeClass	Object
BrowseName	2:Historicaldata
DisplayName	Historical Data
Description	
WriteMask	0
UserWriteMask	0
EventNotifier	Subscribe

Message Type	Timestamp	Message
[Control]	2022-02-08 13:03:09	Read operation of the variable [ns=2;s=Tag7] succeeded.
[Control]	2022-02-08 13:01:03	A session "Session0" with the Endpoint [opc.tcp://xps15hph:62640/IntegrationObjects/ServerSimulator - [None:None:Binary]] was successfully created.

2 Messages

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OPC UA with C#

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OPC UA with Visual Studio/C#

- Lots of Packages and Libraries do exist for creating both OPC UA Clients and OPC UA Servers in Visual Studio/C#
- Most of them are payment based
- Many of those can be evaluated for a trial period or used forever with some restrictions
- In this Tutorial, “OPC UA .NET SDK” will be used

OPC UA .NET SDK

Hans-Petter Halvorsen

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OPC UA .NET SDK

- The “OPC UA .NET SDK” comes with an evaluation license which can be used unlimited for each application run for 30 minutes
- It comes in a NuGet Package you can install and use in your Visual Studio Project
- https://opcfoundation.org/products/view/opc-ua-net-sdk-for-client-and-server

Visual Studio/C# Example

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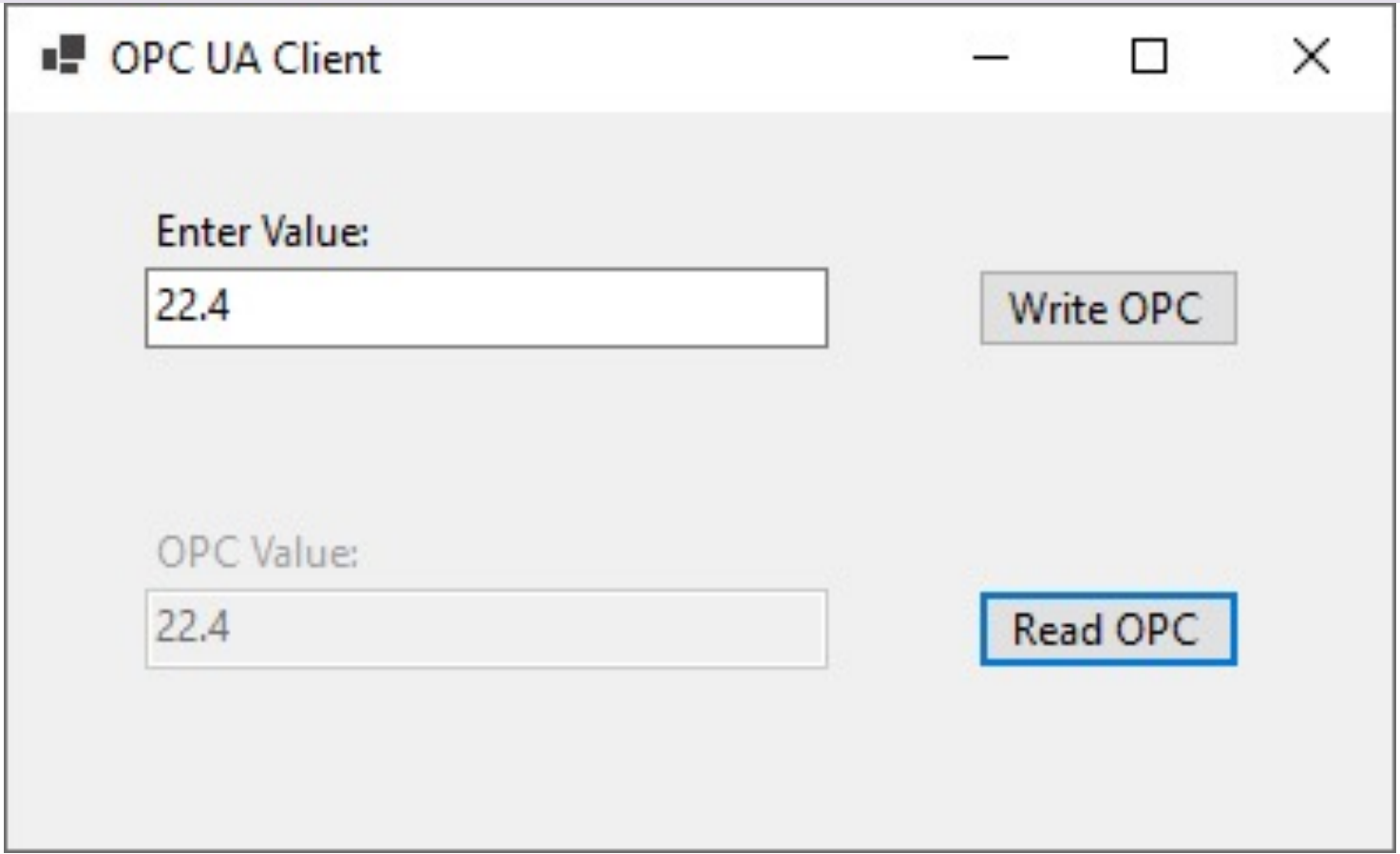
Visual Studio/C# Example



Visual Studio/C# Example

- Not that this is a simplified example in order demonstrate the principle of Writing Data to an OPC UA Server and Reading Data from an OPC Server
- Write and Read the same OPC Tag in the same Application makes no sense in a real scenario
- Typically, the OPC clients are distributed in a network and the different Applications are located on different computers in a network

NuGet Package

File Edit View Git Project Build Debug Test Analyze Tools Extensions Window Help Search (Ctrl+Q) OPCUAClient

Debug Any CPU OPCUAClient ▶ OPCUAClient Live Share

NuGet:...UAClient | Form1.cs | Form1.cs [Design]

Browse Installed Updates

NuGet Package Manager: OPCUAClient

opc.ua Include prerelease Package source: nuget.org

Opc.UaFx.Advanced by Traeger.de, **82.9K** downloads 2.21.0
OPC UA .NET Standard / .NET Framework / .NET Core SDK for simple and fast Client and Server Development within seconds.

Opc.UaFx.Client by Traeger.de, **52.2K** downloads 2.21.0
OPC UA .NET Standard / .NET Framework / .NET Core SDK for simple and fast Client Development within seconds.

OPCFoundation.NetStandard.Opc.Ua by OPC Foundation, **8** 1.4.367.95
This package contains the OPC UA reference implementation and is targeting the .NET Standard Library.

OpcLabs.QuickOpc by OPC Labs, **147K** downloads 5.62.1032
Rapid OPC client development. Supports OPC Data Access, XML-DA, Alarms&Events and Unified Architecture (OPC UA), including PubSub....

OPCFoundation.NetStandard.Opc.Ua.Core by OPC Founda 1.4.367.95
OPC UA Core Class Library

opc.ua.pubsub.dotnet.binary by Siemens AG, **10.7K** downloads 1.0.16
The opc-ua-pubsub-dotnet binary is a library which implements OPC UA PubSub encoding and decoding in a simplified way. This package contains...

opc.ua.pubsub.dotnet.client by Siemens AG, **10.1K** downloads 1.0.16
The opc-ua-pubsub-dotnet client is a library which implements OPC UA PubSub communication via MQTT protocol in a simplified way.

OPCFoundation.NetStandard.Opc.Ua.Client by OPC Founc 1.4.367.95
OPC UA Client Class Library

OPCFoundation.NetStandard.Opc.Ua.Configuration by 1.4.367.95
OPC UA Configuration Class Library

OPCFoundation.NetStandard.Opc.Ua.Server by OPC Four 1.4.367.95
OPC UA Server Class Library

OPCFoundation.NetStandard.Opc.Ua.Security.Certific 1.4.367.95
OPC UA Security X509 Certificates Class Library

Opc.UaFx.Client

nuget.org

Version: Latest stable 2.21.0 Install

Options

Description

OPC UA Client SDK supporting OPC DA, AE and HDA for quick & easy OPC UA Client development using .NET Framework and .NET Standard. Simple & familiar .NET API, portability, features, patterns, samples and technical support. Unlimited free evaluation & royalty free licensing. Designed and implemented using Microsoft's Framework Design Guidelines by Traeger in Germany/ Bavaria with over 30 years of experience in industrial communication.

NEW!
Samples available at https://github.com/ Traeger-GmbH/opcuanet-samples

OPC Watch
Download: https://docs.traeger.de/en/ software/sdk/opc-ua/net#download
Usage: Browse, read, write, subscribe nodes or generate code for user defined types from server or nodeset.

Features:
- DA: Data Access
- HDA: Historical Data Access
- AE: Alarms & Events + Conditions
- IO: FileAccess
- API: Methods and Enumerations
- OPC Classic Support
- Others:
  - Units of Measurements
  - Complex/Structured Data Types

Characteristics:

Solution Explorer

Search Solution Explorer (Ctrl+¨)

- Solution 'OPCUAClient' (1 of 1 project)
  - OPCUAClient
    - Dependencies
      - Analyzers
      - Frameworks
    - Form1.cs
      - Form1.Designer.cs
      - Form1.resx
    - Program.cs

Solution Explorer | Git Changes

Properties

Data Sources | Diagnostic Tools

Ready 275 , 44 75 x 23 Add to Source Control Select Repository

Visual Studio Project

File Edit View Git Project Build Debug Test Analyze Tools Extensions Window Help Search (Ctrl+Q) OPCUAClient

Debug Any CPU OPCUAClient OPCUAClient Live Share

Form1.cs Form1.cs [Design]

OPCUAClient OPCUARead.Form1 btnOpcWrite_Click(object sender, EventArgs e

```
using Opc.UaFx.Client;

namespace OPCUARead
{
    3 references
    public partial class Form1 : Form
    {
        public string opcUrl = "opc.tcp://localhost:62640/"; //OPC UA Server Simulator

        1 reference
        public Form1()
        {
            InitializeComponent();
        }

        1 reference
        private void btnOpcWrite_Click(object sender, EventArgs e)
        {
            var tagName = "ns=2;s=Tag7";

            var client = new OpcClient(opcUrl);
            client.Connect();

            double temperature;

            temperature = Convert.ToDouble(txtOpcDataWrite.Text);

            client.WriteNode(tagName, temperature);

            client.Disconnect();
        }

        1 reference
        private void btnOpcRead_Click(object sender, EventArgs e)
        {
            var tagName = "ns=2;s=Tag7";
```

100 % No issues found Ln: 13 Ch: 1 SPC CRLF

Solution Explorer

Search Solution Explorer (Ctrl+¨)

- Solution 'OPCUAClient' (1 of 1 project)
  - OPCUAClient
    - Dependencies
      - Analyzers
      - Frameworks
      - Packages
        - Opc.UaFx.Client (2.21.0)
    - Form1.cs
      - Form1.Designer.cs
      - Form1.resx
    - Program.cs

Solution Explorer Git Changes

Properties

Error List

Entire Solution 0 Errors 0 Warnings 0 of 2 Messages Build + IntelliSe Search Error List

Co...	Description	Project	File	L...	Suppression S

Error List Output

This item does not support previewing Add to Source Control Select Repository

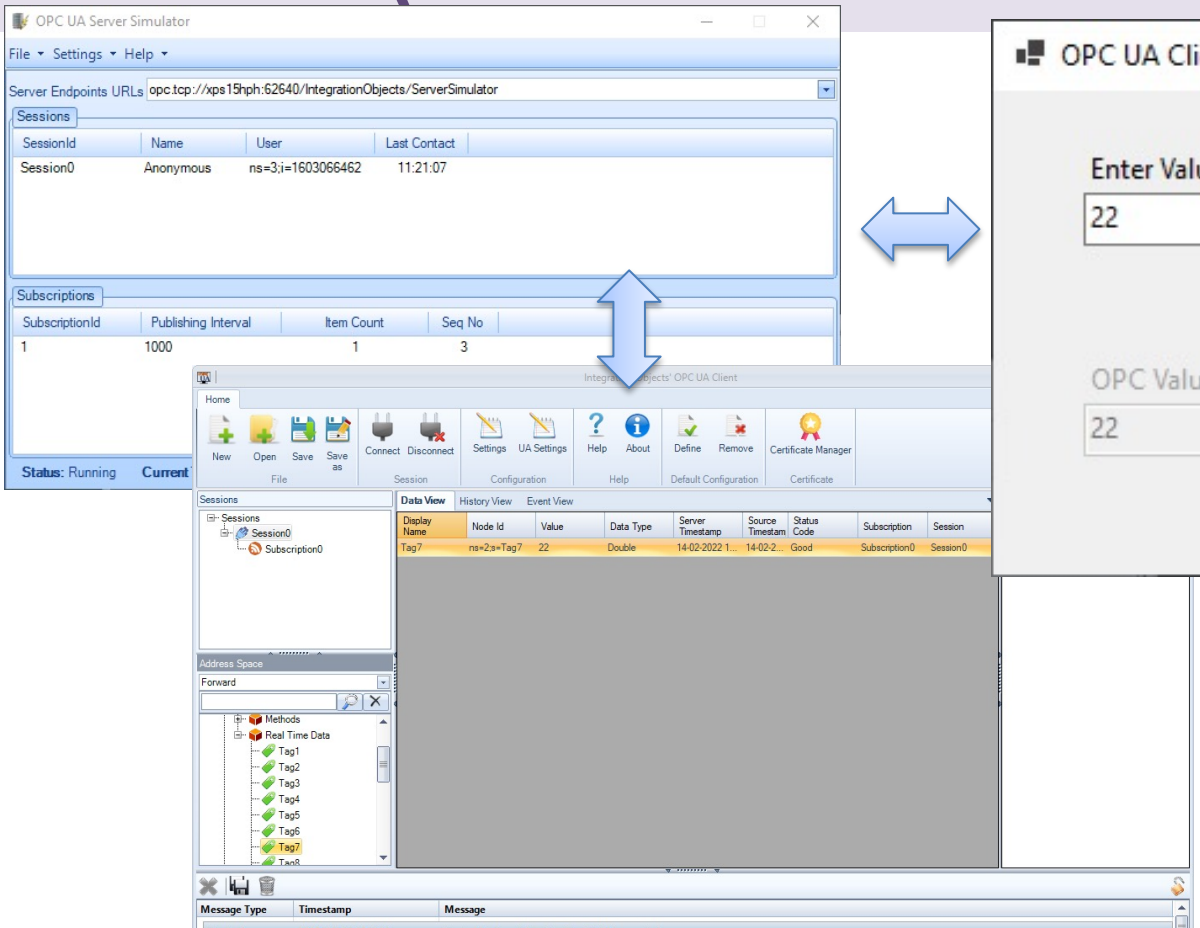
OPC UA Write

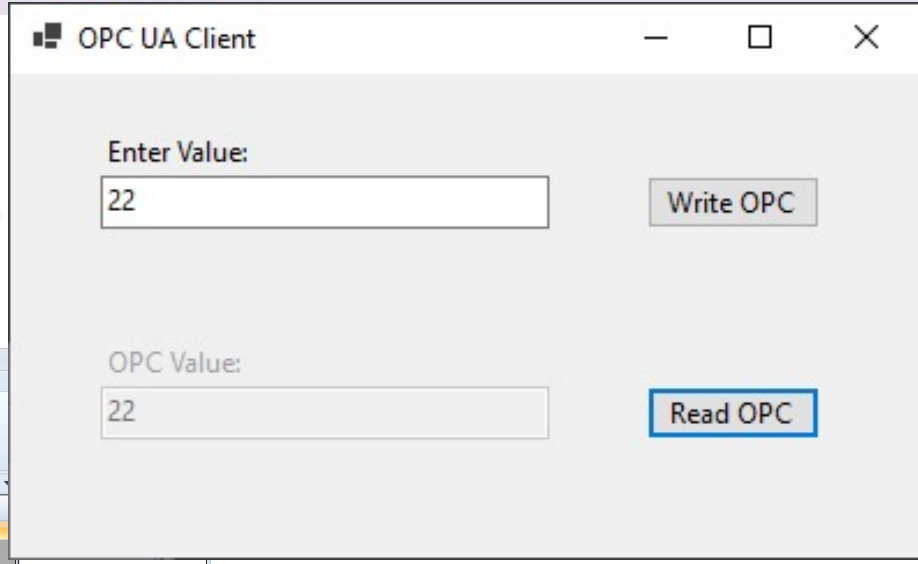
```
private void btnOpcWrite_Click(object sender, EventArgs e)
{
        string opcUrl = "opc.tcp://localhost:62640/";
        var tagName = "ns=2;s=Tag7";

        var client = new OpcClient(opcUrl);
        client.Connect();

        double temperature;
        temperature = Convert.ToDouble(txtOpcDataWrite.Text);

        client.WriteNode(tagName, temperature);

        client.Disconnect();
}
```

OPC UA Read

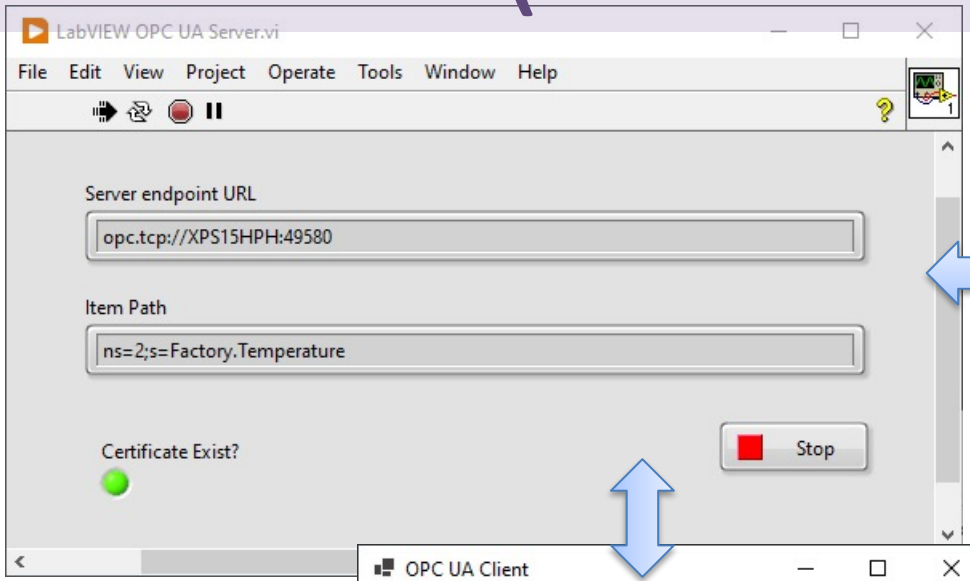
```
private void btnOpcRead_Click(object sender, EventArgs e)
{
    string opcUrl = "opc.tcp://localhost:62640/";
    var tagName = "ns=2;s=Tag7";

    var client = new OpcClient(opcUrl);
    client.Connect();

    var temperature = client.ReadNode(tagName);
    txtOpcDataRead.Text = temperature.ToString();

    client.Disconnect();
}
```

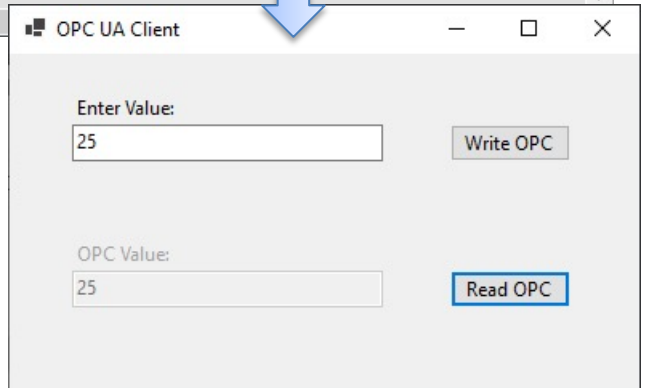
Test 1 (OPC UA Server Simulator)

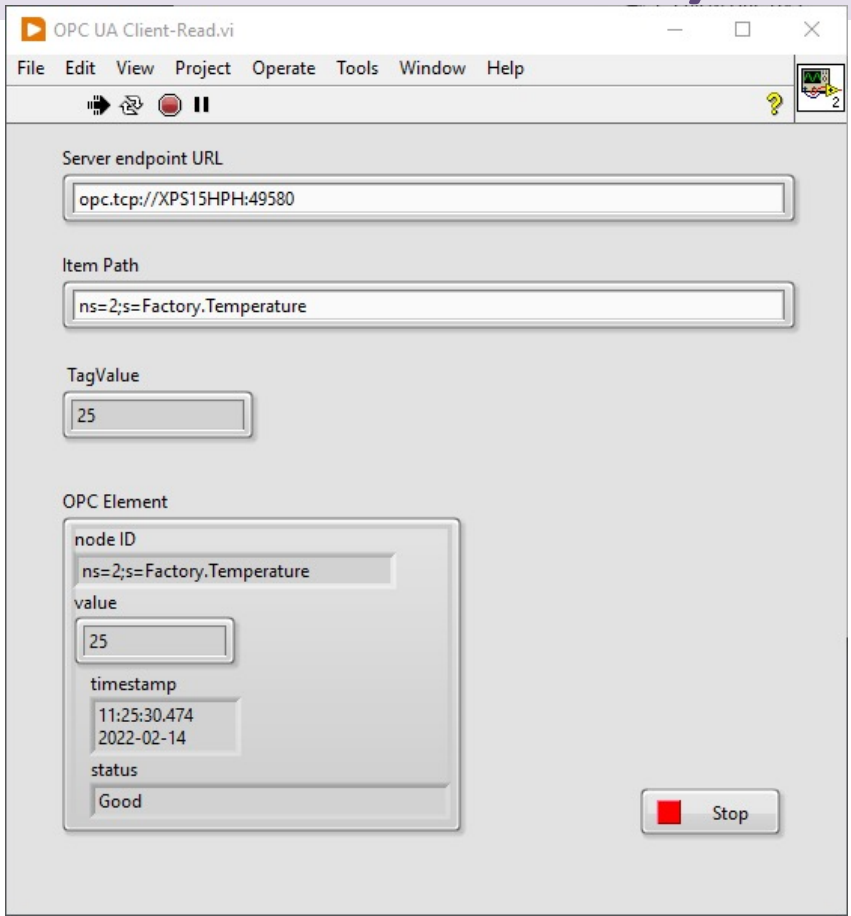




Test 2 (LabVIEW OPC Server)





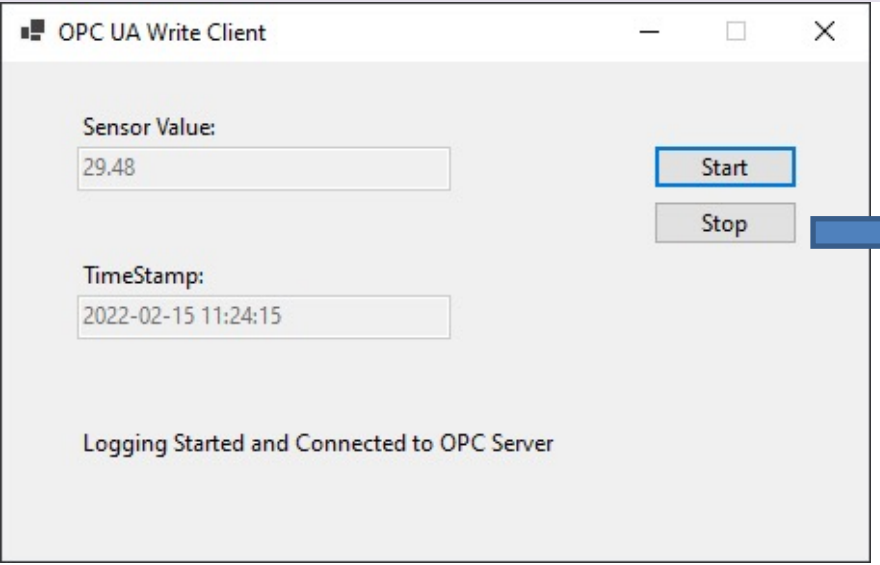


Improved Example

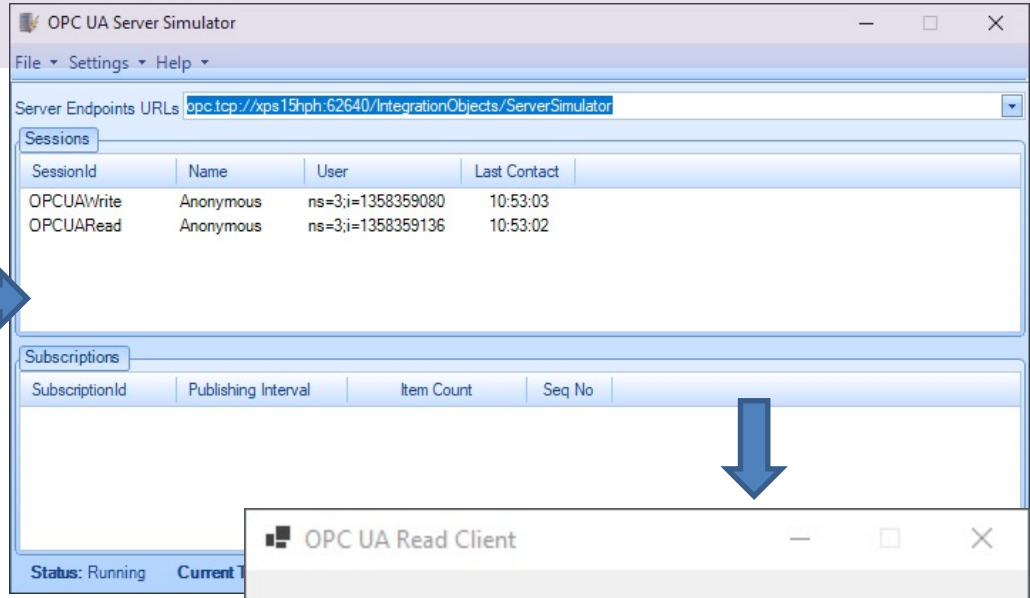
Improved Example

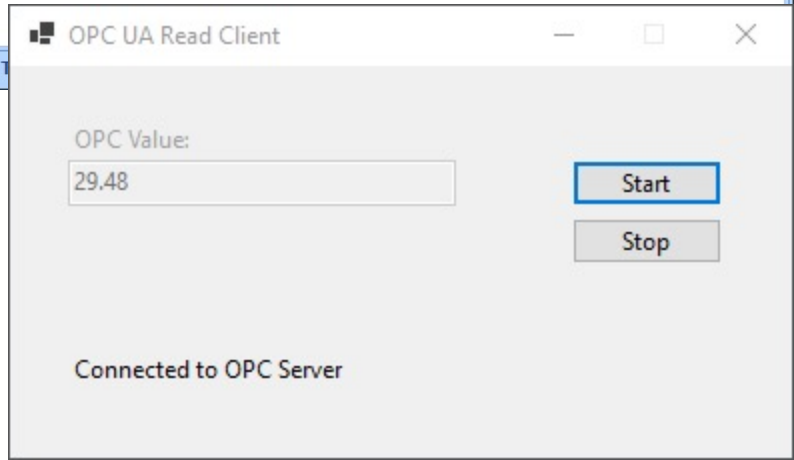
We will implement some Improvements:

- Separate Applications for Write and Read
- Start and Stop Buttons
- Formatting Number of Decimals
- Property window (preventing resizing of the window):
  - form1.FormBorderStyle = FormBorderStyle.FixedSingle;
  - Form1.MaximizeBox = false;
- Using a Timer (Writing/Reading at specific Intervals)
- General Improvements in the Code



OPC UA Write C# App

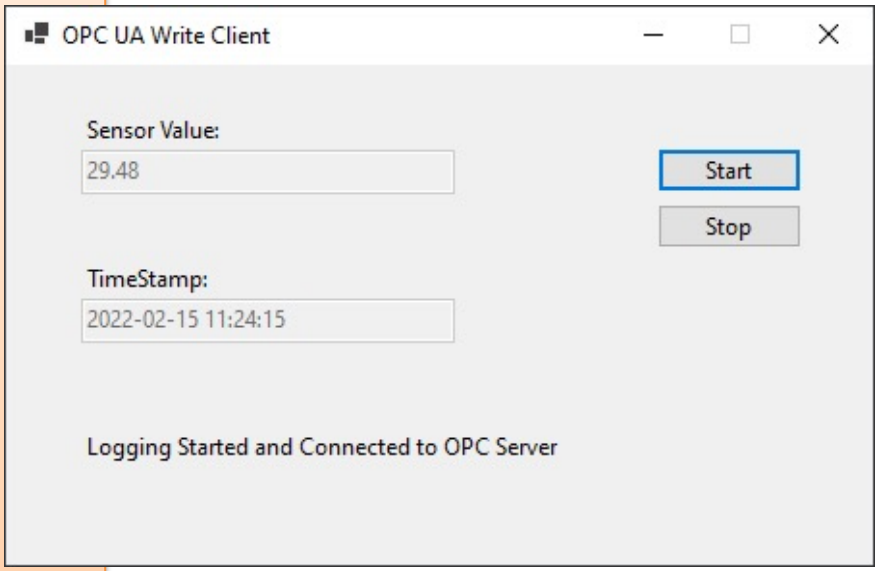




OPC UA Read C# App

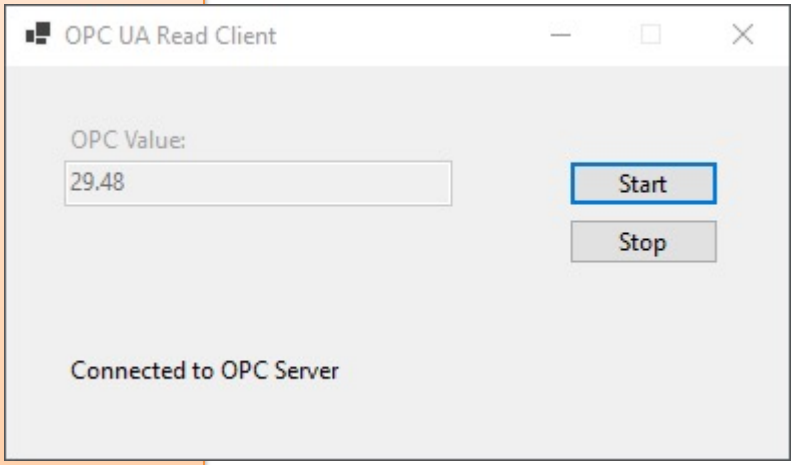
OPC UA Write

```
using Opc.UaFx.Client;

namespace OPCUARead
{
  public partial class Form1 : Form
  {
    public OpcClient client = new OpcClient("opc.tcp://localhost:62640/");

    public Form1()
    {
      InitializeComponent();
      timer1.Interval = 10000;
    }

    private void Form1_FormClosing(object sender, FormClosingEventArgs e)
    {
      if (client != null)
        client.Disconnect();
    }


    private void timer1_Tick(object sender, EventArgs e)
    {
      double sensorValue;

      sensorValue = ReadSensorData();
      OpcWrite(sensorValue);
    }

    double ReadSensorData()
    {
      var rand = new Random();
      int minValue = 20, maxValue = 30;
      double sensorValue;

      sensorValue = rand.NextDouble() * (maxValue - minValue) + minValue;
      txtSensorValue.Text = sensorValue.ToString("#.##");
      DateTime sensorDateTime = DateTime.Now;
      txtTimeStamp.Text = sensorDateTime.ToString("yyyy-MM-dd HH:mm:ss");

      return sensorValue;
    }

    void OpcWrite(double sensorValue)
    {
      string tagName = "ns=2;s=Tag7";
      client.WriteNode(tagName, sensorValue);
    }

    private void btnStart_Click(object sender, EventArgs e)
    {
      client.Connect();
      timer1.Start();
      lblStatusMessage.Text = "Logging Started and Connected to OPC Server";
    }

    private void btnStop_Click(object sender, EventArgs e)
    {
      timer1.Stop();
      if (client != null)
        client.Disconnect();
      lblStatusMessage.Text = "Logging Stopped and Disconnected from OPC Server";
    }

  }
}
```



OPC UA Read

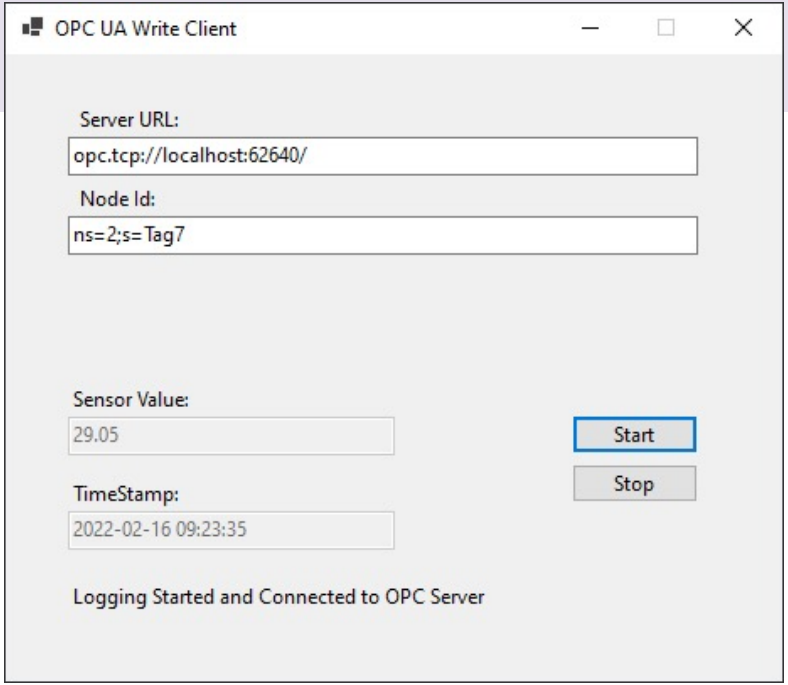
```
using Opc.UaFx.Client;

namespace OPCUARead
{
  public partial class Form1 : Form
  {
    public OpcClient client = new OpcClient("opc.tcp://localhost:62640/");

    public Form1()
    {
      InitializeComponent();
      timer1.Interval = 2000;
    }

    private void timer1_Tick(object sender, EventArgs e)
    {
      OpcRead();
    }

    void OpcRead()
    {
      string tagName = "ns=2;s=Tag7";

      Opc.UaFx.OpcValue opcData = client.ReadNode(tagName);

      double temperature = (double)opcData.Value;

      txtOpcValue.Text = temperature.ToString("#.##");
    }

    private void btnStart_Click(object sender, EventArgs e)
    {
      client.Connect();
      timer1.Start();
      lblStatusMessage.Text = "Connected to OPC Server";

    }

    private void btnStop_Click(object sender, EventArgs e)
    {
      timer1.Stop();
      if (client != null)
        client.Disconnect();
      lblStatusMessage.Text = "Disconnected from OPC Server";
    }

    private void Form1_FormClosing(object sender, FormClosingEventArgs e)
    {
      if (client != null)
        client.Disconnect();
    }

  }
}
```



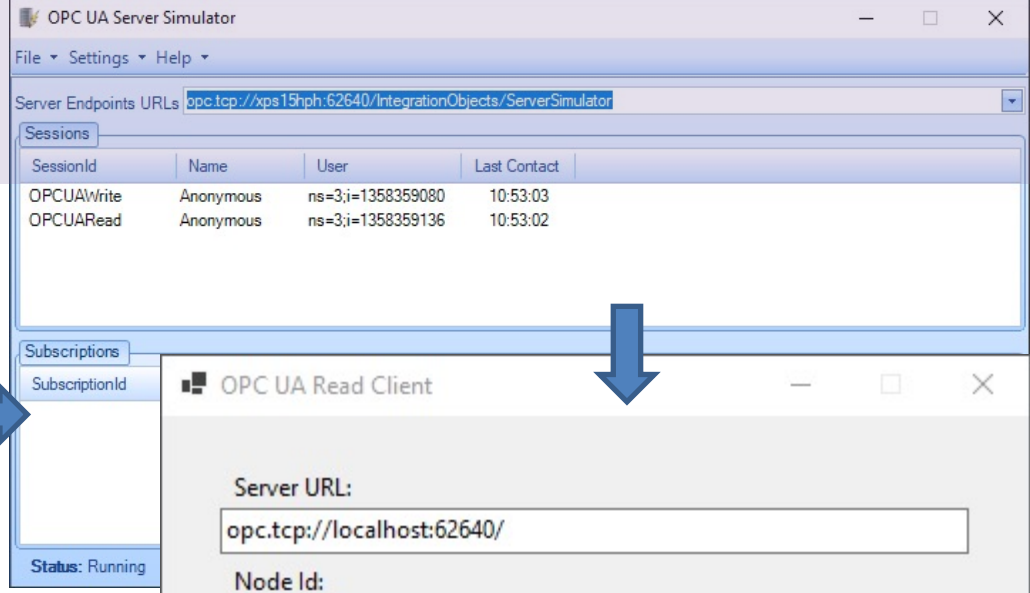
More Improvements

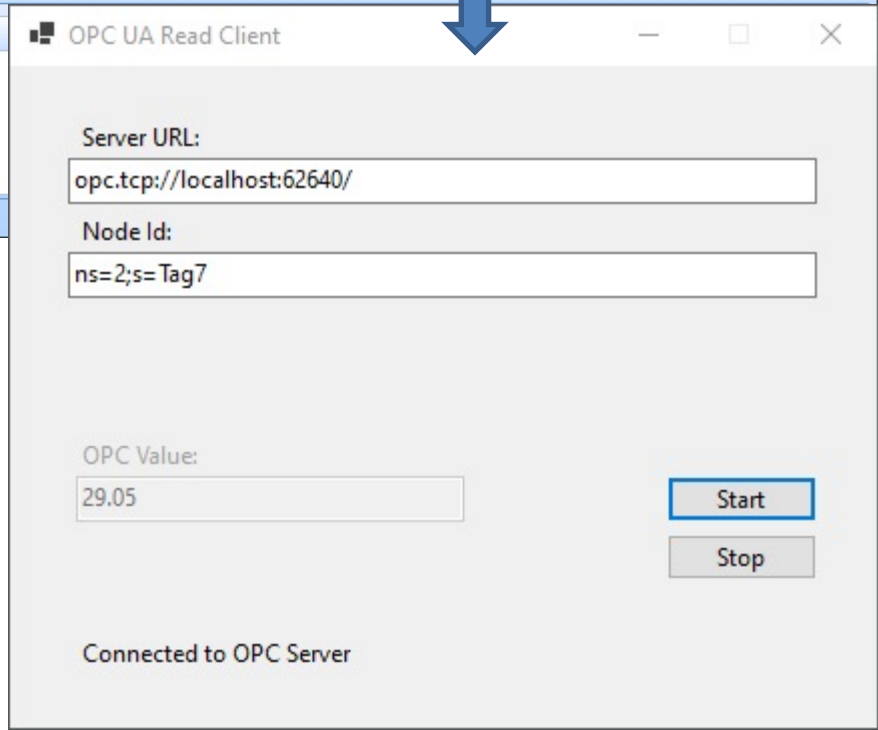
We will implement some more Improvements:

- Possible to specify ServerUrl and NodeId (TagName) from the GUI



OPC UA Write C# App





OPC UA Read C# App

Furter Work

Still, lots of improvements can be made

- Possible to change the Logging Interval from the GUI
- Add a Chart
- Get Data from a real Sensor
- Add Units
- Etc.
- In addition, the “OPC UA .NET SDK” comes with many features that will not be demonstrated here

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