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OPC-UA Industrial Communication Standard

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Agenda

1. OPC-UA Overview
2. OPC-UA Integration Within Glass Industry
3. Benefits & Challenges
4. Conclusion

Agenda

1. OPC-UA Overview
   - **1.1 Characteristics**
   - **1.2 Structure / Architecture**
   - **1.3 Application Areas**
   - **1.4 Hardware & Software**
2. OPC-UA Integration Within Glass Industry
3. Benefits & Challenges
4. Conclusion

OPC-UA Overview
1.1 Characteristics

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➢ **OPC-UA**

Open Platform Communications Unified Architecture

➢ **Key Features → 6 Technical Pillars**

- Secure Communication
- Rich Information Modelling
- Automatic Discovery
- Platform Independance
- Flexible messaging patterns
- Extensibility

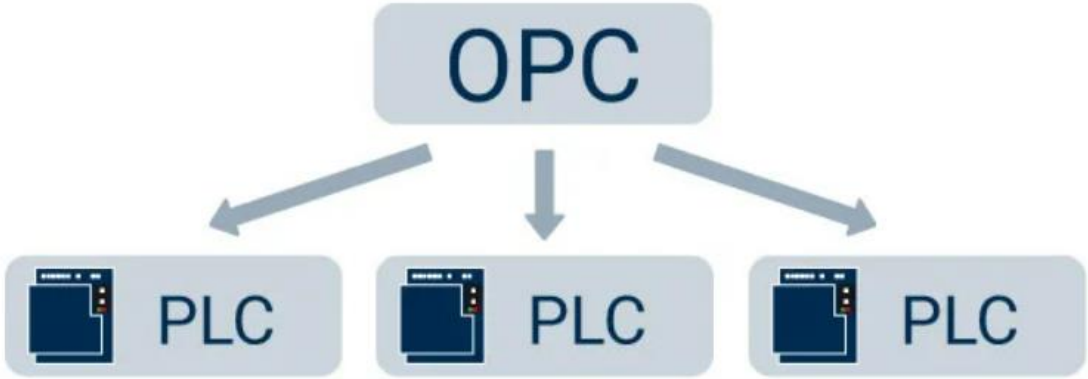

Figure 1.1: OPC-UA Communication [1]

➢ **Further Characteristics**

- Real-Time + Historic Data Access
- Accepts different Data Types
- Different forms of communication
  - ✓ TCP for local requirements
  - ✓ HTTPS when crossing firewalls

OPC-UA Overview
1.2 Structure / Architecture

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- **OPC-UA Structure**
  - I. **Field Layer :** Generates raw process signals
  - II. **Control Layer :** Executes real-time logic
  - III. **Information Layer :** Normalise all lower level signals into one secure address space
  - IV. **Application Layer :** Consume data & issue high level commands

- **OPC-UA Architecture**
  - I. **Information Model Layer:** Objects, variables and methods.
  - II. **Service Layer:** Standard APIs, implemented by servers, controlled by clients.
  - III. **Secure Channel & Session Layer :** Encrypted messages, and user authentication
  - IV. **Transport Mapping Layer:** Communication (TCP, HTTPS)
  - V. **Network Layer:** Any IP Network

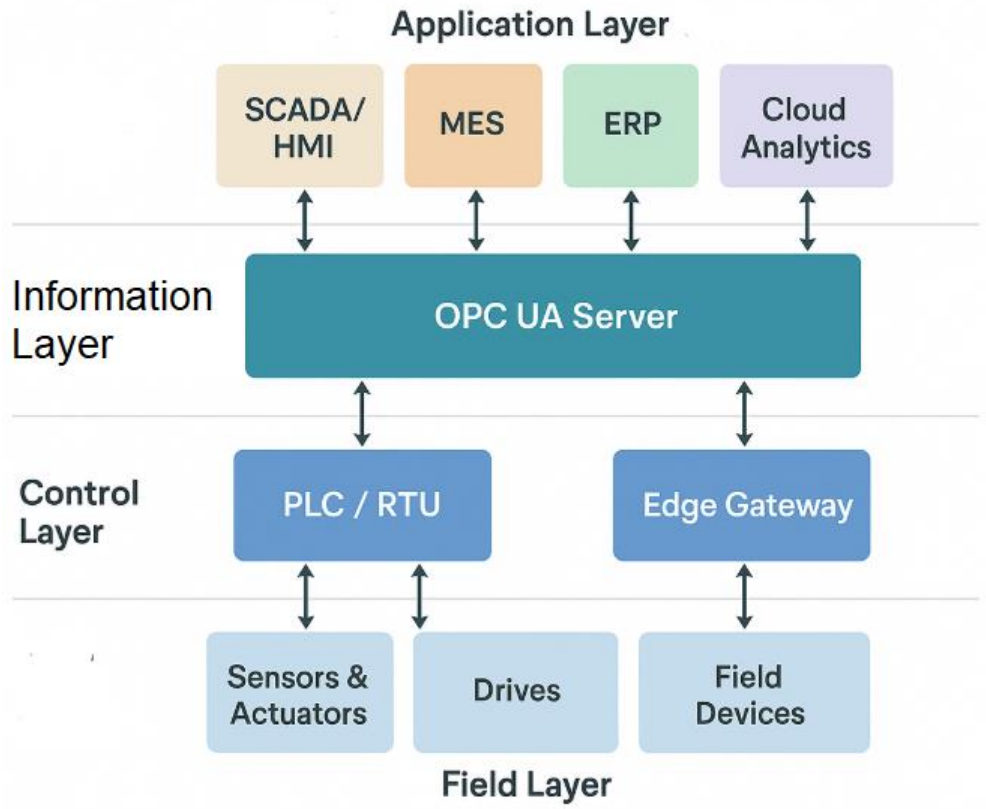

Figure 1.2: OPC-UA Structure / Architecture

OPC-UA Overview
1.3 Application Areas

Figure 1.3: Glass Industry [2]

Figure 1.4: Automotive Industry [2]

Figure 1.5: Smart Infrastructure [2]

OPC-UA Overview
1.4 Hardware & Software

- **Hardware Requirements**
  - Demaning Industrial PC is **NOT** required
  - Hardware ranges from PLC – 32 Bit Microcontroller
  - External components required at times (Ewon Module)

Figure 1.6: Siemens S7-1500 PLC [3]

- **Software Requirements**
  - Software depends on Hardware
  - Some Hardware have integrated Software (TIA Portal for Siemens PLCs)
  - Open available stacks for every major programming language
    - C / C++ → Open62541
    - Java → Eclipse Milo

Figure 1.7: Schneider Electric LMC Pacdrive [4]

Figure 1.8: HMS Ewon Cosy Module [5]

Agenda

1. OPC-UA Overview
2. OPC-UA Integration Within Glass Industry
   - **2.1 Data Collection**
   - **2.2 Programming The OPC Server**
   - **2.3 Completed Server**
3. Benefits & Challenges
4. Conclusion

OPC-UA Integration within Glass Industry

Figure 2.1 : Gerrsesheimer Group Logo [6]

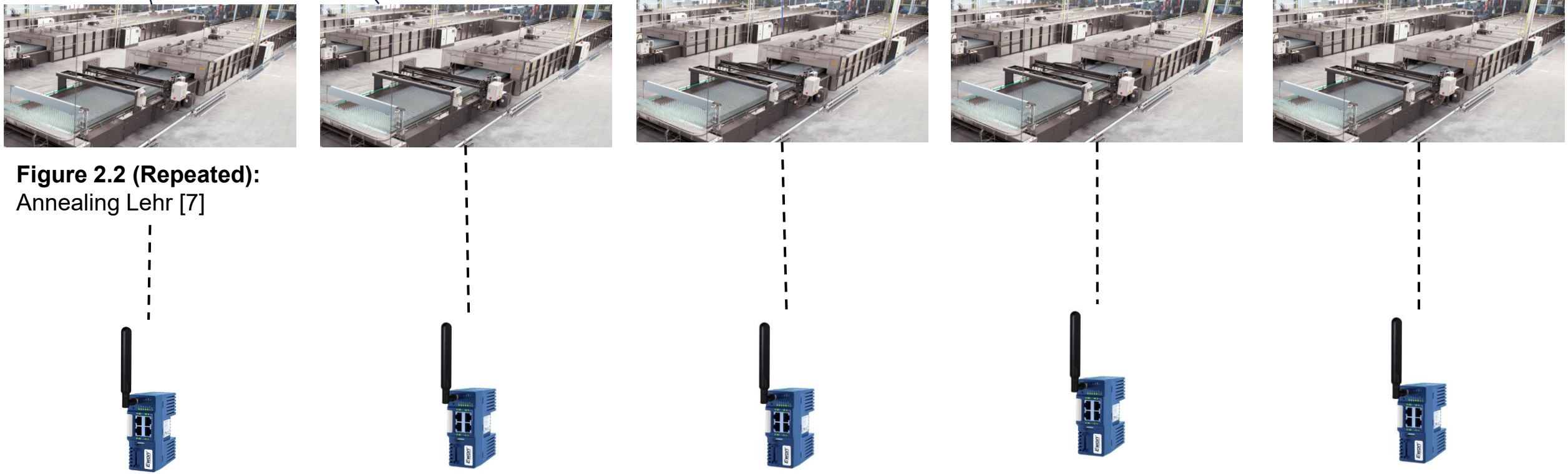

Figure 2.2 (Repeated):
Annealing Lehr [7]

OPC-UA Integration within Glass Industry
2.1 Data Collection

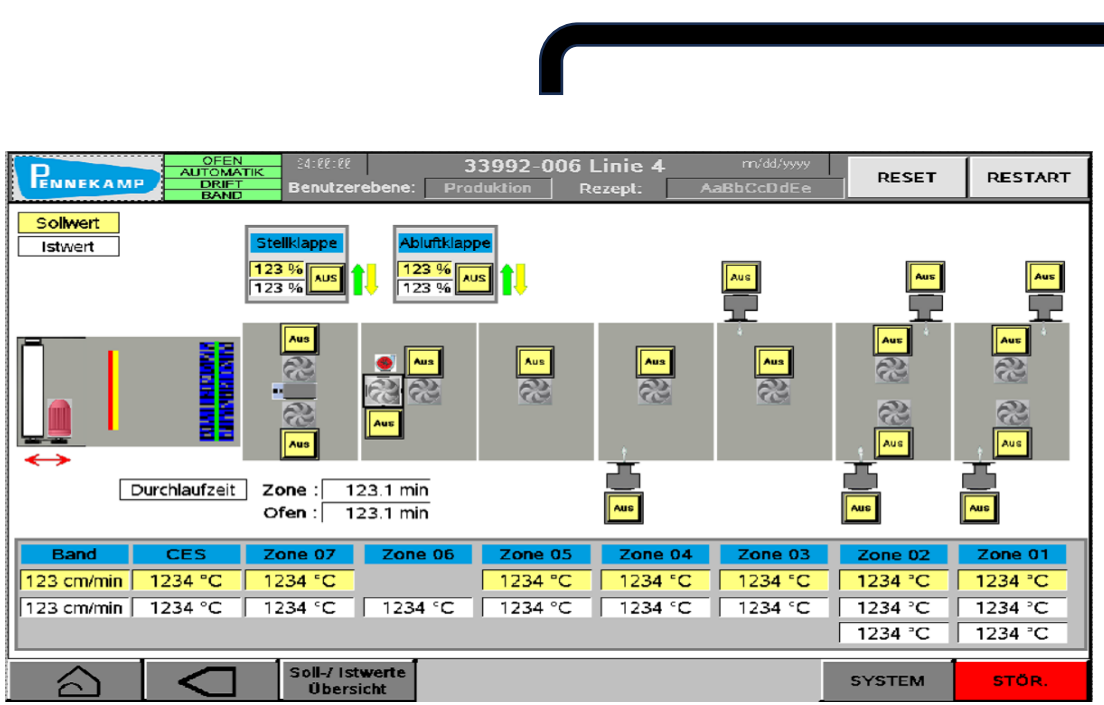

Figure 2.3 : Required Parameters from Vijeo Designer

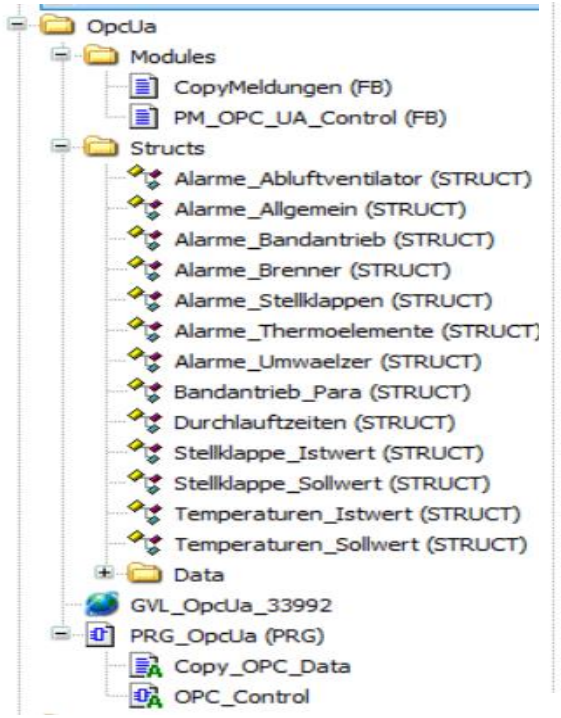

Figure 2.4 : OPC-UA Struct View

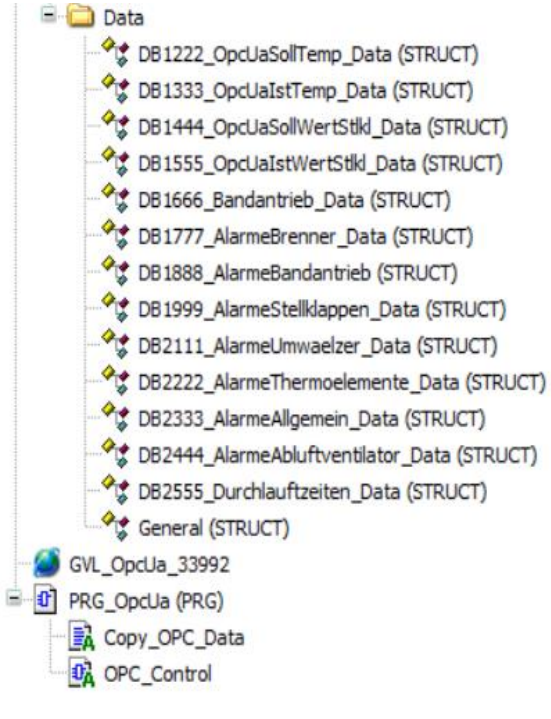

Figure 2.5 : OPC-UA Data View

OPC-UA Integration within Glass Industry
2.2 Programming The OPC Server

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```
cUaIstTemp_Data    DB1444_OpcUaSollWertStkl_Data    DB1666_Bandantri
1  TYPE Temperaturen_Sollwert :
2  STRUCT
3          Data            : DB1222_OpcUaSollTemp_Data;
4  END_STRUCT
5  END_TYPE
6
```

Figure 2.6 : Within the Data Blocks

```
DB1222_OpcUaSollTemp_Data ×    DB1333_OpcUaIstTemp_Data
TYPE DB1222_OpcUaSollTemp_Data :
STRUCT
        Zone_1_TemperaturSollwertHMI    : REAL;
        Zone_2_TemperaturSollwertHMI    : REAL;
        Zone_3_TemperaturSollwertHMI    : REAL;
        Zone_4_TemperaturSollwertHMI    : REAL;
        Zone_5_TemperaturSollwertHMI    : REAL;
        Zone_6_TemperaturSollwertHMI    : REAL;
        Zone_7_TemperaturSollwertHMI    : REAL;



        Zone_1_TemperaturSollwertOpc    : REAL;
        Zone_2_TemperaturSollwertOpc    : REAL;
        Zone_3_TemperaturSollwertOpc    : REAL;
        Zone_4_TemperaturSollwertOpc    : REAL;
        Zone_5_TemperaturSollwertOpc    : REAL;
        Zone_6_TemperaturSollwertOpc    : REAL;
        Zone_7_TemperaturSollwertOpc    : REAL;

END_STRUCT
END_TYPE
```

Figure 2.7 : Within the Struct Blocks

[redacted]

```
// Solltemperatur Zone 2
IF HMI.G2Plc_astZ02HeizG[1].rSoll <> GVL_OpcUa_36121.DB1222_OpcUaSollTemp.Data.Zone_2_TemperaturSollwertOpc AND (PM_OPC_UA_Control.UserILoggedIn) THEN
HMI.G2Plc_astZ02HeizG[1].rSoll := LIMIT(0.0, GVL_OpcUa_36121.DB1222_OpcUaSollTemp.Data.Zone_2_TemperaturSollwertOpc, 650.0 );
END_IF
```

Figure 2.8 : Sample Segment of Code

OPC-UA Integration within Glass Industry
2.1 Programming OPC- Server

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```
IF iOpcUaUser = 'PKP' AND iOpcUaPassword = '1234' AND TrigLogin.Q THEN

xLogin:=TRUE;

User1LoggedIn := TRUE;

 ELSE

User1LoggedIn := FALSE;

END_IF
```

Figure 2.9 : Remote Access Server Security System

#	Server	Node Id	Display Name	Value	Datatype
1	OpcServer@172...	NS2|String|...	st_OpcUaPassword	1234	String
2	OpcServer@172...	NS2|String|...	st_OpcUaUser	PKP	String
3	OpcServer@172...	NS2|String|...	xLogin	true	Boolean

Figure 2.10 : UA-Expert Security Nodes

```
// Solltemperatur Zone 2
IF HMI.G2Plc_astZ02HeizG[1].rSoll <> GVL_OpcUa_36121.DB1222_OpcUaSollTemp.Data.Zone_2_TemperaturSollwertOpc AND (PM_OPC_UA_Control.User1LoggedIn) THEN
HMI.G2Plc_astZ02HeizG[1].rSoll := LIMIT(0.0, GVL_OpcUa_36121.DB1222_OpcUaSollTemp.Data.Zone_2_TemperaturSollwertOpc, 650.0 );
END_IF
```

Figure 2.11 : Highlighted Security Variable

OPC-UA Integration within Glass Industry
2.3 Completed Server

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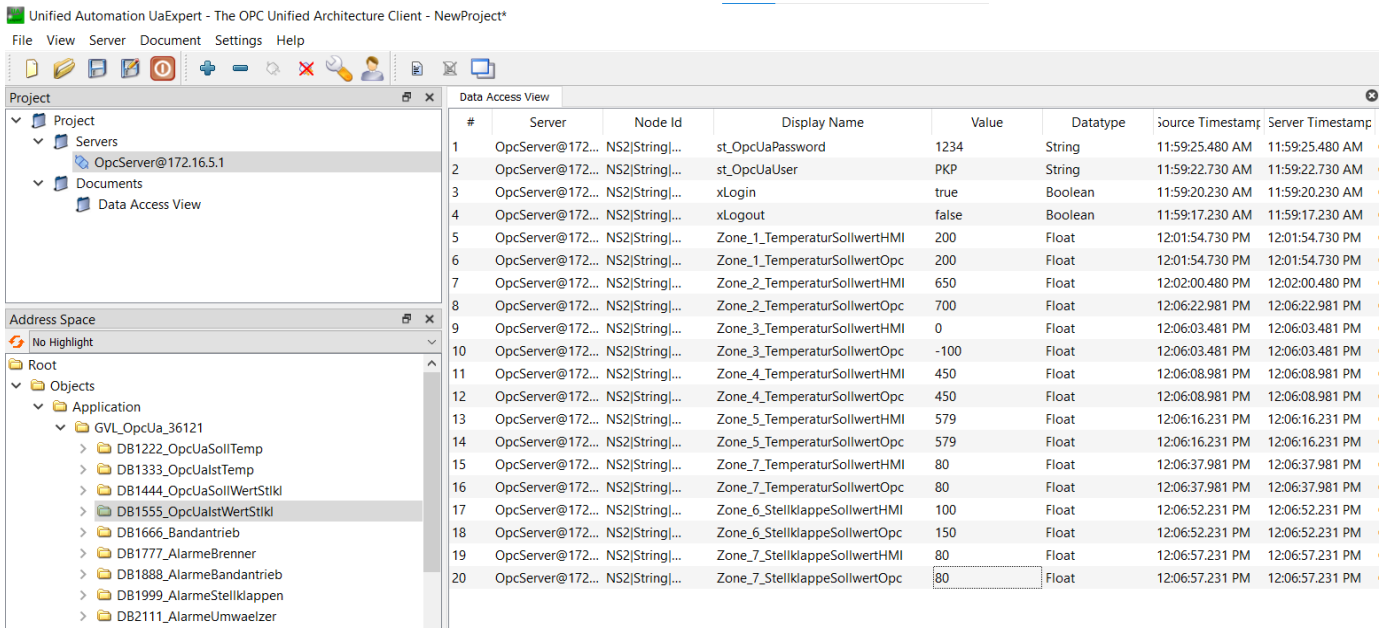
GVL_OpcUa_33992

```
{attribute 'qualified_only'}
VAR_GLOBAL
    DB1222_OpcUaSollTemp          : Temperaturen_Sollwert;
    DB1333_OpcUaIstTemp           : Temperaturen_Istwert;
    DB1444_OpcUaSollWertStlkl     : Stellklappe_Sollwert;
    DB1555_OpcUaIstWertStlkl      : Stellklappe_Istwert;
    DB1666_Bandantrieb            : Bandantrieb_Para;
    DB1777_AlarmeBrenner          : Alarme_Brenner;
    DB1888_AlarmeBandantrieb      : Alarme_Bandantrieb;
    DB1999_AlarmeStellklappen     : Alarme_Stellklappen;
    DB2111_AlarmeUmwaelzer        : Alarme_Umwaelzer;
    DB2222_AlarmeThermoelemente   : Alarme_Thermoelemente;
    DB2333_AlarmeAllgemein        : Alarme_Allgemein;
    DB2444_AlarmeAbluftventilator : Alarme_Abluftventilator;
    DB2555_Durchlauftzeiten       : Durchlauftzeiten;
    General                       : General;

END_VAR
```

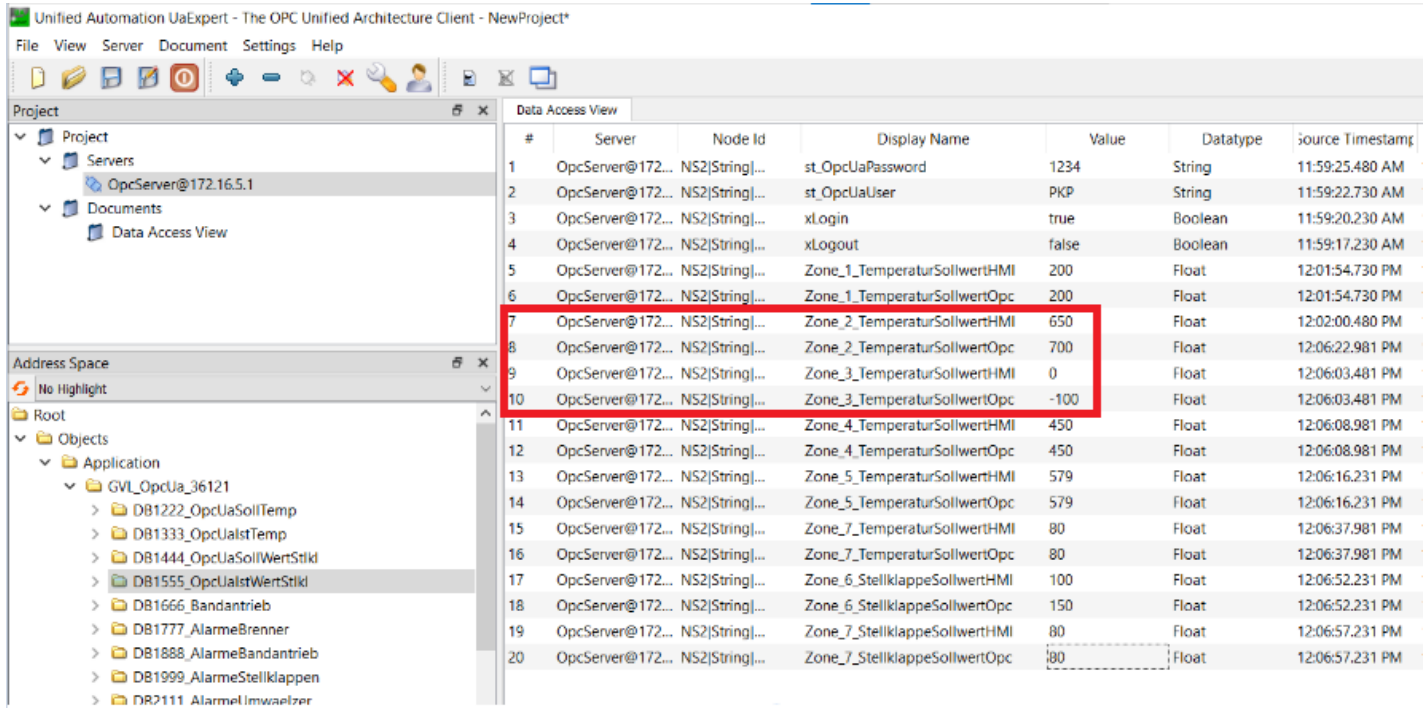
Figure 2.12 : Global Variables of the Project



#	Server	Node Id	Display Name	Value	Datatype	Source Timestamp	Server Timestamp
1	OpcServer@172...	NS2|String|...	st_OpcUaPassword	1234	String	11:59:25.480 AM	11:59:25.480 AM
2	OpcServer@172...	NS2|String|...	st_OpcUaUser	PKP	String	11:59:22.730 AM	11:59:22.730 AM
3	OpcServer@172...	NS2|String|...	xLogin	true	Boolean	11:59:20.230 AM	11:59:20.230 AM
4	OpcServer@172...	NS2|String|...	xLogout	false	Boolean	11:59:17.230 AM	11:59:17.230 AM
5	OpcServer@172...	NS2|String|...	Zone_1_TemperaturSollwertHMI	200	Float	12:01:54.730 PM	12:01:54.730 PM
6	OpcServer@172...	NS2|String|...	Zone_1_TemperaturSollwertOpc	200	Float	12:01:54.730 PM	12:01:54.730 PM
7	OpcServer@172...	NS2|String|...	Zone_2_TemperaturSollwertHMI	650	Float	12:02:00.480 PM	12:02:00.480 PM
8	OpcServer@172...	NS2|String|...	Zone_2_TemperaturSollwertOpc	700	Float	12:06:22.981 PM	12:06:22.981 PM
9	OpcServer@172...	NS2|String|...	Zone_3_TemperaturSollwertHMI	0	Float	12:06:03.481 PM	12:06:03.481 PM
10	OpcServer@172...	NS2|String|...	Zone_3_TemperaturSollwertOpc	-100	Float	12:06:03.481 PM	12:06:03.481 PM
11	OpcServer@172...	NS2|String|...	Zone_4_TemperaturSollwertHMI	450	Float	12:06:08.981 PM	12:06:08.981 PM
12	OpcServer@172...	NS2|String|...	Zone_4_TemperaturSollwertOpc	450	Float	12:06:08.981 PM	12:06:08.981 PM
13	OpcServer@172...	NS2|String|...	Zone_5_TemperaturSollwertHMI	579	Float	12:06:16.231 PM	12:06:16.231 PM
14	OpcServer@172...	NS2|String|...	Zone_5_TemperaturSollwertOpc	579	Float	12:06:16.231 PM	12:06:16.231 PM
15	OpcServer@172...	NS2|String|...	Zone_7_TemperaturSollwertHMI	80	Float	12:06:37.981 PM	12:06:37.981 PM
16	OpcServer@172...	NS2|String|...	Zone_7_TemperaturSollwertOpc	80	Float	12:06:37.981 PM	12:06:37.981 PM
17	OpcServer@172...	NS2|String|...	Zone_6_StellklappeSollwertHMI	100	Float	12:06:52.231 PM	12:06:52.231 PM
18	OpcServer@172...	NS2|String|...	Zone_6_StellklappeSollwertOpc	150	Float	12:06:52.231 PM	12:06:52.231 PM
19	OpcServer@172...	NS2|String|...	Zone_7_StellklappeSollwertHMI	80	Float	12:06:57.231 PM	12:06:57.231 PM
20	OpcServer@172...	NS2|String|...	Zone_7_StellklappeSollwertOpc	80	Float	12:06:57.231 PM	12:06:57.231 PM

Figure 2.13: UA-Expert Server View

OPC-UA Integration within Glass Industry
2.3 Completed Server



#	Server	Node Id	Display Name	Value	Datatype	Source Timestamp
1	OpcServer@172...	NS2|String|...	st_OpcUaPassword	1234	String	11:59:25.480 AM
2	OpcServer@172...	NS2|String|...	st_OpcUaUser	PKP	String	11:59:22.730 AM
3	OpcServer@172...	NS2|String|...	xLogin	true	Boolean	11:59:20.230 AM
4	OpcServer@172...	NS2|String|...	xLogout	false	Boolean	11:59:17.230 AM
5	OpcServer@172...	NS2|String|...	Zone_1_TemperaturSollwertHMI	200	Float	12:01:54.730 PM
6	OpcServer@172...	NS2|String|...	Zone_1_TemperaturSollwertOpc	200	Float	12:01:54.730 PM
7	OpcServer@172...	NS2|String|...	Zone_2_TemperaturSollwertHMI	650	Float	12:02:00.480 PM
8	OpcServer@172...	NS2|String|...	Zone_2_TemperaturSollwertOpc	700	Float	12:06:22.981 PM
9	OpcServer@172...	NS2|String|...	Zone_3_TemperaturSollwertHMI	0	Float	12:06:03.481 PM
10	OpcServer@172...	NS2|String|...	Zone_3_TemperaturSollwertOpc	-100	Float	12:06:03.481 PM
11	OpcServer@172...	NS2|String|...	Zone_4_TemperaturSollwertHMI	450	Float	12:06:08.981 PM
12	OpcServer@172...	NS2|String|...	Zone_4_TemperaturSollwertOpc	450	Float	12:06:08.981 PM
13	OpcServer@172...	NS2|String|...	Zone_5_TemperaturSollwertHMI	579	Float	12:06:16.231 PM
14	OpcServer@172...	NS2|String|...	Zone_5_TemperaturSollwertOpc	579	Float	12:06:16.231 PM
15	OpcServer@172...	NS2|String|...	Zone_7_TemperaturSollwertHMI	80	Float	12:06:37.981 PM
16	OpcServer@172...	NS2|String|...	Zone_7_TemperaturSollwertOpc	80	Float	12:06:37.981 PM
17	OpcServer@172...	NS2|String|...	Zone_6_StellklappeSollwertHMI	100	Float	12:06:52.231 PM
18	OpcServer@172...	NS2|String|...	Zone_6_StellklappeSollwertOpc	150	Float	12:06:52.231 PM
19	OpcServer@172...	NS2|String|...	Zone_7_StellklappeSollwertHMI	80	Float	12:06:57.231 PM
20	OpcServer@172...	NS2|String|...	Zone_7_StellklappeSollwertOpc	80	Float	12:06:57.231 PM

Figure 2.14: Testing Limits on UA-Expert

```
// Solltemperatur Zone 2
IF HMI.G2Plc_astZ02HeizG[1].rSoll <> GVL_OpcUa_36121.DB1222_OpcUaSollTemp.Data.Zone_2_TemperaturSollwertOpc AND (PM_OPC_UA_Control.User1LoggedIn) THEN
HMI.G2Plc_astZ02HeizG[1].rSoll := LIMIT(0.0, GVL_OpcUa_36121.DB1222_OpcUaSollTemp.Data.Zone_2_TemperaturSollwertOpc, 650.0 );
END_IF
```

Figure 2.15 : Highlighted limits for parameters

Agenda

1. OPC-UA Overview
2. OPC-UA Integration within Glass Industry
3. **Benefits & Challenges**
   - **3.1 Benefits**
   - **3.2 Challenges**
   - **3.3 Why OPC-UA?**
4. Conclusion

Benefits & Challenges of OPC-UA
3.1 Benefits

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- **Benefits of OPC-UA**
  - ✓ **Decentralization –** Flexibility in terms of data modeling structures in a mesh network**.**
  - ✓ **Platform Independance –** seamlessly integrate software from any vendor using any OS.
  - ✓ **Scalability –** makes the industrial communication method future proof.
  - ✓ **Interoperability** – allowing end user to build custom industrial systems using any device.

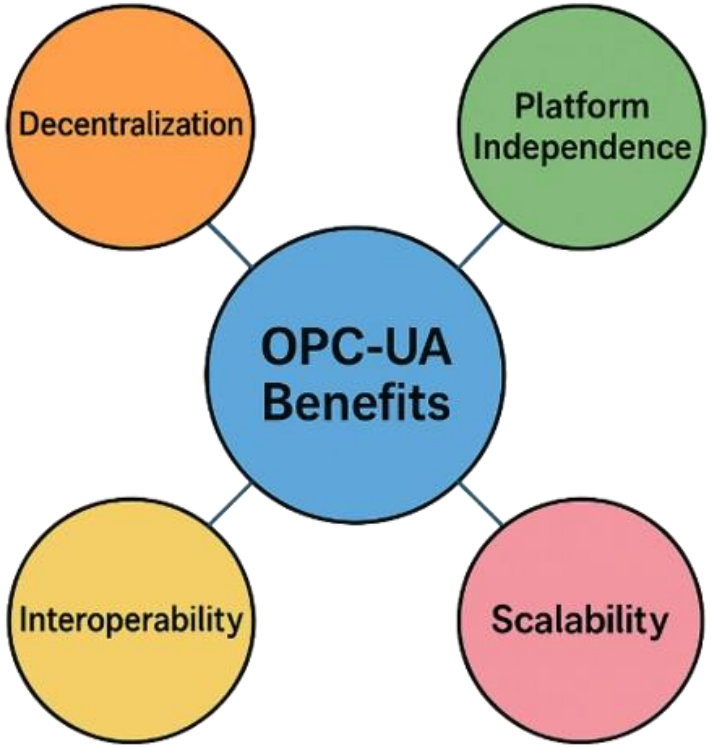

Figure 3.1 : OPC-UA Benfits

Benefits & Challenges of OPC-UA
3.2 Challenges

- **Challenges of OPC-UA**
  - **High Complexity –** Programming, variable connection and security implementation
  - **Performance –** at times problems in terms of high latency arise
  - **Security / Privacy –** Though OPC-UA has built in security, added layers must be considered
  - **Infrastructure –** The combination of different hardware might result in complex infrastructure that can be hard to handle

Figure 3.2 : OPC-UA Challenges

Benefits & Challenges of OPC-UA
3.3 Why OPC-UA?

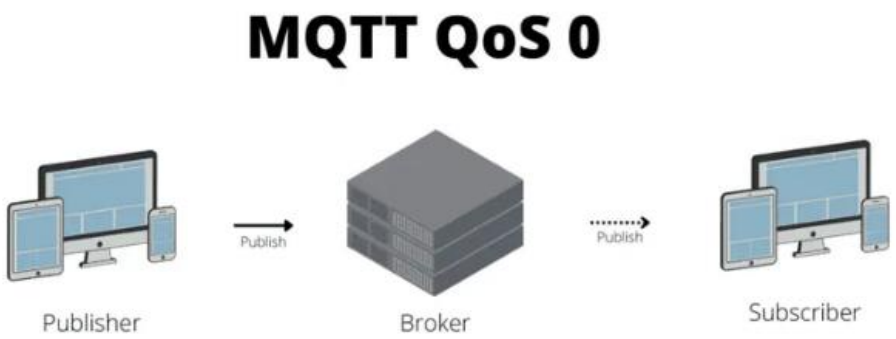

Figure 3.3 : MQTT Communication [8]

Figure 3.4 : Modbus Communication [9]

- **MQTT Challenges** [10]
  - Lightweight messaging Protocol
  - Mainly used for implementing IoT
  - Lacks advanced data structure
  - Lacks advanced Security algorithms

- **Modbus Challenges** [11]
  - Differ in how objective is reached
  - Simple, Open protocol
  - Lacks security features
  - Not designed for Real-Time communication

Agenda

1. OPC-UA Overview
2. OPC-UA Integration Within Glass Industry
3. Benefits & Challenges
4. **Conclusion**

Conclusion

- **Future Work**
  1. UA Pubsub over TSN
  2. Wireless 5G / 6G integration
  3. Cloud-native & Data-space interoperability
  4. Security hardening & Quantom crypto
  5. Sematic Modelling
  6. Scaling the certification
  7. Edge analytics and AI pipelines

Figure 3.5 : Future Work for OPC-UA

Conclusion

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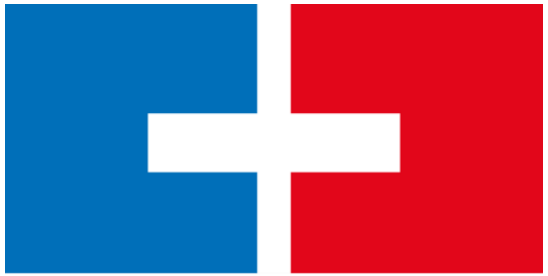
THANK YOU FOR YOUR ATTENTION!



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Background Information
1.1 Hardware Equipment

- **Schneider Electric LMC Pacdrive**
- **Software** : SoMachine & Vijeo Designer
- **Use case** : IoT / Cloud connectivity

Figure 1.3: Schneider Electric LMC Pacdrive [3]

Background Information
1.1 Hardware Equipment

- HMS Network **Ewon Module**
- Industrial VPN Router

- **Software** : Talk2M & Ecatcher

- **Use case** : Network Bridging & Secure Remote Access

Figure 1.5: HMS Network Ewon Module [5]

Background Information
1.2 Software Applications

- **SoMachine**
- Programming Software for Schneider Electric PLCs

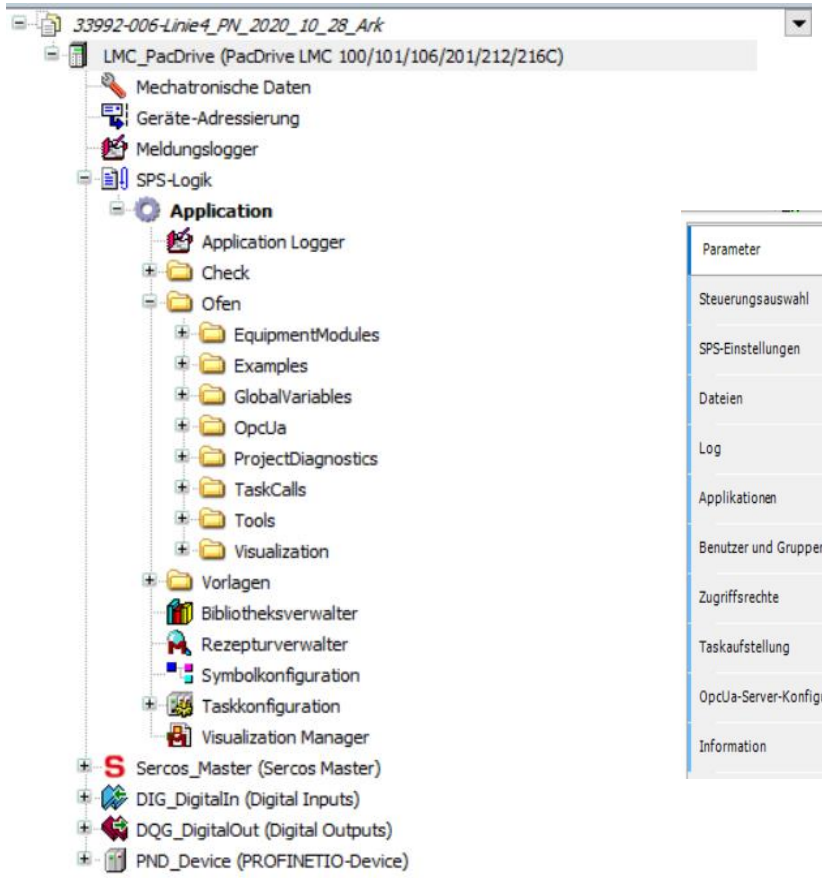

Figure 1.10: SoMachine Main Screen

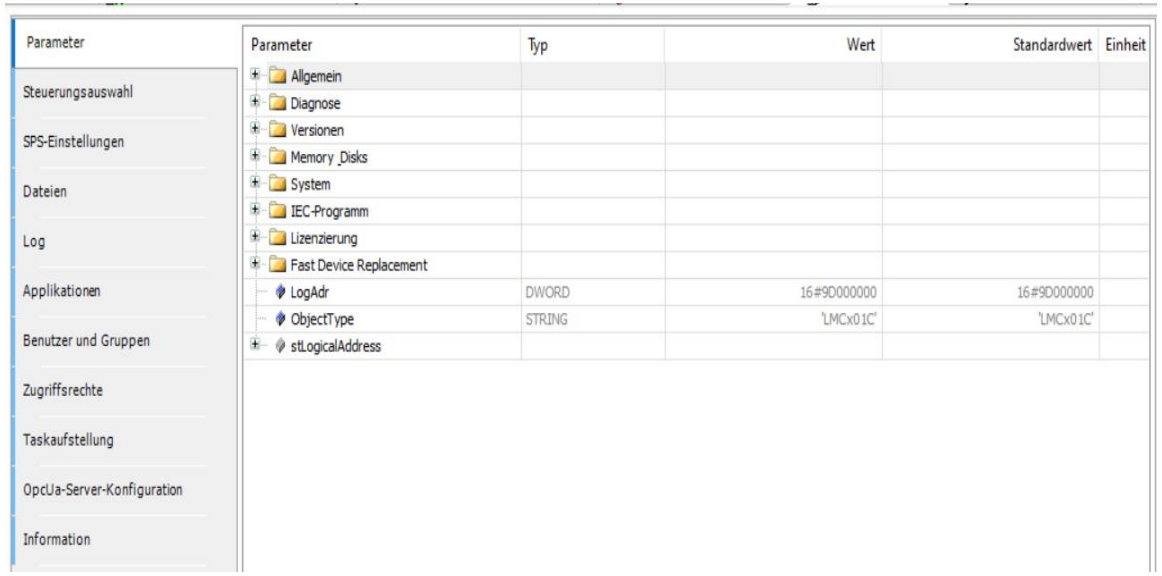

Figure 1.11: SoMachine Settings Adjusment

Background Information
1.2 Software Applications

- **Vijeo Designer**
- HMI Design Software for Schneider Electric HMIs

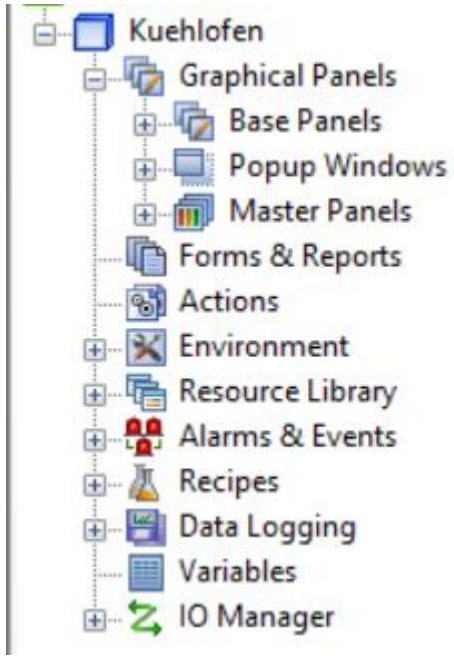

Figure 1.12: Vijeo Designer Main Screen

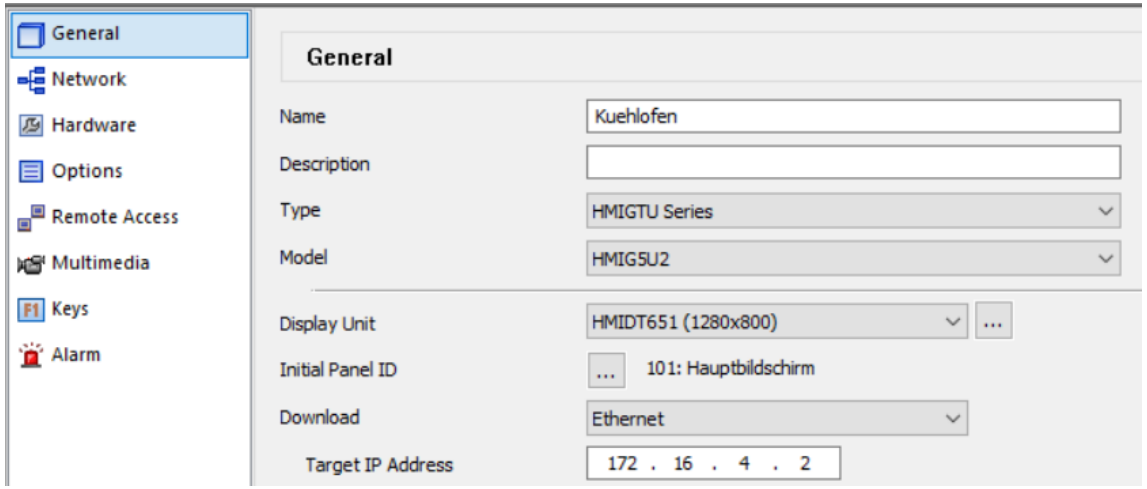

Figure 1.13: Vijeo Designer Settings Screen

Background Information
1.2 Software Applications

HOCHSCHULE HAMM-LIPPSTADT

- **UA-Expert**
- OPC-UA Client for testing and troubleshooting OPC-UA Servers

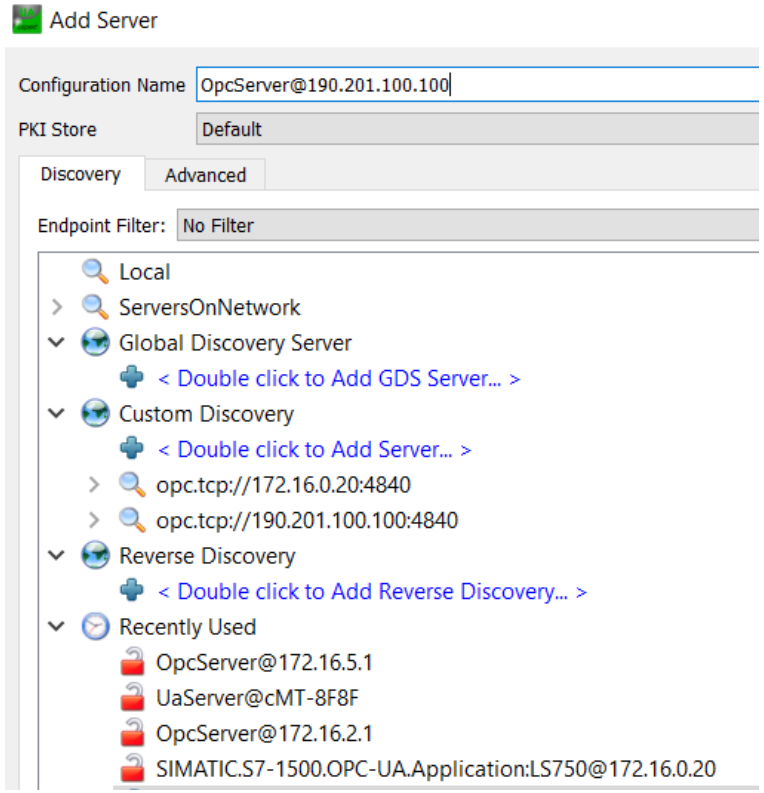

Figure 1.14: UA-Expert Server Adding Screen

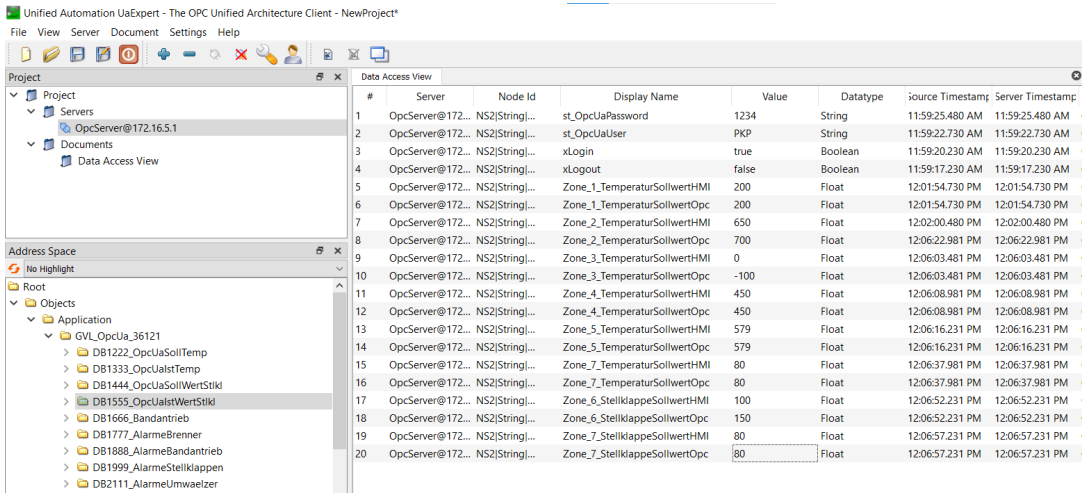

Figure 1.15: UA-Expert Main Screen

Background Information
1.3 Project Details

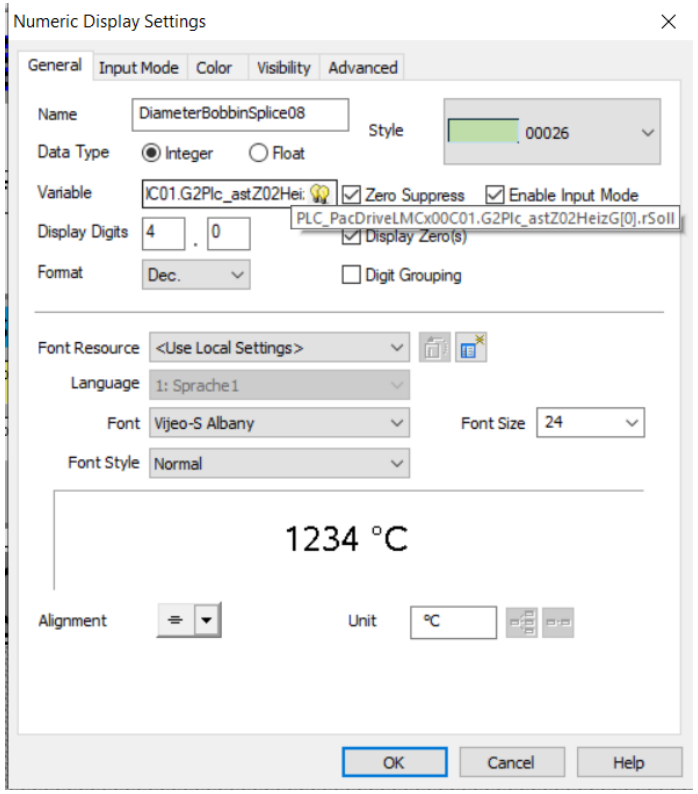

Figure 1.17: Variable name from Vijeo Designer