Build efficient Automation Solutions with OPC UA and PLCopen

July 22nd 2010

Stefan Hoppe, stefan.hoppe@opcfoundation.org
Chairman PLCopen OPC Foundation working group
President OPC-Europe
Product Manager Beckhoff Automation

Matthias Damm, matthias.damm@ascolab.com
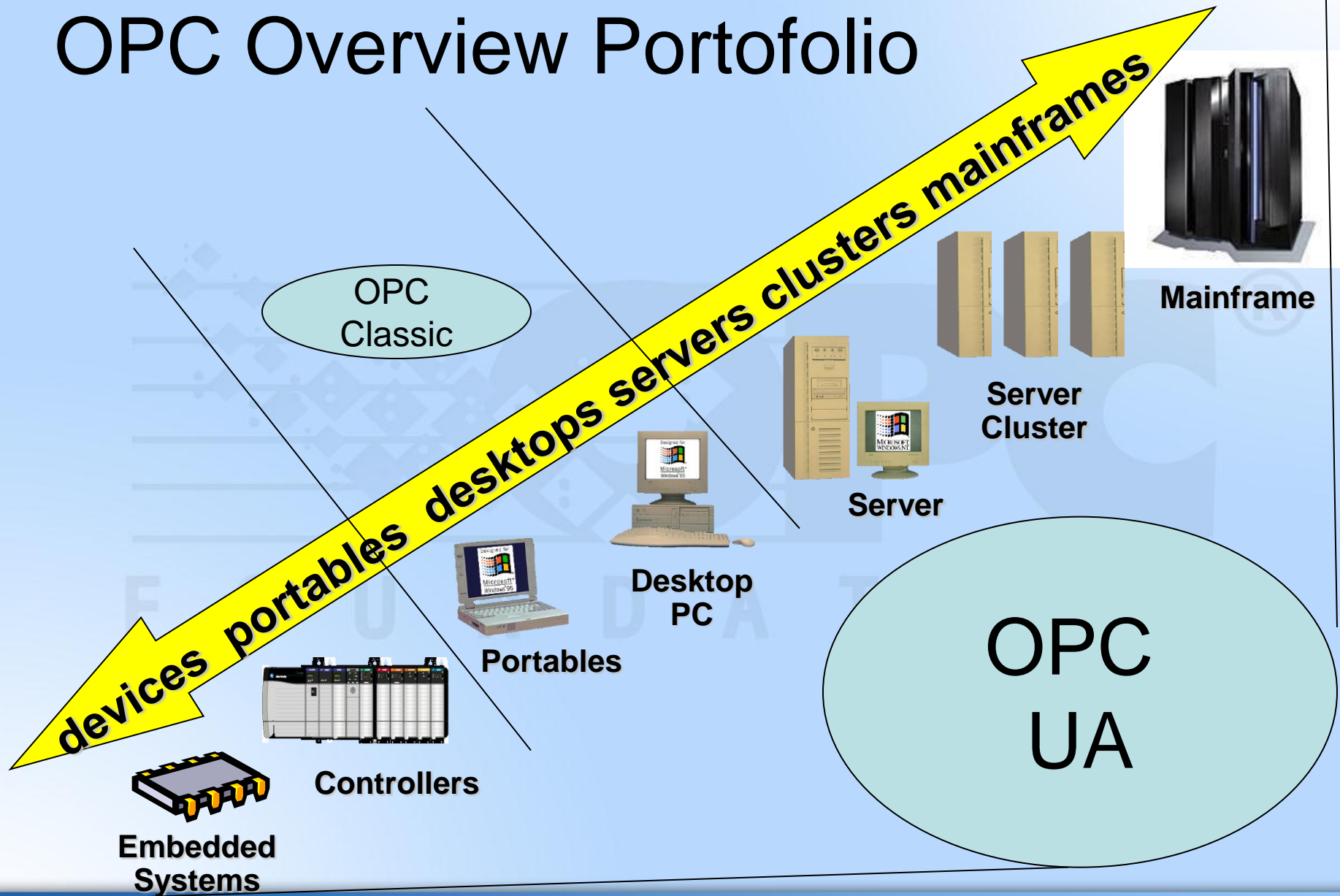Editor PLCopen OPC Foundation working group
Editor OPC UA specifications
Executive Director ascolab

Agenda

- **Introduction OPC UA and PLCopen**

- **Status of Collaboration**

- **Advantages of Combined Standards**

- **Technical Introduction**

- **Demo**

OPC Overview Portofolio

OPC-UA Technical Overview

OS platform independent: Windows, WinCE, Linux, Euros, QNX, VX-Works…

- avoid DCOM, offers direct communication via TCP / HTTP
- allows to integrate UA products directly into controllers

Protocols/Bindings

- Binary: best performance, one single TCP port 4840
- Web service (SOAP): firewall friendly (e.g. port 80/443)

OPC Foundation

- providing an SDK containing UA stacks and sample code
  C/C++ stack / .NET stack / JAVA stack

Security (mandatory implemented in UA stack, optional use)

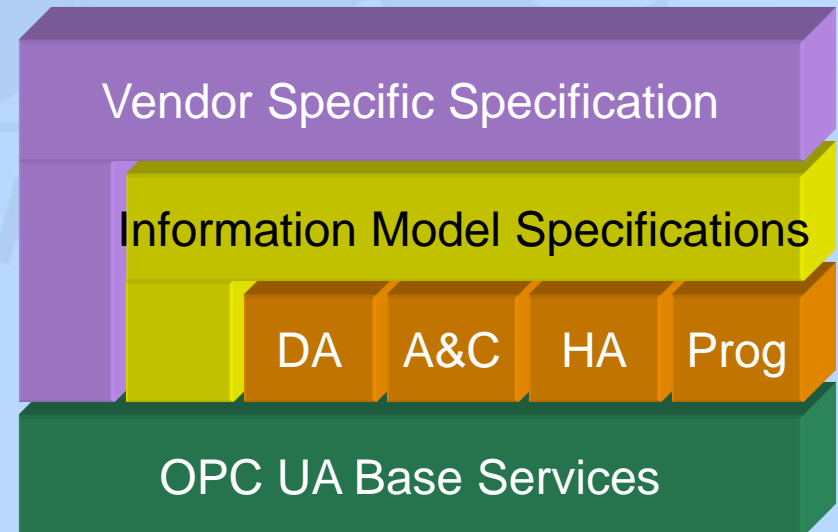- Authentication via x509 certificate, SSL-encryption and data integrity

Technical potential:

- Support for redundancy
- Heartbeat for connections in both directions
- Buffering of data and acknowledgements of transmitted data
  Lost connections don't lead to lost data

IEC 62541 Norm

OPC UA Base for Information Models

- Device Integration (DI): Released 2009
  - Common device configuration model

- Analyzer Device Integration (ADI): Released 2009

- Field Device Integration (FDI): Release planned for 2010
  - EDDL and FDT Consortium, field device configuration

- PLCopen: Released 2010

- Upcoming UA information models
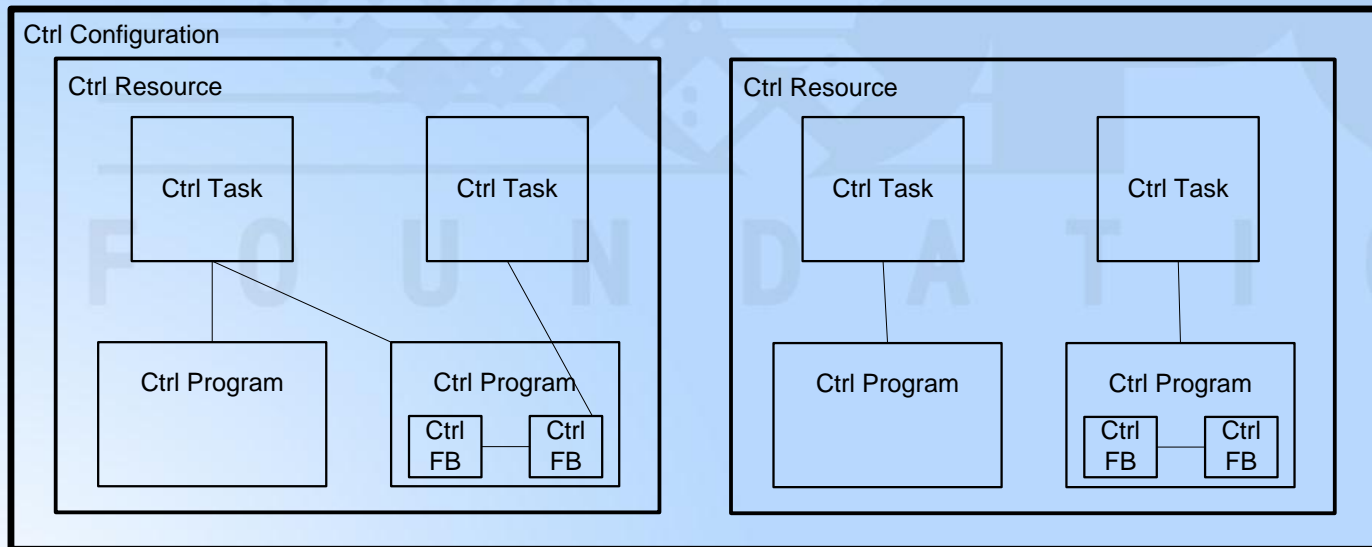 - IEC 61850 CIM
  - MTConnect
    BACnet
  - ISA-95 and ISA-88

Vendor Specific Specification

Information Model Specifications

| DA | A&C | HA | Prog |

OPC UA Base Services

PLCopen Overview

PLCopen *for efficiency in automation*

PLCopen : www.plcopen.org

- Global standard for Industrial Control Programming
- IEC 61131-3 describes the common elements and programming languages (textual and graphical languages: ST, IL, LD, FBD)
- Software model

```
Ctrl Configuration
┌─────────────────────────────────────────────────────────────────────────┐
│  Ctrl Resource                          Ctrl Resource                     │
│  ┌──────────────────────────────┐       ┌──────────────────────────────┐  │
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│  │  │Ctrl      │  │Ctrl Program│ │       │  │Ctrl      │  │Ctrl Program│ │  │
│  │  │Program   │  │ ┌────┐┌────┐│ │       │  │Program   │  │ ┌────┐┌────┐│ │  │
│  │  │          │  │ │Ctrl││Ctrl││ │       │  │          │  │ │Ctrl││Ctrl││ │  │
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└─────────────────────────────────────────────────────────────────────────┘
```

*The prefix Ctrl is there to avoid conflicts with the OPC UA terminology

PLCopen motion control

PLCopen safety

PLCopen Benchmarking

PLCopen XML
EXTENSIBLE <MARKUP> LANGUAGE

OPC FOUNDATION

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PLCopen & OPC Group: Motivation

- PLC controllers executing <u>identical</u> PLC-IEC 61131-3 logic should
    - provide <u>identical</u> protocol access for data exchange
      provide integrated standardized UA access in controller
    - provide <u>identical</u> complete information model about IEC6-1131-3 logic

- Establish easier data exchange
    - Vertical: between SCADA/MES/ERP with PLC
    - Horizontal: between PLC to PLC

- Advantages:
    - Rapidly engineering for UA –clients
        - HMI: create re-useable HMI faceplates
        - MES/ERP: identical access to data profiles in shop floor devices

        → Transparent PLC controller
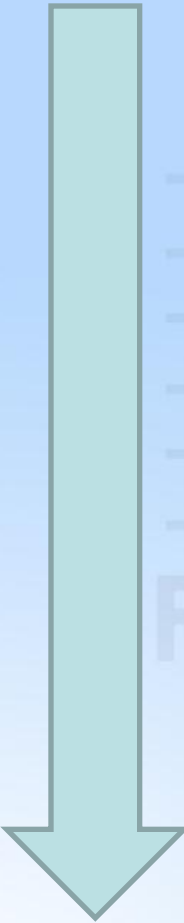
PLCopen & OPC Group: Motivation

- Issues:
    - different data types, different elementary data types
      e.g. INT, DT (DayTime)
    - no descriptions of complex data
    - engineering efforts when switching PLC vendors

- Summary:
    - Common information model required
      Goal for V1.0 of joined working group:

      "Mapping of the IEC 61131-3 Software Model to
      OPC United Architecture Information Model and Namespace"

PLCopen & OPC Group: Timeline

2008 October: Kick off meeting common group

- Chairman   Stefan Hoppe (Beckhoff)
  OPC Editor   Matthias Damm (ascolab)
  PLCopen Editor   Prof. Rene Simon (ifak)

- Goal V1: Common Namespace for IEC 61131-3 Information model
- Goal V2: PLCopen-OPC-UA function blocks and services

2009 November: V0.9 Release Candidate available

- Live demo on SPS/IPC/Drives 2009

2010 March: V1.0 Released from both organizations

- multi vendor demo at April-2010 Light&Building and Hanover Fair

2010 October: continue with goals V2

PLCopen & OPC: Team Members

- PLCopen: IEC61131-3 vendors and users
- OPC-Foundation: SCADA vendors, UA experts
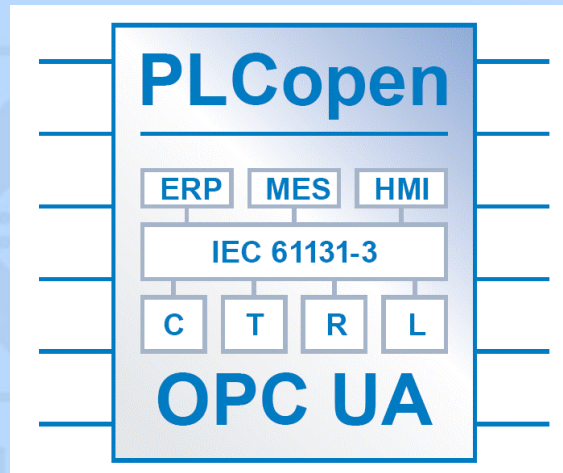
PLCopen & OPC: Team Members
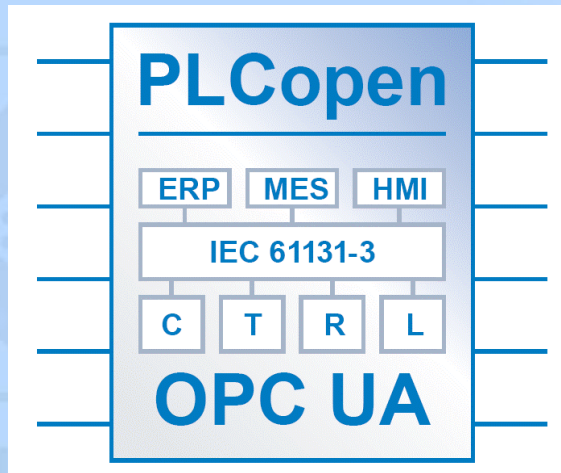
- PLCopen: IEC61131-3 vendors and users
- OPC-Foundation: SCADA vendors, UA experts

PLCopen & OPC: Results

PLCopen:

Content „WHAT"

All information about

IEC61131-3 project:

- FB's
- POU's
- Structures
- Tasks / Resources..
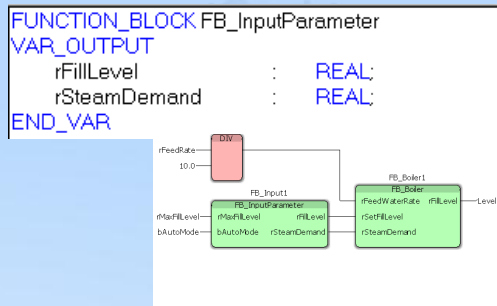
OPC-UA-Server:

Communication „HOW"
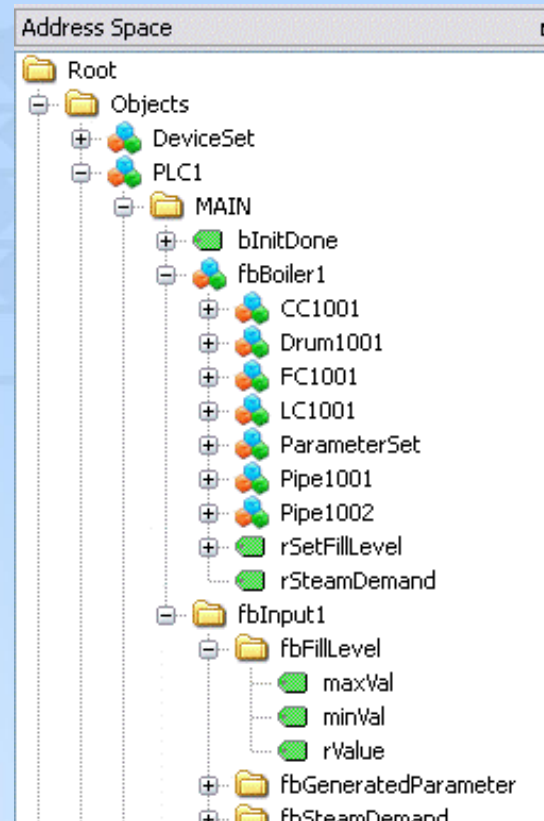
UA-Clients: SCADA/MES/ERP

Presentation

- Standardized UA access
- Identical namespace
- Complete information model

Advantages:
- Re-useable HMI Faceplates"
- Rapidly engineering
- Transparent PLC controller

PLCopen & OPC: Adoption

- Demo at Light&Building 2010 and Hanover trade show 2010

  - HMI / SCADA as OPC UA client
    - Allmendinger – OPC UA Client Channel for Siemens SIMATIC WinCC
    - Ascolab – UA Expert
    - Certec – atvise
    - CopaData - zenOn
    - ICONICS – Genesis 64
    - INOSOFT – VisiWinNET

  - ERP: SAP – "SAP Plant connectivity"

  - OPC UA servers
    - Beckhoff – Embedded into controller
    - Bosch Rexroth - Embedded into controller
    - ifak – Siemens S7 controller
    - KW Software – Embedded into Phoenix Contact controller
    - logi.cals / HIMA – Embedded into controller
    - Unified Automation – Offline server loading address space from XML export

PLCopen & OPC: Demo (1/3)

- Demo at Light&Building 2010 and Hanover trade show 2010

  - provide PLCopen IEC 61131-3 code (ST) to demo a boiler scenario demo with configuration, resources, tasks, programs, function blocks, global and local variable definition

current feedwater flow rate — FD
estimated feedwater demand based on current steam flow
feed forward element

LY

FT

$F_{setpoint}$

Steam

steam demand varies (a disturbance)

FC

$L_{setpoint}$

LC

steam

Feedwater

boiler liquid

feedwater pressure varies (a disturbance)

Boiler Drum

FT = flow transmitter
FC = flow controller
LC = level controller
FD = flow difference
LY = summing relay

  - run boiler demo on 6 different vendor controllers

PLCopen & OPC: Demo (2/3)

- Demo at Light&Building 2010 and Hanover trade show 2010

    - 6 SCADA/HMI vendors to access different controllers in identical way

PLCopen & OPC: Demo (3/3)

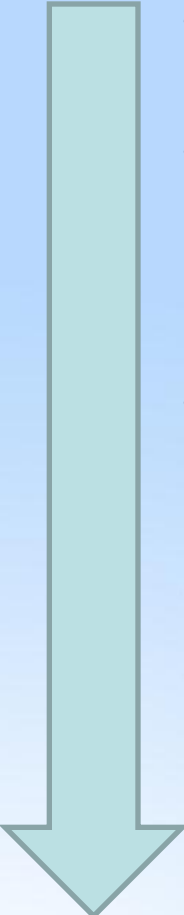The Perfect plant: Harmonizes Complex Manufacturing Network Interdependencies

SAP product „SAP Plant Connectivity"
provides OPC-UA-client
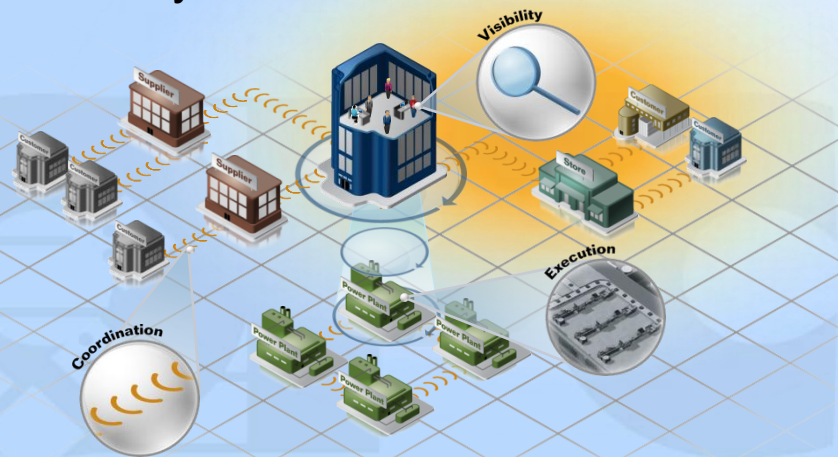
„OPC UA allows a platform independent, easy and secure connection between SAP business systems with distributed shop floor data even on smallest embedded devices"

Dr. Arne Manthey, Product Manager, SAP AG

PLCopen & OPC: Future

- **2010 March:** **V1.0 released by both organizations**

- **2010 November** **Extended Demo with more vendors**
  - **SPS / IPC / Drives show in Nuremberg / Germany**
  - **Manufacturing Open Forum 2010 in Tokyo / Japan**

- **2010 End Year:** **First meetings for future activities**
  - **Additional standardization of PLCopen and OPC**
    - **Focus on additional features**
    - **Mapping of Sequential Function Charts (SFC)**
    - **Standard PLC-UA communication function blocks**
    - **Standard function blocks for Alarm handling and mapping to OPC UA Alarms and Conditions**
    - **Best practice guidelines for using OPC UA concepts like Methods, Events, Alarms & Conditions, Historical Access and Programs**

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PLCopen & OPC: Benefits

- UA provides communication directly from HMI to PLC without specific drivers or Windows-Gateway-PC's

- PLCopen controllers to expose PLC information model in a standardized format via an OPC-UA interface

- PLC controllers will become more and more transparently

- HMI faceplates can be re-used without reconfiguration even on different PLCs provided from different vendors

- Seamlessly moving automation data from shop floor to enterprise world

- Vertical markets:
    - define a profile within the PLCopen controller
    - secured, remotely "out-of-the-PLCopen-box" communication
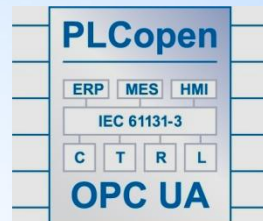
"Communication will never be the same"
"OPC UA: Interoperability on the Next Level"

PLCopen & OPC: Call for Action

- PLCopen vendors
  Participate in working group?

- OPC members / PLCopen members:
  Participate with your controller or HMI in multi-vendor demo?
  Add your logo to marketing activities?

  Contact Stefan Hoppe, stefan.hoppe@opcfoundation.org

- End users
  Ask your controller vendor to support this standard
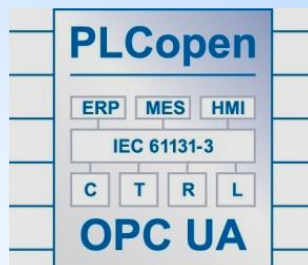
"OPC UA: Interoperability on the Next Level"

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IEC 61131-3

- Standardizes programming languages for industrial automation
- Describes the Common Elements and Programming Languages
- Software Model:
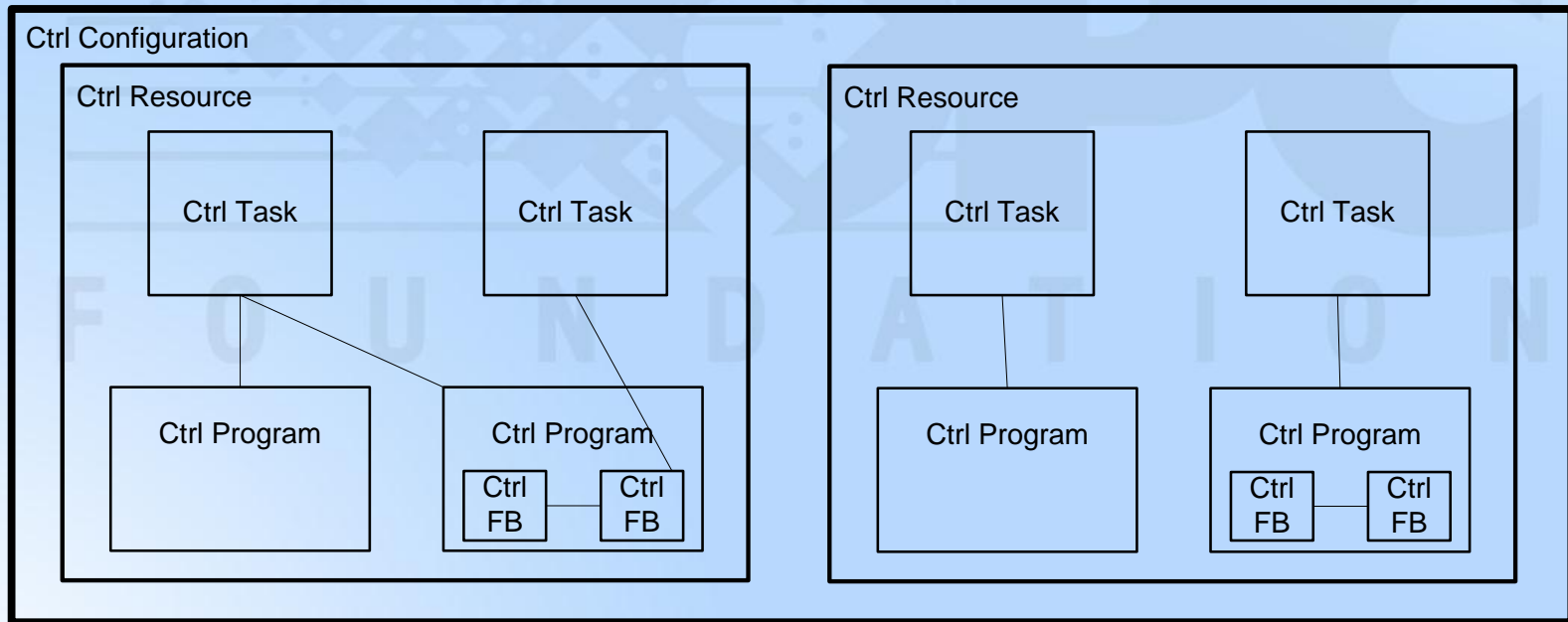
IEC 61131-3 Code

```
FUNCTION_BLOCK CTU_INT

VAR_INPUT
  CU: BOOL;
  R: BOOL;
  PV: INT;
END_VAR

VAR
  PVmax: INT := 32767;
END_VAR

VAR_OUTPUT
  Q: BOOL;
  CV: INT;
END_VAR

  IF R THEN
    CV := 0;
  ELSIF CU AND (CV < PVmax) THEN
    CV := CV + 1;
  END_IF ;
  Q := (CV >= PV);

END FUNCTION BLOCK
```

```
PROGRAM MyTestProgram

VAR_INPUT
  Signal: BOOL;
  Signal2: BOOL;
END_VAR

VAR
  MyCounter: CTU_INT;
  MyCounter2: CTU_INT;
END_VAR

VAR_TEMP
  QTemp: BOOL;
  CVTemp: INT;
END_VAR

  MyCounter(CU := Signal, R := FALSE, PV := 24);

  QTemp := MyCounter.Q;
  CVTemp := MyCounter.CV;


  MyCounter2(CU := Signal2, R := FALSE, PV := 19);

  QTemp := MyCounter2.Q;
  CVTemp := MyCounter2.CV;

END_PROGRAM
```

Use cases for OPC UA mapping

- **Observation**
  - Reading and monitoring of online data from PLC program
  - Type information for rapid engineering
  - Data from function blocks and program variables

- **Operation**
  - Includes Observation
  - Writing data from function blocks and program variables

- **Engineering**
  - Includes Observation
  - Modification of programs and configurations
  - Download of programs and configurations

- **Service**
  - Includes Engineering
  - Reading writing of special configuration data like firmware updates

Scope Combined Working Group

- Joined working group PLCopen and OPC Foundation

- Scope for V1.0 is mapping of IEC 61131-3 to OPC UA
  - Focus on content of IEC 61131-3 specification
  - IEC 61131-3 software model → UA object types
  - IEC 61131-3 data types → UA data types
  - IEC 61131-3 variable qualifiers → UA properties

- OPC UA properties and attributes → PLCopen XML export
  - OPC UA base concepts like AccessLevel not covered by IEC 61131-3
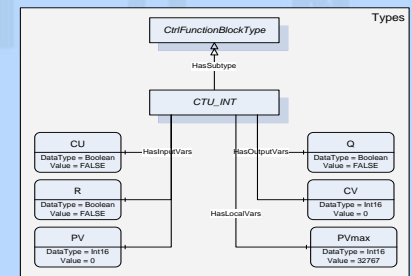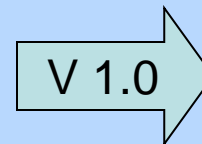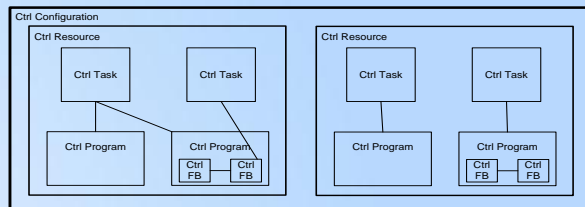
PLC Program → OPC UA Nodes

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VAR
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END_VAR

VAR_OUTPUT
  Q: BOOL;
  CV: INT;
END_VAR

  IF R THEN
    CV := 0;
  ELSIF CU AND (CV < PVmax) THEN
    CV := CV + 1;
  END_IF ;
  Q := (CV >= PV);

END FUNCTION BLOCK
```

Function Block declaration

OPC UA Object Type

Types

CtrlFunctionBlockType

HasSubtype

CTU_INT

CU	Q
HasInputVars	HasOutputVars
DataType = Boolean Value = FALSE	DataType = Boolean Value = FALSE

| R | CV |
| DataType = Boolean Value = FALSE | DataType = Int16 Value = 0 |

HasLocalVars

| PV | PVmax |
| DataType = Int16 Value = 0 | DataType = Int16 Value = 32767 |

PLC Program → OPC UA Nodes
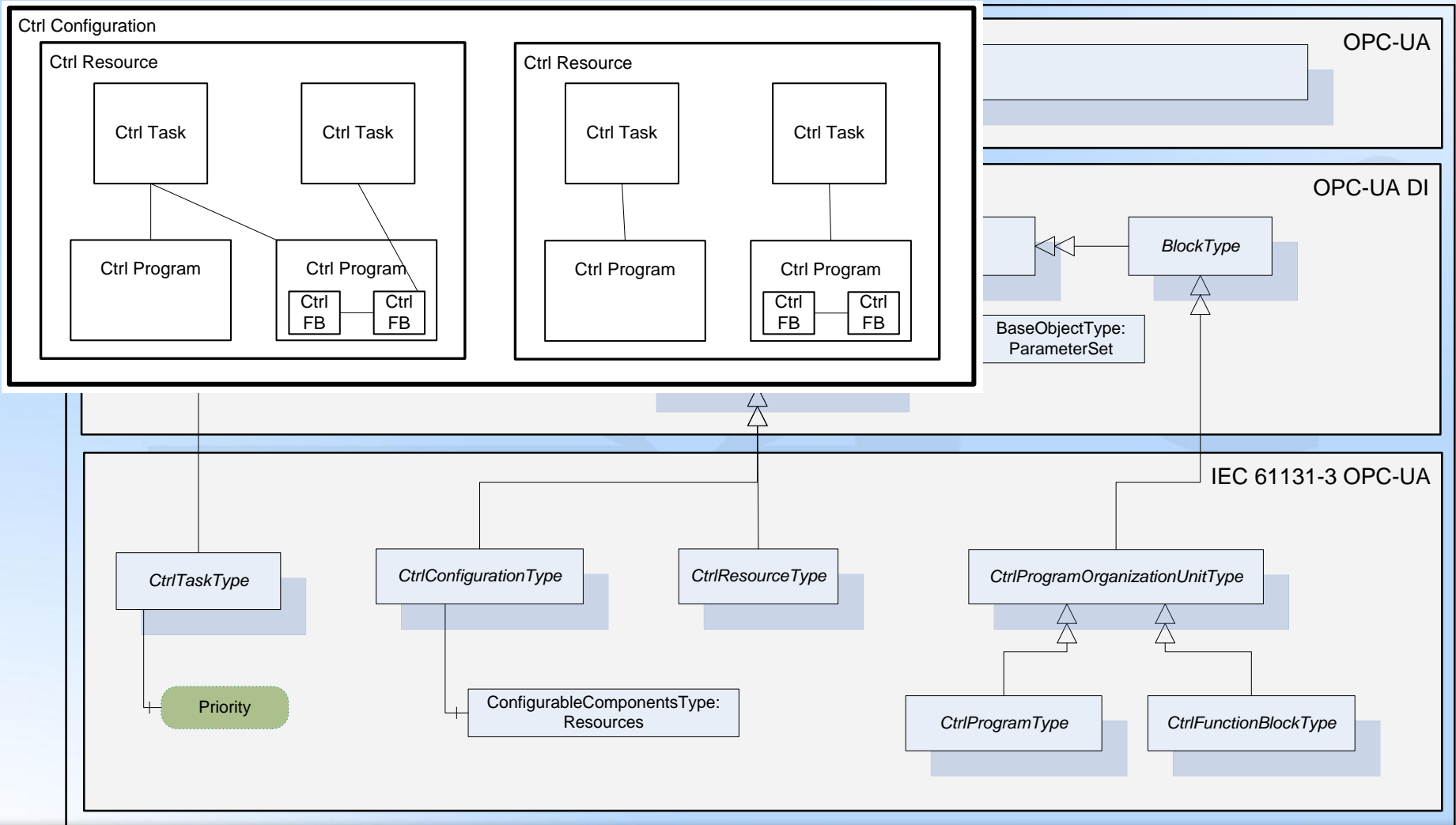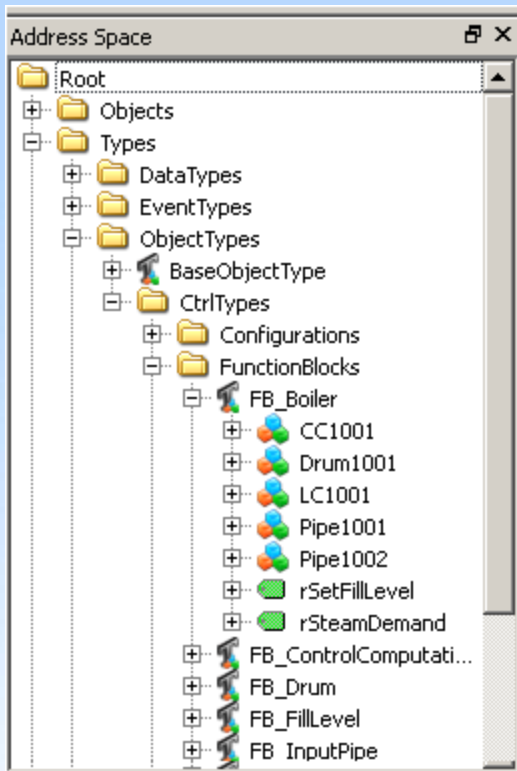
IEC 61131-3 model based on DI
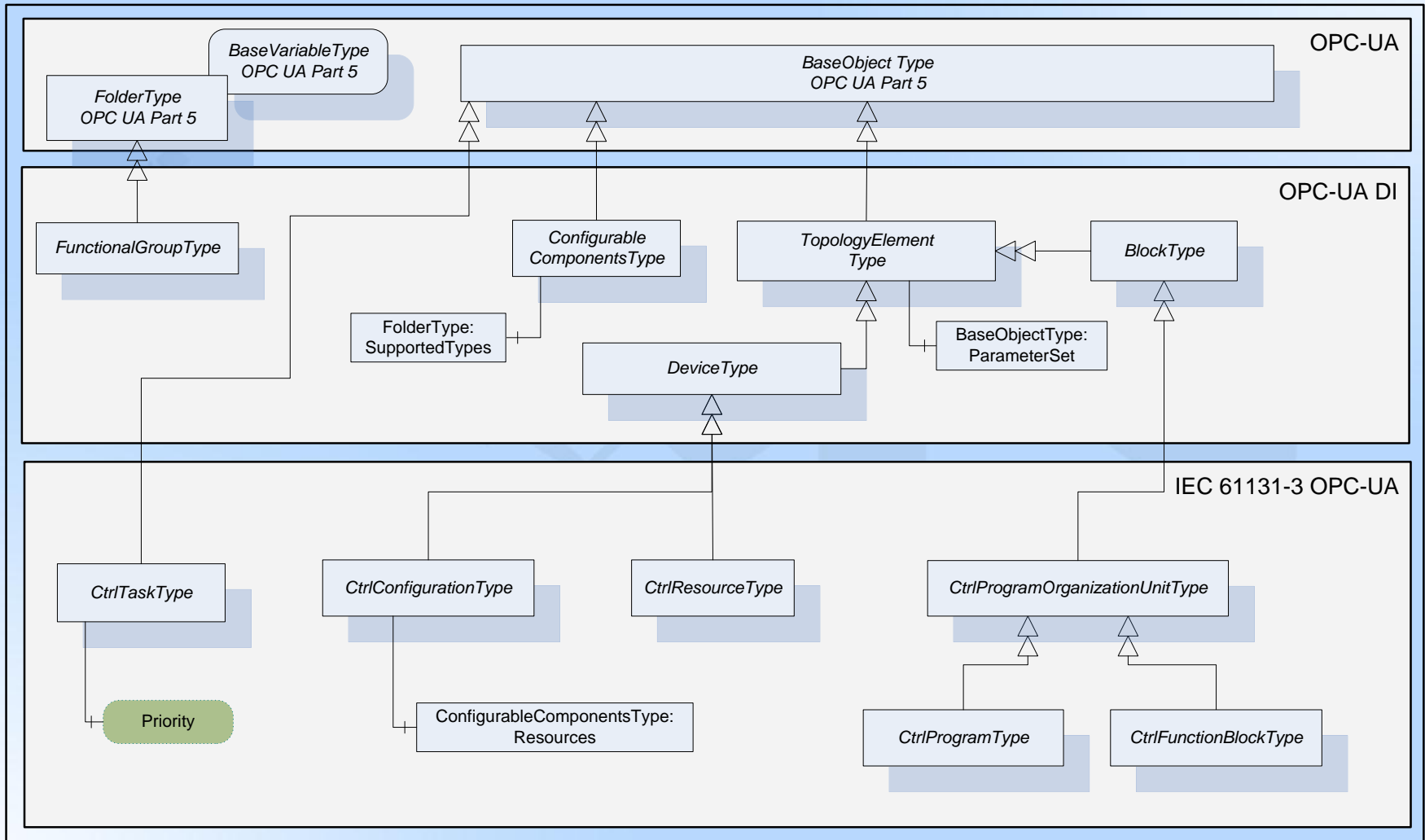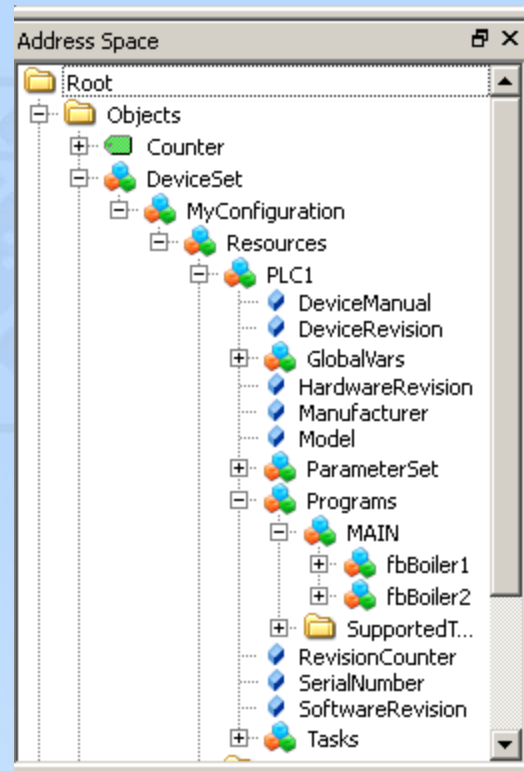
IEC 61131-3 → OPC UA
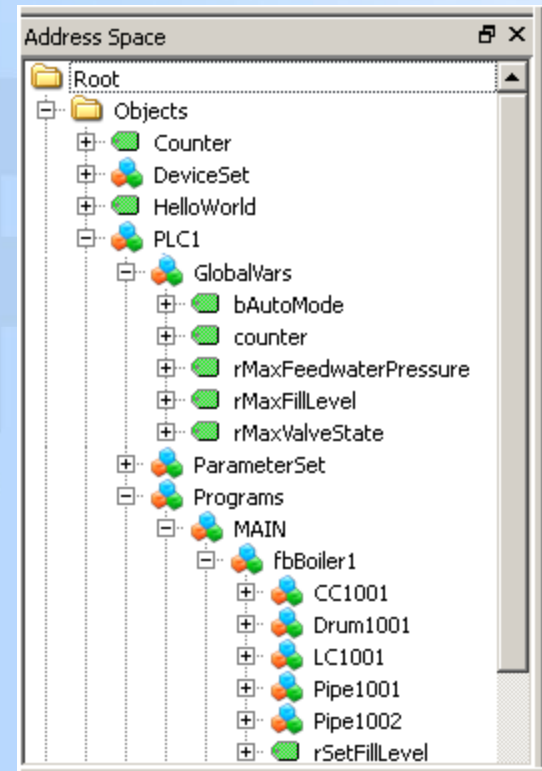
Entry points into Address Space

Object types based on Function Blocks

Full object hierarchy below DeviceSet

Entry point for DA Clients like HMI

Based on UaExpert Client and OPC UA C++ Server SDK demo from
www.unifiedautomation.com

Data Type Mapping

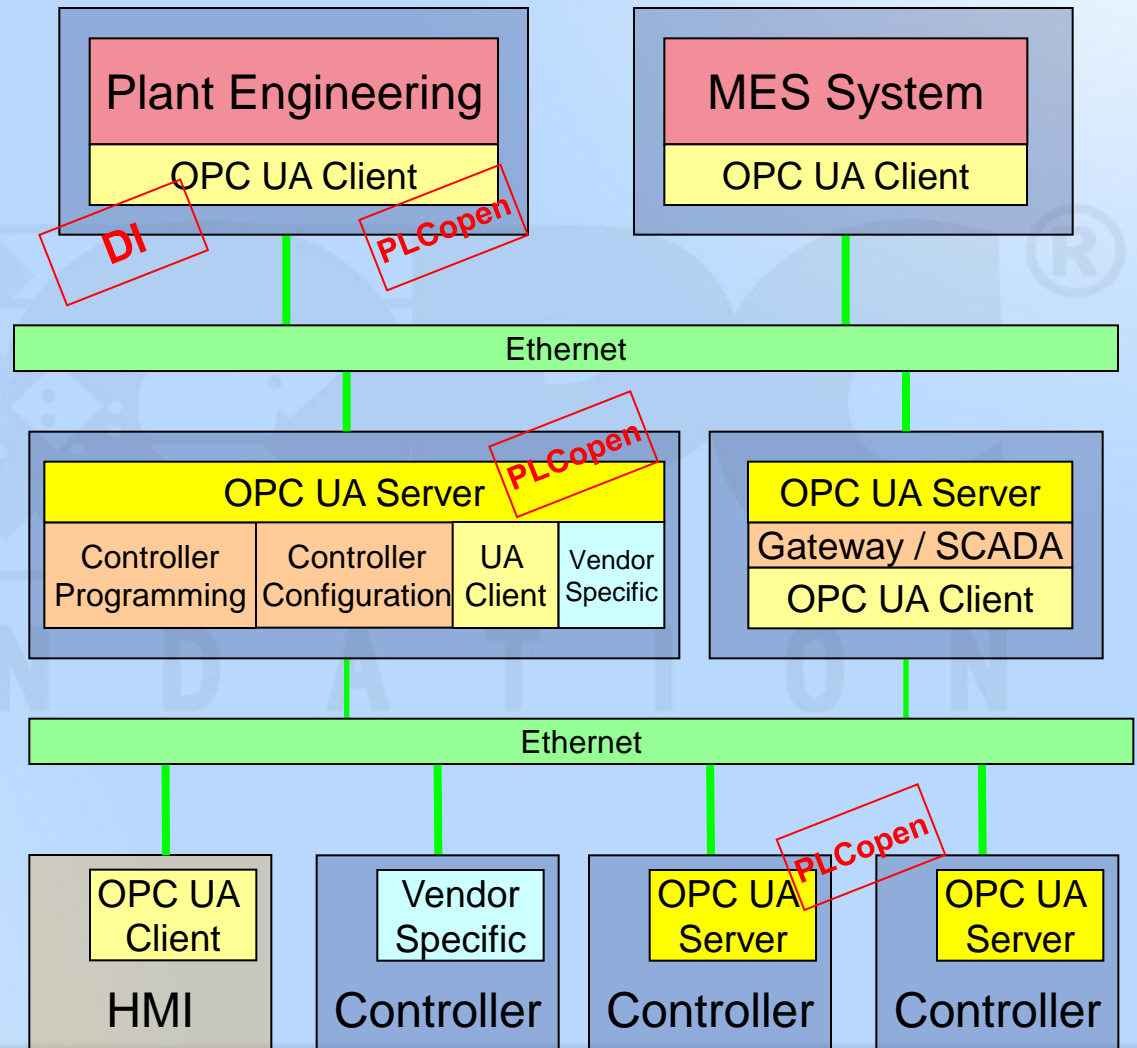| IEC 61131-3	OPC UA
Elementary data type	Built in data type
Derived data types	
Enumerated type	Enumerated data type
Subrange	Data type derived from the related Number built in type with properties indicating the range
Array data types	Data type derived from the related built in type with properties indicating the array range and dimension. OPC UA has array information on variable attributes.
Structure data types	Data type derived from Structure
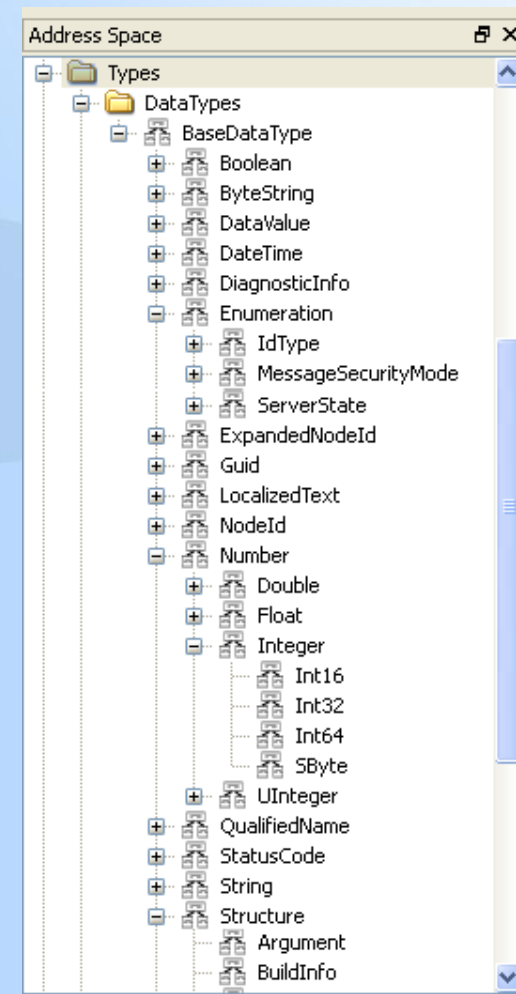
System Architecture PLCopen

- Enterprise systems
- Plant engineering
- Asset management

- PC bases Systems
  - PLC Programming Tools – access to configuration
  - SCADA

- Embedded Devices
  - Access to FB and Variables
  - RTOS

Plant Engineering	MES System
OPC UA Client	OPC UA Client

DI   PLCopen

Ethernet

OPC UA Server	
Controller Programming	Controller Configuration	UA Client	Vendor Specific

PLCopen

OPC UA Server
Gateway / SCADA
OPC UA Client

Ethernet

OPC UA Client	Vendor Specific	OPC UA Server	OPC UA Server
HMI	Controller	Controller	Controller

PLCopen

OPC FOUNDATION

Adoption of PLCopen Model

- ## OPC UA Server
  - Servers embedded in PLCs or Servers aggregating PLC data on a PC need to implement the PLCopen model and the mapping of Function Blocks to OPC UA object types and instances
  - Full information for Use Cases Engineering and Service is only provided by special servers that have also access to PLC engineering

- ## OPC UA Client
  - **Clients for Use Cases Observation and Operation (HMI) do not need to know anything about the PLCopen model**

  - But HMI clients can benefit from the object model for rapid HMI configuration
  - OPC UA HMI clients can be embedded too
  - Only engineering clients need to know the PLCopen model

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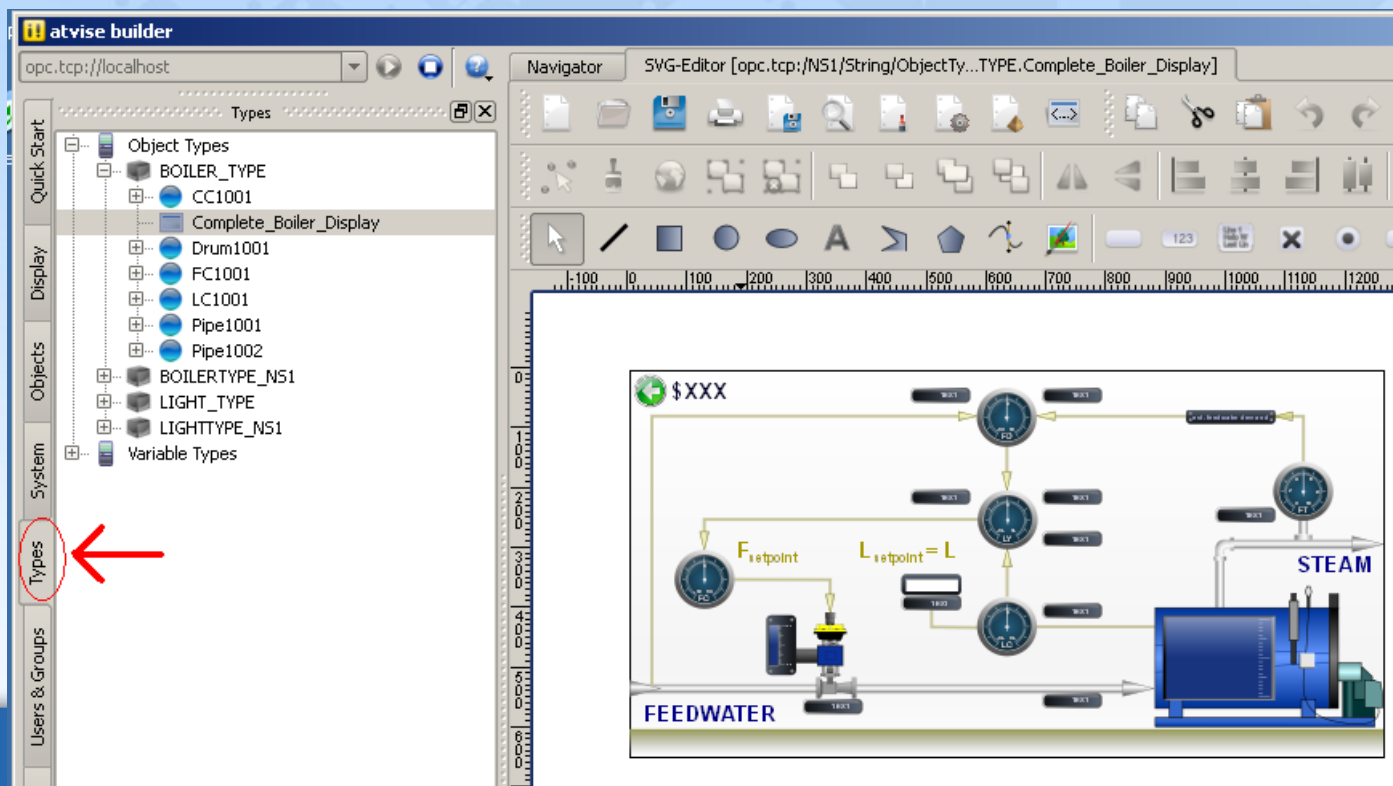
- **Demo**

Boiler Demo
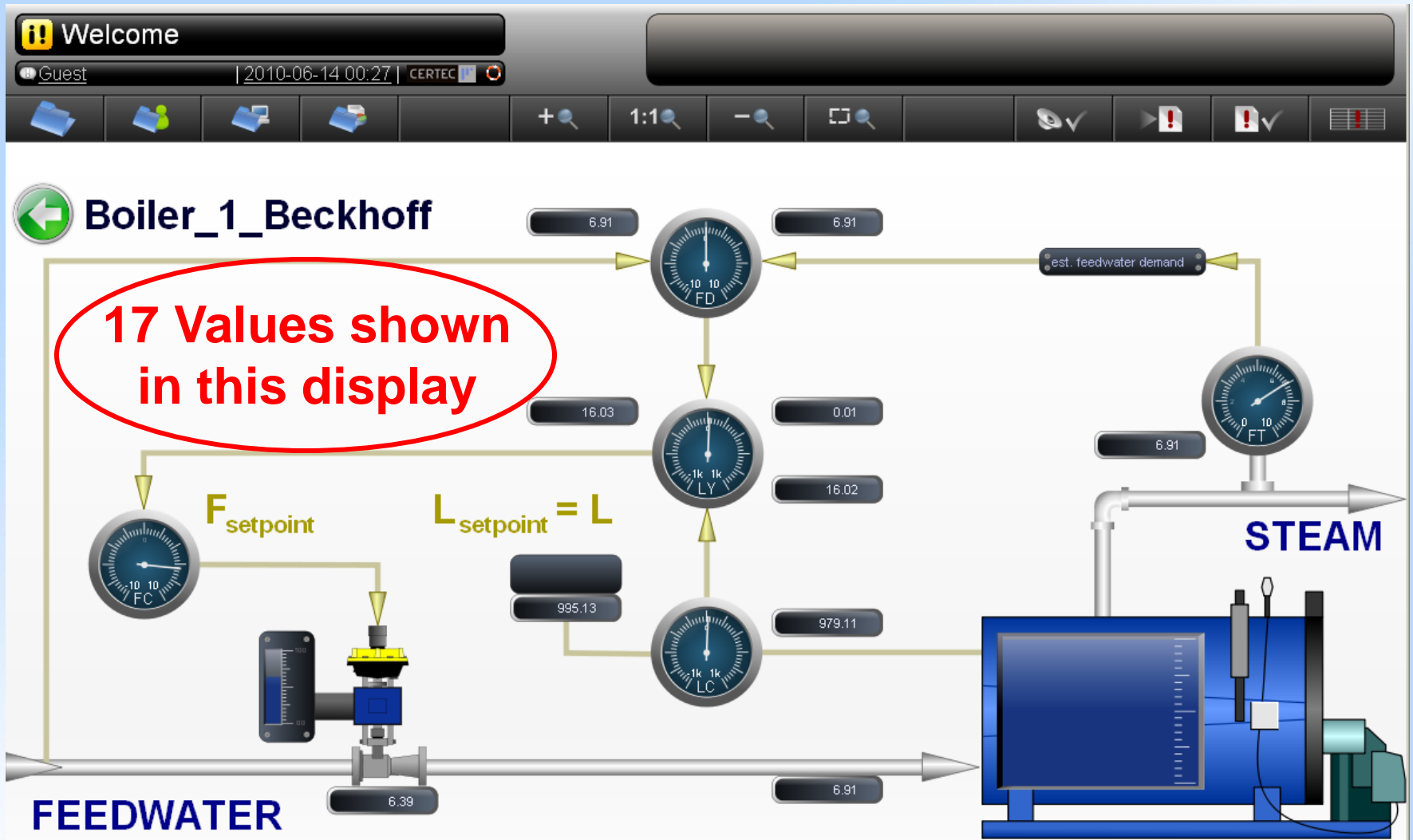
HMI Engineering of Complex Displays in Minutes – Step 1 (done once)

Step 1: Creation of graphical template in SCADA / HMI (atvise)

- Object type in atvise mirrors object type in OPC UA server
- Graphical template is assigned to atvise object
- Graphical template displays values of atvise object

HMI Engineering of Complex Displays in Minutes – Step 2 (for each instance)

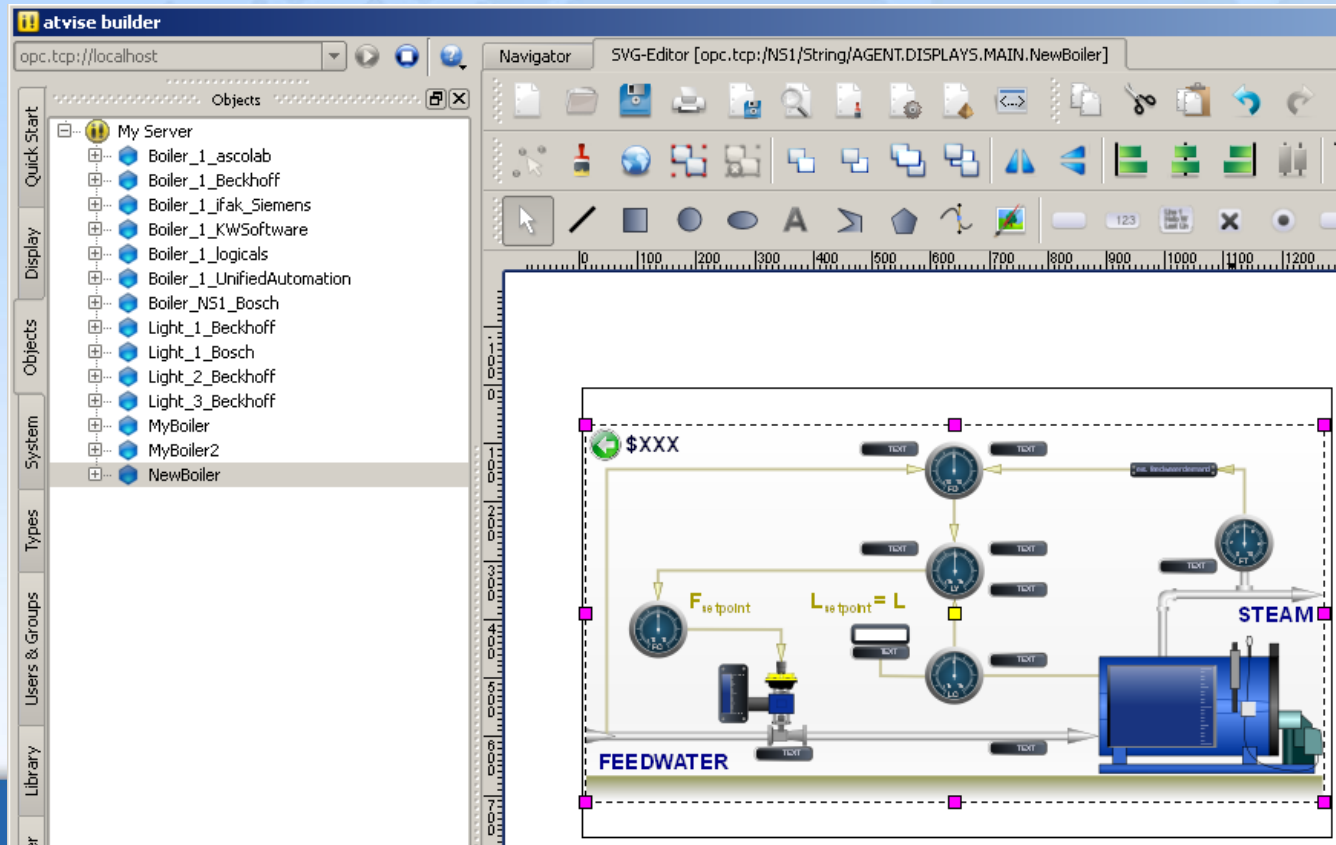Step 2: Connect SCADA object with OPC UA server object

- Create object instance in atvise as mirror object
- Connect atvise mirror object to OPC UA server boiler object
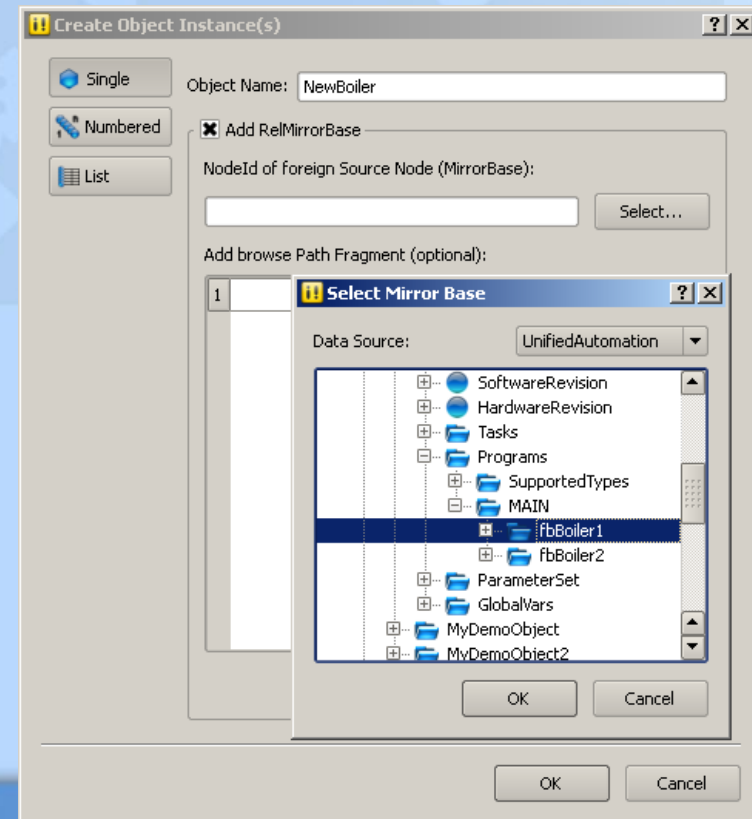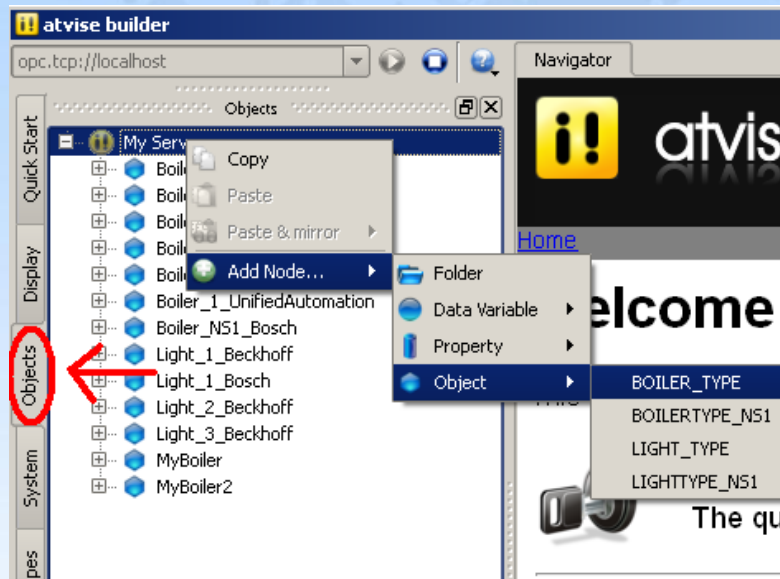
# HMI Engineering of Complex Displays in Minutes – Step 3 (for each instance)

Step 3: Use object in display

- Drag & Drop object to a new display
- Start web browser to view new display

Demo

- atvise SCADA
  - Web based HMI
  - OPC UA used for configuration and communication
  - Uses OPC UA types for engineering

- Unified Automation OPC UA Server SDK
  - Development environment for OPC UA servers
  - Demo server provides PLCopen Boiler demo
  - Support for PLCopen and OPC DI

- Beckhoff PLC
  - Embeeded OPC UA server
  - Support for PLCopen OPC UA model
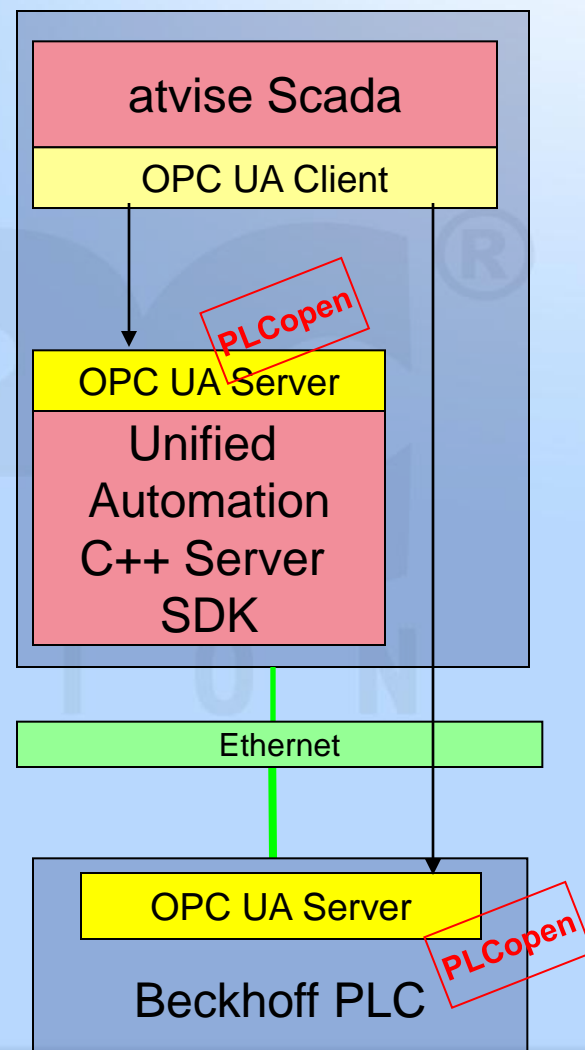
More Information

- OPC Foundation   www.opcfoundation.org
  - All information about OPC-UA in general
  - Free download of PLCopen/OPC-UA specification
  - See Downloads → Specifications → OPC UA for IEC 61131-3

- PLCopen   www.plcopen.org
  - Free download of introduction papers
  - See TC4 - Communication

- Unified Automation   www.unifiedautomation.com
  - Fully functional development environment demos for OPC UA server and client
  - Examples for PLCopen Information Model
  - See Downloads → OPC UA Development

PLCopen & OPC UA: Interoperability On The Next Level

- Enables embedded OPC interfaces
- PLC information model in a standardized format
- Rapid engineering for HMI / MES / ERP
- Moving information from shop floor to enterprise
- Secure, remote "out-of-the-PLCopen-box" communication