OPC UA for Field eXchange (FX):
Extending OPC UA to the field incl. Determinism, Safety & Motion

OPC UA FX:
OPC UA Extensions for Field eXchange (FX)
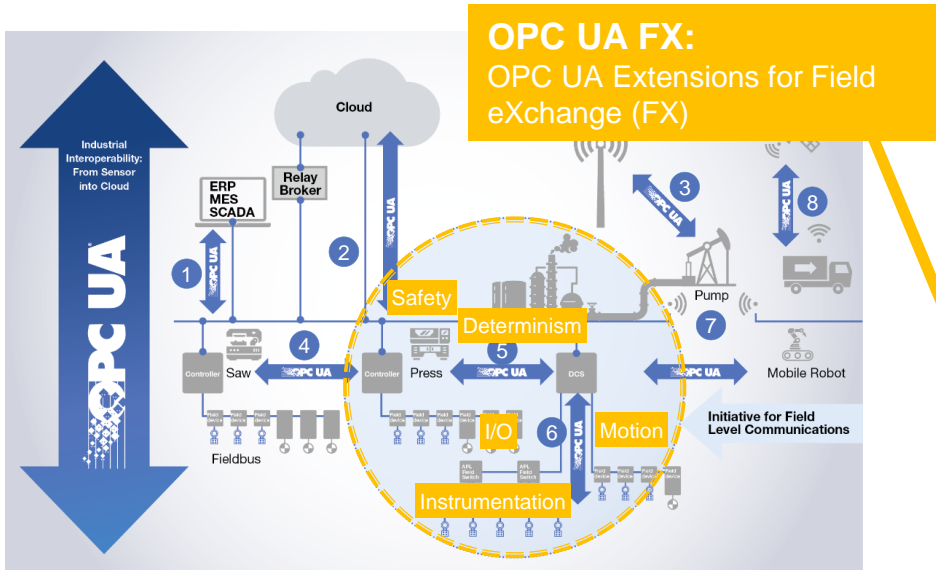
1. IT / OT Communication
2. Cloud Integration
3. Secure Remote Access
4. Local OT Communication
5. Controller to Controller
6. Controller to Device incl. Device to Device
7. Wireless Integration (5G)
8. Future Ready

OPC UA Field eXchange (FX) System Architecture
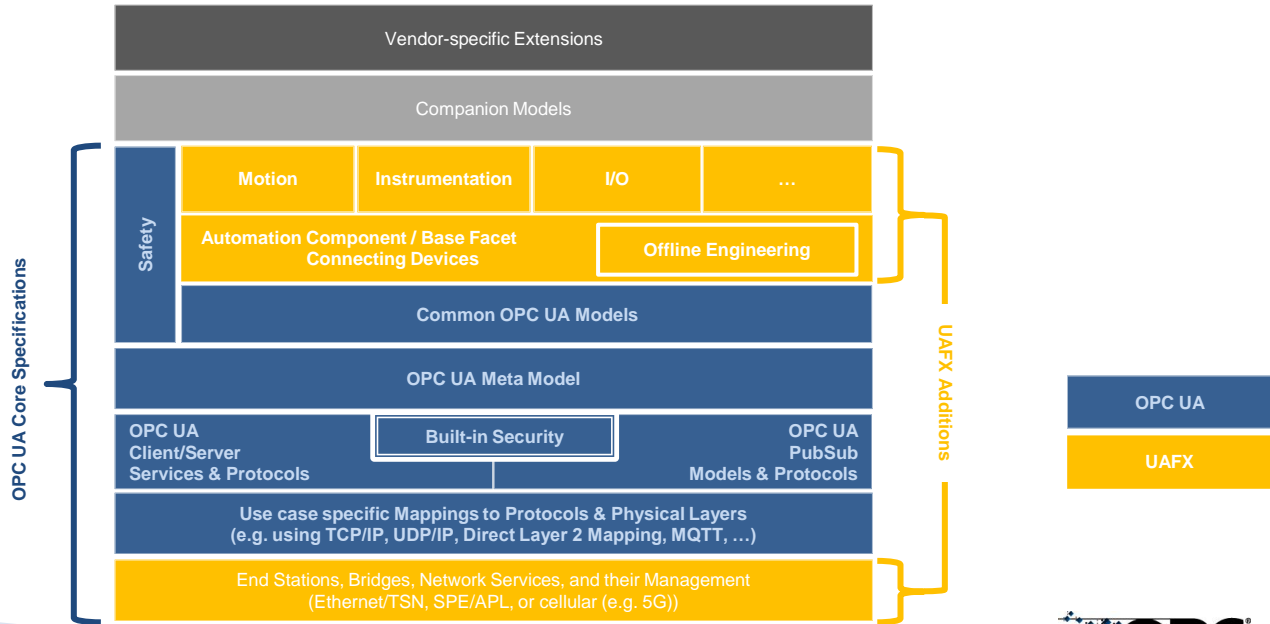
Cooperations to speed-up & to align developments
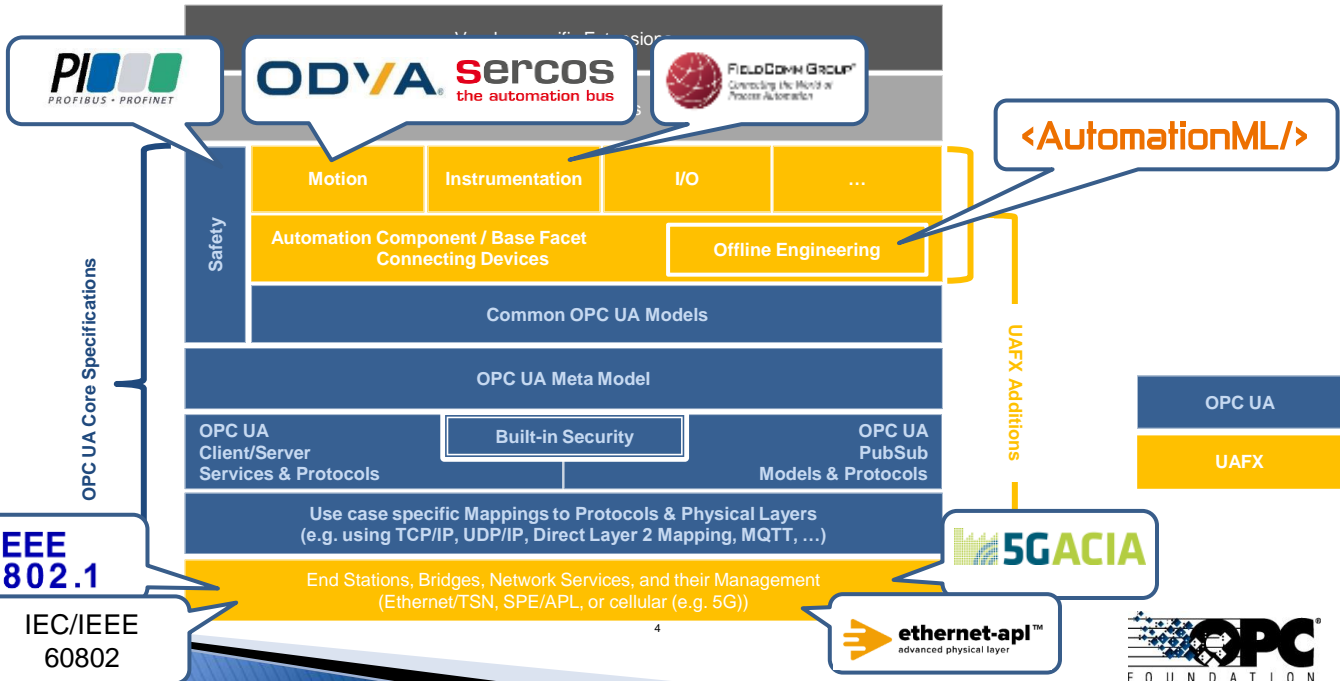
OPC UA FX Specification Series: Parts 80-84
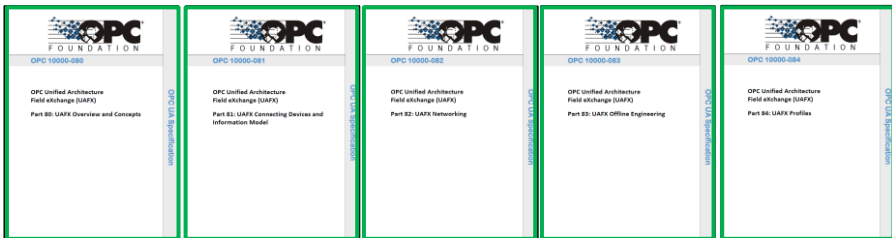
UNCHANGED

Part 80: UAFX Overview and Introduction

REVISIONS

Part 81: UAFX Connecting Devices and Information Model
Part 82: UAFX Networking
Part 84: UAFX Profiles

NEW

Part 83: UAFX Offline Engineering

(New) Part 83 and Revision of Parts 81, 82 and 84 submitted for OPCF member review, to be published in January 2024

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OPC UA FX Offline Engineering (Part 83)

- ▶ Offline Descriptor describes capabilities, functionality, configuration and assets of an automation component
- ▶ Essential part for development, commissioning, operation, and maintenance phases of an automation system

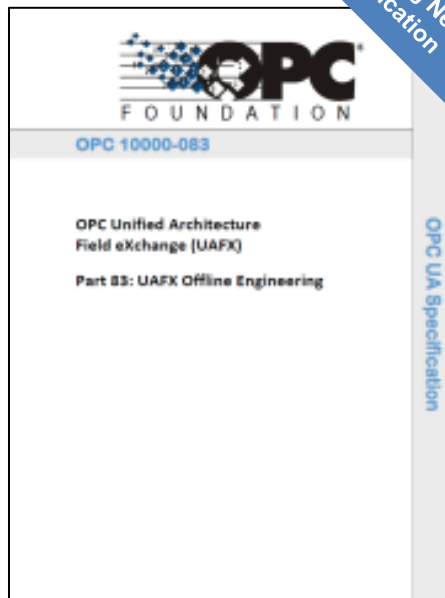- ▶ Open Packaging Convention document (ECMA-376)
  - ◦ Packaging of Modelling and Attachment files
  - ◦ Relationships (internal and external)
  - ◦ Digital Signature
- ▶ Information Model described using AutomationML (AML) (IEC 62714)
  - ◦ XML-based data exchange format for plant engineering
- ▶ Attachments
  - ◦ Integration of "other" Information Models (e.g. PLCopen, Yang,…)
  - ◦ Document, manuals, drawings …

F O U N D A T I O N

OPC 10000-083

**OPC Unified Architecture
Field eXchange (UAFX)**

Part 83: UAFX Offline Engineering

OPC UA Specification

Upcoming New Specification

6

OPC UA Safety Specification: Part 15

▸ OPC UA Safety Specification R 1.05.02

History:

▸ Cooperation with PROFIBUS & PROFINET International (PI) started in 02/2018
▸ Release 1.04: Client/Server support (10/2019)
▸ Release 1.05: PubSub support (11/2021)
▸ Release 1.05.02: Revisions (11/2022)

- **Related Activities:**
  - Safety Test Tool (UASCTT) prototype available
  - Safety Stack prototype available
  - TÜV Assessment & Certification planned for Q1/2024

Revision available

F O U N D A T I O N

OPC 10000-15

OPC Unified Architecture
Part 15: Safety

Release 1.05.02
2022-11-01

OPC UA Specification
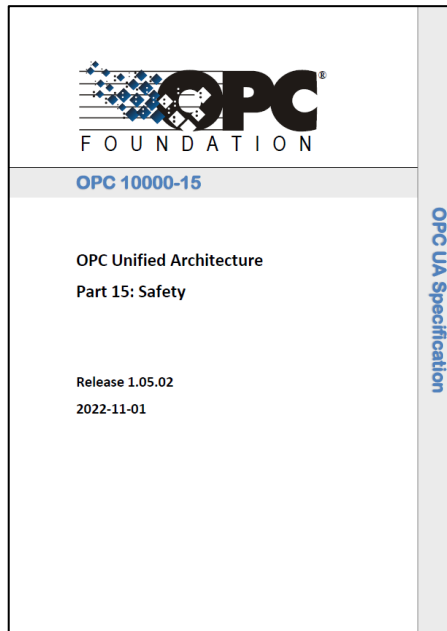
Major achievements of FLC Initiative Phase 1 (Summary)

- One harmonized **communication solution** for FA & PA & …
  - OPC UA-based with focus on C2C (controller-to-controller)
  - supporting cyclic real-time (and safety) process data exchange
  - supporting wired and wireless data exchange (Ethernet, Ethernet TSN, 5G, …)
  - pepared for use cases C2D (Controller-to-Device) and D2D (Device-to-Device)
- One common **UAFX controller profile** for all types of controllers
  - including PLC, DCS, MC/RC/NC (Motion/Robot/Numerical Controllers)
  - including information model for Automation Components (Asset & FEs)
- One scalable **networking concept** for UAFX controllers
  - Mandatory: PubSub via UDP/IP (routable)
  - Optional: PubSub via Ethernet Layer 2 (for higher efficiency)
  - Optional: embedded Ethernet/TSN bridge
- One **safety solution** for OPC UA & UAFX (OPC UA Safety)
  - supporting Client/Server and PubSub, transport protocol independent
  - designed for safety applications up to SIL 4
- Concept for **offline engineering** scenarios
  - with product/configuration descriptors based on AML
- UAFX **conformance test** in work

FLC Phase 1
(2019 – 2023)

Concepts & specifications agreed by FLC SC member companies incl. all major automation suppliers and
Spec. Parts 15, 80, 81, 82, and 84 released by the OPC Foundation (Part 83 to be released Jan 2024)

FLC Initiative:
Members of the FLC Steering Committee

ABB BECKHOFF rexroth A Bosch Company B&R cisco EMERSON

FESTO hilscher HIRSCHMANN HUAWEI intel KUKA

Lenze Mitsubishi Electric molex MOXA MURR ELEKTRONIK OMRON

PHOENIX CONTACT PILZ Rockwell Automation Schneider Electric SIEMENS WAGO YOKOGAWA

UAFX Transport Architecture

5+6+7 Application Presentation Session	OPC UA / UAFX Information Model			
	OPC UA Client/Server	OPC UA PubSub		
	UA Binary, JSON, XML	JSON, UADP		
	UA Secure Conversation		MQTT, AMQP	
	UA-TCP, WSS, HTTP, …	TLS		
4 Transport	TCP			UDP
3 Network	IP			
1 + 2 Data Link and Physical Layer	IEEE 802.1 + IEEE 802.3 (incl. TSN)			
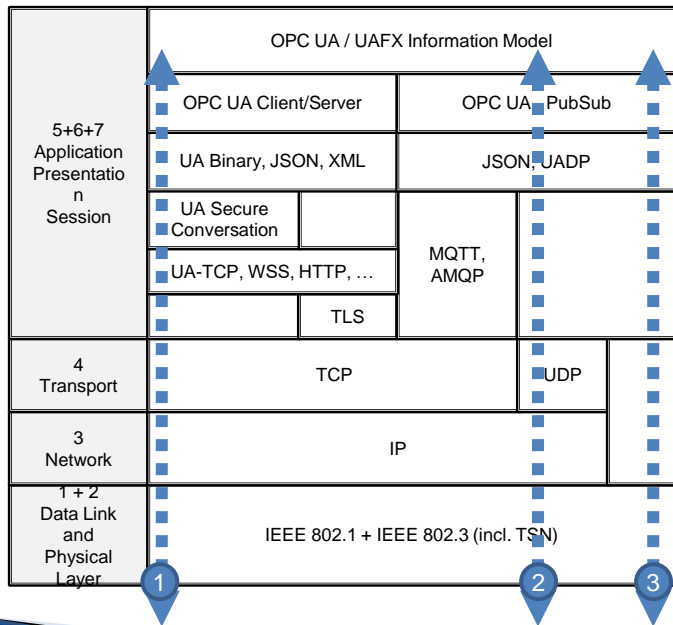
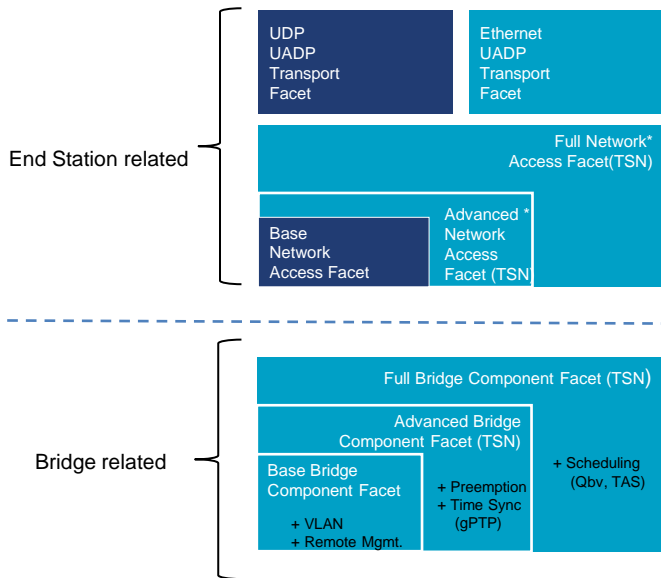1. **OPC UA Client/Server** is using TCP/IP. For small data sizes, this is very inefficient because significant protocol overhead is added. And TCP/IP is not real-time! UAFX uses C/S for setting up UAFX connections.

   **OPC UA PubSub** is using the UADP encoding which can be transmitted over different underlying protocols.

2. Mandatory for UAFX connections is OPC UA **PubSub over UDP/IP** which is real-time capable -> UDP UADP

3. The most efficient way is to insert data **directly into Ethernet** frames. No additional protocol overhead is added (optional for UAFX connections). -> ETH UADP

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UAFX Networking Facets

End Station related

| UDP
UADP
Transport
Facet | Ethernet
UADP
Transport
Facet |

Full Network*
Access Facet(TSN)

| Base
Network
Access Facet | Advanced *
Network
Access
Facet (TSN) |

Bridge related

Full Bridge Component Facet (TSN)

Advanced Bridge
Component Facet (TSN)

| Base Bridge
Component Facet

+ VLAN
+ Remote Mgmt. | + Preemption
+ Time Sync
(gPTP) | + Scheduling
(Qbv, TAS) |

- Interoperability guaranteed as IP Best Effort is **mandatory** for all UAFX controllers / devices
- Direct Layer 2 mapping & support of TSN-features is **optional**
- Three types of bridges defined (Base, Advanced, Full) – **optional** for end stations.
- **Graceful degradation** of QoS (Quality of Service) depending on capabilities of connected end stations, bridges and bridged end stations

| Required |
| Optional |
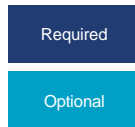
* Will be added for C2D

UAFX Testing & Certification

Developments of OPC Foundation:

▸ UAFX Extensions for the OPC UA Compliance Test Tool (CTT) are under development, expected to be available in Q1/2024

▸ OPC UA Safety Compliance Test Tool is under development, expected to be available in Q1/2024

▸ OPCF's Test Lab is prepared for testing of products supporting APL (Advanced Physical Layer)
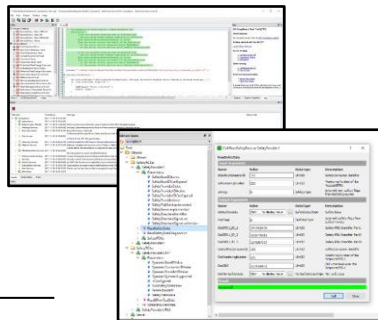
Joint activities with other Standards Developing Organizations (SDO):

▸ TIACC (TSN Industrial Automation Conformance Collaboration) TSWG (Test Spec Working Group) has been established to develop & maintain the TIACC "Common Test Specification".

▸ Ethernet APL Maintenance Collaboration has been established to maintain APL Specifications & Testing Tools, and to elaborate a Mutual Recognition Agreement

UAFX Multi-Vendor Demos @ SPS 2023

▸ UAFX Controller-to-Controller (C2C) + OPC UA Safety + OPC UA over 5G Demo
  (More than 20 participating companies incl. all major automation suppliers)

Ethernet-APL: Enabler for OPC UA in the field

- ▸ OPC UA is the chosen Industrial Interoperability solution by NOA, OPAF, MTP and MDIS
- ▸ Direct cloud connectivity or utilization of gateways based on well-defined semantics

OPC UA Integration options:

- ▸ OPC UA as „second channel" for monitoring & optimization (NOA = Namur Open Architecture)
- ▸ OPC UA as „first channel" for exchange of cyclic process data

- ▸ Communication options
  - ◦ OPC UA over MQTT
  - ◦ OPC UA Client/Server over TCP/IP
  - ◦ OPC UA PubSub over UDP/IP or Layer 2 Ethernet

ethernet-apl™
advanced physical layer

OPCF Live Demo at booth @SPS 2023

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FLC Initiative: Launch of Phase 2 (2024 – 2027)

- FLC Phase 1 (2019 – 2023):
  - Focus on C2C Use Case
  - UAFX Base Concepts for Controllers (and Field Devices)
  - Online & Offline scenarios
- **OPC Foundation now launches Phase 2 (2024 – 2027)**
  - Focus on C2D and D2D
  - Extend existing UAFX base concepts (e.g. Parametrization, Diagnosis and Networking)
  - Develop application profiles for motion control, I/O and instrumentation
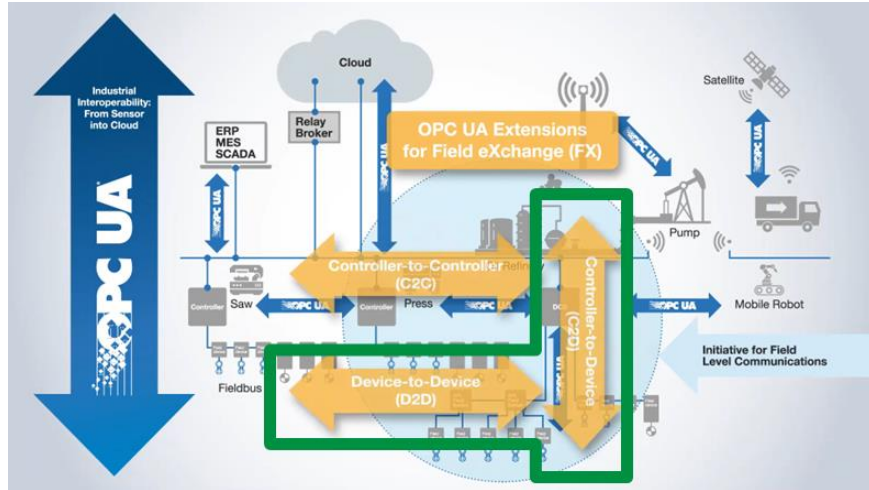
- **Technical working groups & FLC Steering Committee open to all OPC Foundation members**
- **FLC Steering Committee members provide extra support (financial contributions & man-power)**

Technical Working Groups of OPCF's FLC Initiative

FLC Architecture WG (started in Jan 2019)

NEW

| Safety WG (started in Feb 2018) | Motion WG (started in May 2020) | IO WG (will start in Dec. 2023) | Instrumentation WG (started in June 2023) |

Base Facet WG (started in Jan 2019)

Offline Engineering WG (started in Jan 2019)

Prototyping WG (started in Jul 2020)

Networking WG (started in Jan 2019)

Test Development WG (started in Oct 2020)

Infrastructure

FLC Supergroup WG =
FLC Architecture WG +
Base Facet WG +
Offline Engineering WG +
Networking WG

Infra-structure

No.	FLC Working Group	Chair	E-Mail
1	FLC Architecture WG	Gregory Majcher (Rockwell Automation)	gamajcher@ra.rockwell.com
2	Base Facet WG	Paul Hunkar (Yokogawa) / Georg Biehler (Siemens)	Paul.Hunkar@yokogawa.com georg.biehler@siemens.com
3	Offline Engineering WG	Emanuel Kolb (ABB)	emanuel.kolb@de.abb.com
4	Safety WG	Christian Eitner (Siemens)	christian.eitner@siemens.com
5	Motion WG	Rick Blair (Schneider Electric)	rick.blair@se.com
6	Instrumentation WG	Mark Nixon (Emerson) Shanthala Kamath (ABB)	mark.nixon@emerson.com shanthala.kamath@us.abb.com
7	IO WG	Rosh Sreedharan (Rockwell Automation) N.N.	rcsreedharan@ra.rockwell.com
8	Prototyping WG	Jan Murzyn (Mitsubishi Electric)	Jan.Murzyn@mpl.mee.com
9	Test Development WG	Thomas Schreck (Schneider Electric)	thomas.schreck@se.com
10	Networking WG	Alexander Gogolev (Huawei)	alexander.gogolev@huawei.com

FLC I/O WG – Call for Participation

Hello from the OPC Foundation!

You receive this information since you have registered your email with the OPC Foundation.

Kick-Off "FLC I/O" working group on December 11, 2023

The overall goal of the working group, which operates within OPCF as part of the FLC Initiative, is established to drive interoperability of remote I/O devices, such as modular I/Os and compact I/Os. The WG will add to the UAFX base specifications the definition of interfaces and behaviors for the different types of I/O devices.

The interoperable interface between PLC / DCS and I/O devices shall support different industries such as food & beverage, automotive, oil & gas, pharmaceutical, chemicals, energy, water waste, pulp & paper.

The interface shall include the following functionalities:
- data models and behavior for the different I/O device types
- configuration of I/O devices
- functional safety
- diagnostic information which is specific for I/O devices
- operational modes of I/O devices
- state machines and timing models for I/O specific functionality

The I/O working group will use the UAFX base facet and extend it with the elements that are required for interoperability of I/O devices. There is a relation to the Networking WG regarding network functionality and to the Safety WG regarding safe I/O functionality. There is also a relation to the Motion and Instrumentation WGs where standardized I/O channel types may be incorporated into motion or instrumentation devices.

Initial co-chairs of the working group are Rosh Chathoth Sreedharan (Rockwell Automation) and Mark Nixon (Emerson).

The Kick-off Meeting is scheduled for December 11, 2023 as a web conference.

Start Times

    5:00 am PST (US West coast)

    8:00 am EST (US East coast)

    2:00 pm CET (Germany)

    10:00 pm JST (Japan)
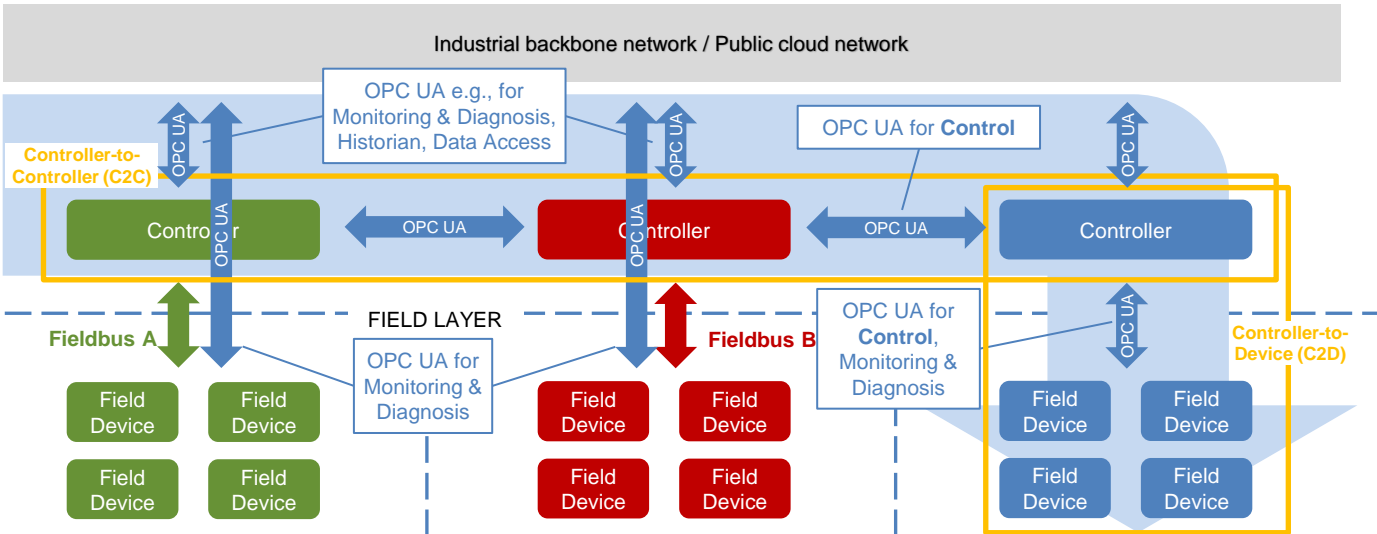
(duration 60-90 minutes)

For registration please contact Peter Lutz, peter.lutz@opcfoundation.org

This group is open for OPC Members of categories "Corporate Members", "End-Users", "Non-Voting-Members" but not open for "UA-Logo-Members".

https://opcfoundation.org/membership/benefits/

Milestones & Migration Path with OPC UA

OPC UA + UAFX incl. APL + TSN support the convergence of industrial communication for FA & PA & beyond

Industrial backbone network / Public cloud network

OPC UA e.g., for Monitoring & Diagnosis, Historian, Data Access

OPC UA for **Control**

Controller-to-Controller (C2C)

OPC UA

Controller

OPC UA

Controller

OPC UA

Controller

Fieldbus A

FIELD LAYER

OPC UA for Monitoring & Diagnosis

Fieldbus B

OPC UA for **Control**, Monitoring & Diagnosis

Controller-to-Device (C2D)

Field Device

Field Device

Field Device

Field Device

Field Device

Field Device

Field Device

Field Device

Field Device

Field Device

Field Device

Field Device

Further Information

Brochures / Technical Papers	
General OPC UA Brochure (60 pages), V15 (11/2023)	Link
FLC Flyer (4 pages), V7 (11/2023)	Link
FLC Technical Paper (40 pages), V3 (11/2023)	Link
APL Brochure (18 pages), (06/2020)	Link
OPC UA Safety – Technical Paper (24 pages), V1 (09/2022)	Link

Specifications	
Part 80: UAFX Overview and Introduction V1.00 (11/2022)	Link
Part 81: UAFX Connecting Devices and Information Model V1.00.1 (01/2023)	Link
Part 82: UAFX Networking V1.00 (11/2022)	Link
Part 83: UAFX Offline Engineering V1.00 RC (under member review)	Link
Part 84: UAFX Profiles V1.00 (11/2022)	Link

Recordings	
OPC UA Field eXchange (FX) Digital Days Day 1 Day 2 Day 3	Link

https://opcfoundation.org/flc

Thank you!

PETER LUTZ
Field Level Communications Director
OPC Foundation

Phone: +49 171 - 404 1028
Peter.Lutz@opcfoundation.org
www.opcfoundation.org

Looking for more information?
Brochures, Recordings, Slides, …

https://opcfoundation.org/
https://opcfoundation.org/flc
https://opcfoundation.org/apl

advenica   BECKHOFF   brightly   NOKIA   OPC   PROSYS OPC   TGS   prediktor   Unified Automation   Valmet   Wapice   FINNISH SOCIETY OF AUTOMATION SUOMEN AUTOMAATIOSEURA RY