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# SOLEIL HW/SW control experience and future plan

- PLCs at SOLEIL
  - Types, distribution and applications of PLC
  - TANGO integration
  - OPCUA use cases
- Code generation and tests
  - Programming environment and methods
  - Future needs
- Monitoring and maintenance tools
- Hardware evolutions
  - Signal handlings
  - Fieldbuses Protocols



# PLCs at SOLEIL



Technical choices made in 2004:



- SIEMENS S7 300 hardware
- Profibus DP as fieldbus

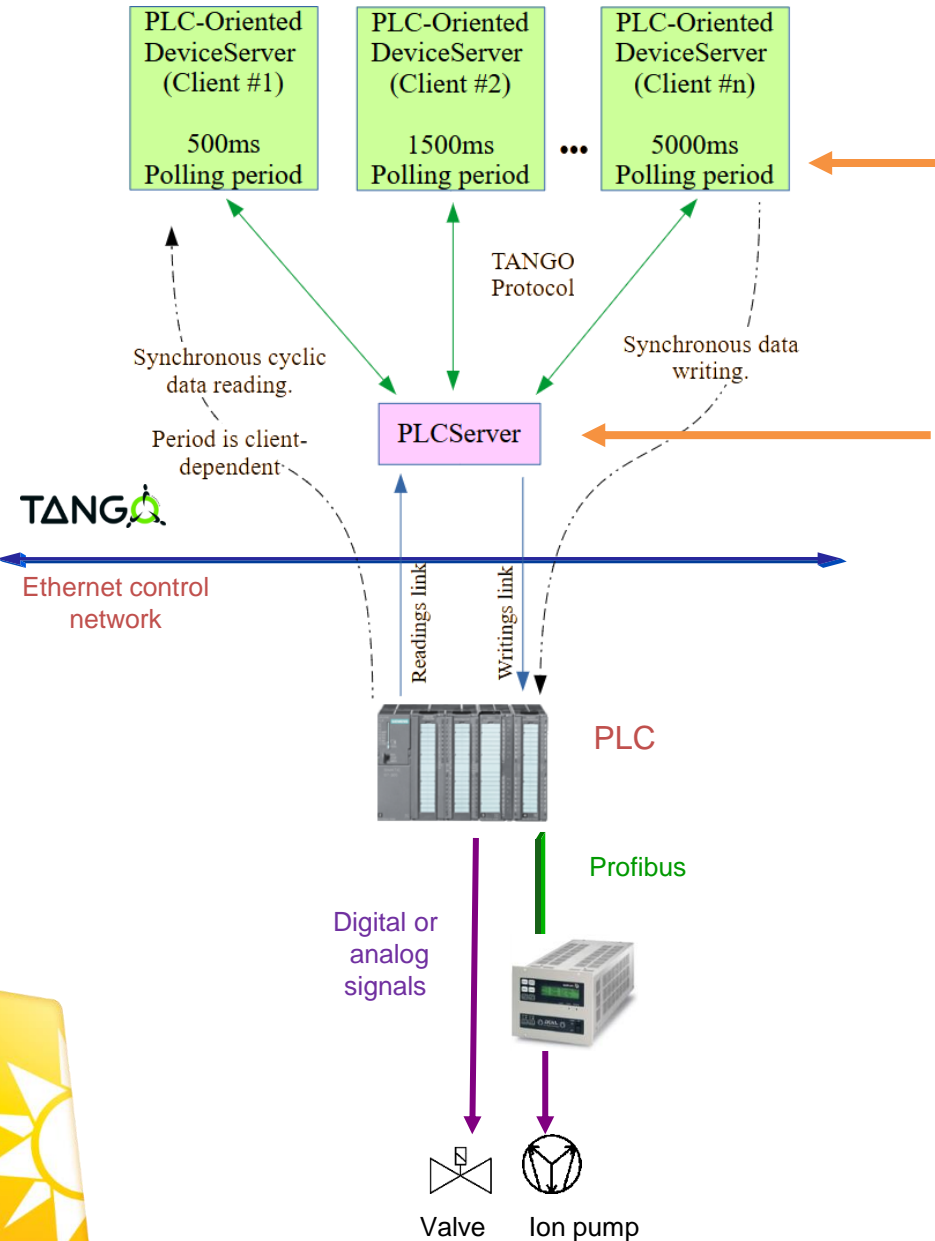


Use of PLC	Complexity	Occurrence frequency
Signals measurement via TANGO Device Servers	 Low    High	Always
Remote control of physical devices		In most cases
Application of security rules		For vacuum, PSS and machine interlocks
PID & regulation loops		Bakeouts, gas flow control, ..
Process control		Rare

Domain	Quantity	Comments
Vacuum	~130	Accelerators & Beamlines
Machine interlocks	21	Use of daisy chained Boolean processors (FM352)
Magnet power supply (DC and pulsed)	31	Large Profibus networks (max 104 slaves, 600 meters long)
Radiofrequency cavities	9	
Personal Safety System	~60	Safety modules & program
Beam Diagnostics	36	
Cryogenics	2	External programming by subcontractors
Ventilation & cooling	~30	Full external supply (HONEYWELL & SCHNEIDER hardware, programming & maintenance)

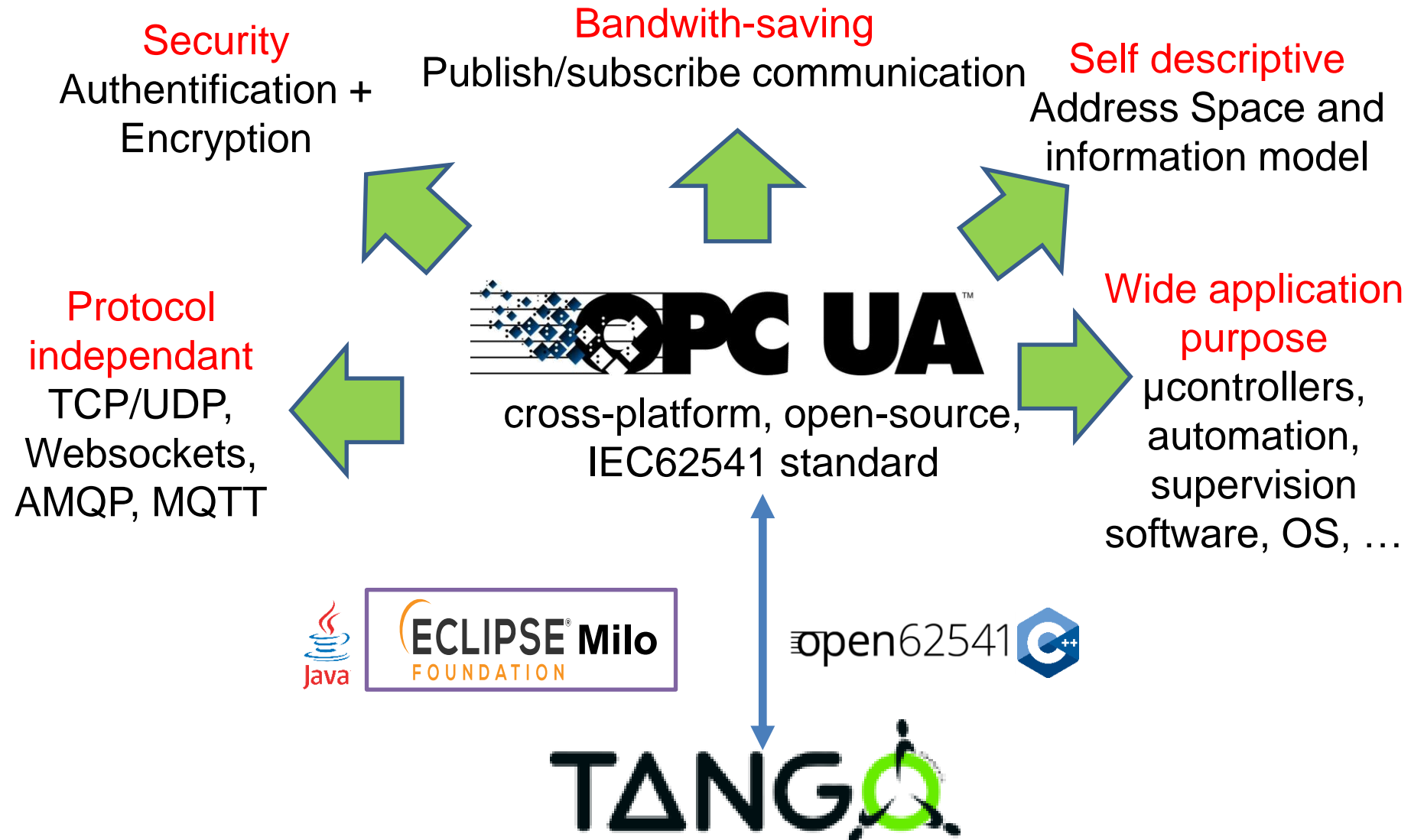


# TANGO integration: Two-stage communication method

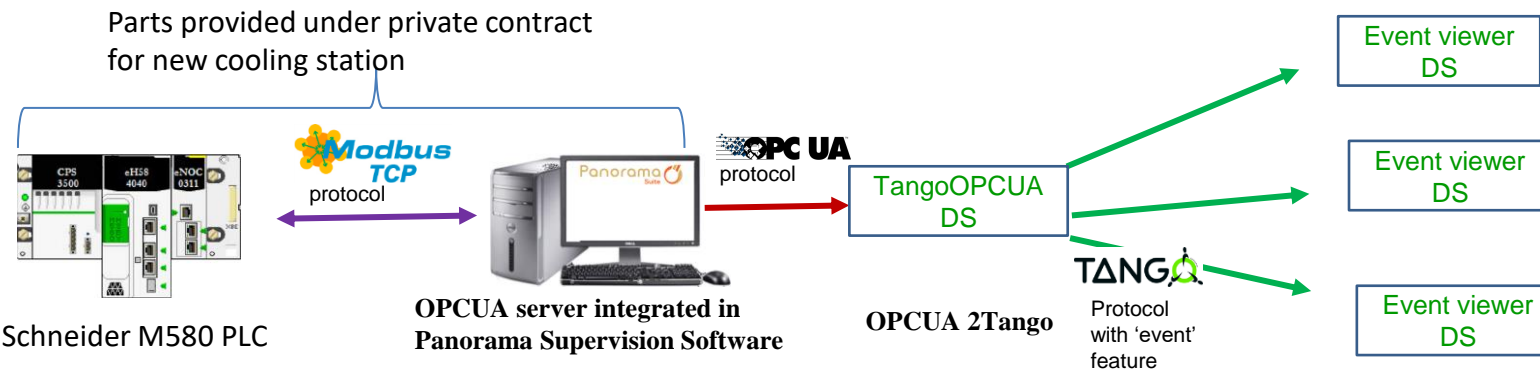


	Since 2004	2017 improvements	For the upgrade
<b>User end client DS</b>	One dedicated binary per physical device type	Systematic use of generic <b>PLCDataViewer DS</b> where commands, attributes, State and Status are defined by properties	
<b>PLCServer performs readings and writes from/to PLC data blocks (DB) for the clients DS</b>	Based on <b>Fetch/Write</b> protocol	Based on <b>S7</b> protocol / SNAP7 Library[1]  Benefits: <ul style="list-style-type: none"> <li>Asynchronism</li> <li>Data aggregation</li> <li>Higher data rate</li> <li>S7 connections do not require PLC-side configuration</li> </ul>	 <b>OPCUA-based?</b>

OPC Unified Architecture is a powerful communication model now widely incorporated in multi hardware platforms.



## Case 1: Distribute data from a third-party software (PANORAMA Supervision)

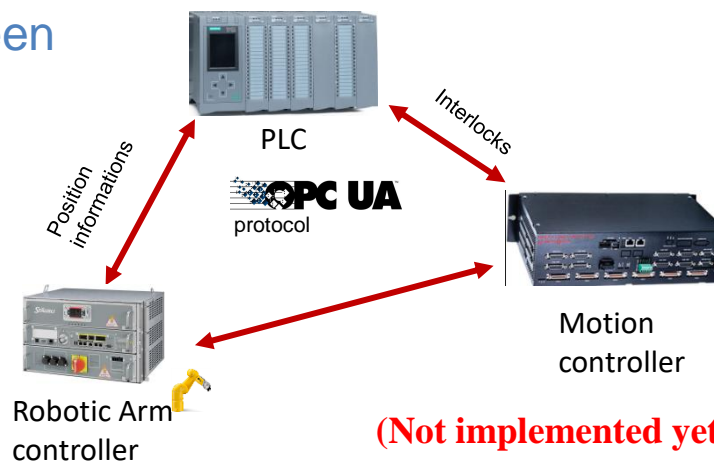


### OPCUA2Tango DS Schneider M580 PLC

- Large amount of data over a limited number of OPCUA connections
- Work as OPCUA client, transform OPCUA Event to TangoEvent ( Archiving and Changing)
- Developed in java using Milo library

## Case 2: Direct communication between controllers: OPCUA Pub/sub

A way to simplify communication between heterogenous devices at the field level



(Not implemented yet)

### Expected benefits:

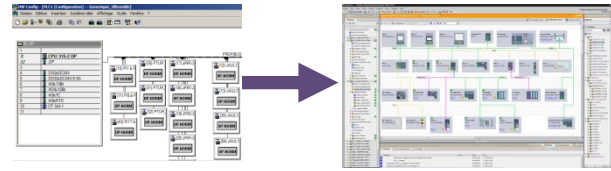
- **Fast and deterministic:** When used on Time Sensitive Networks

# Code generation and tests

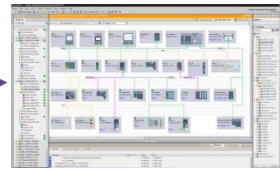




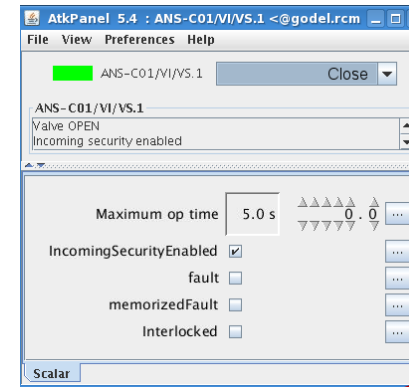
## Programming environment



2004: Step7



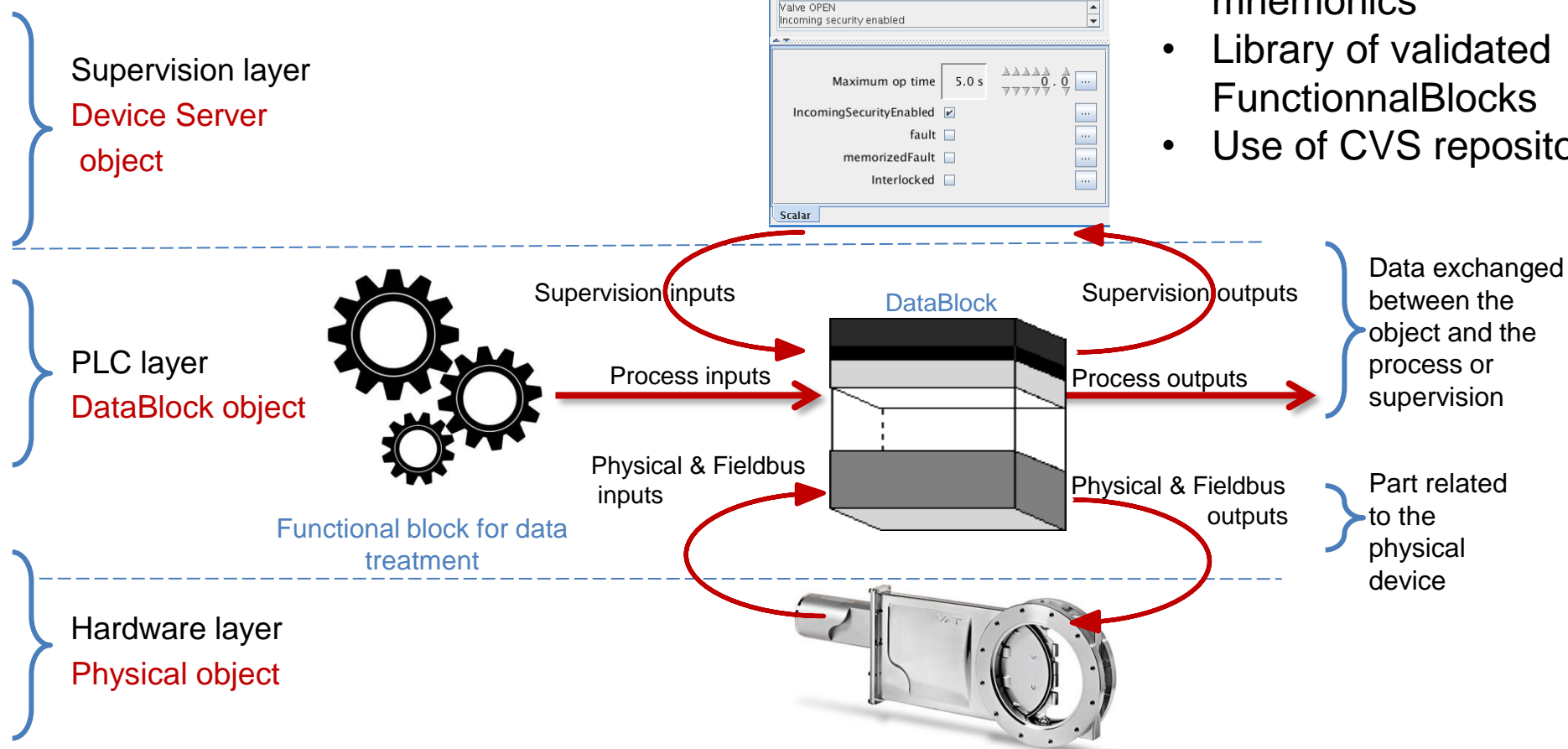
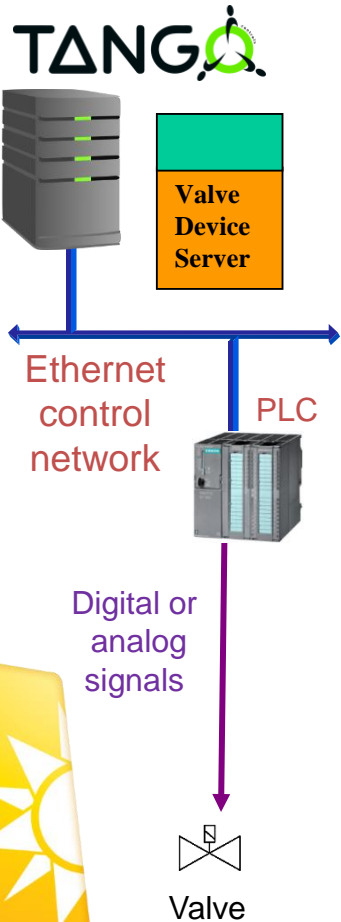
2017: TIA Portal V18

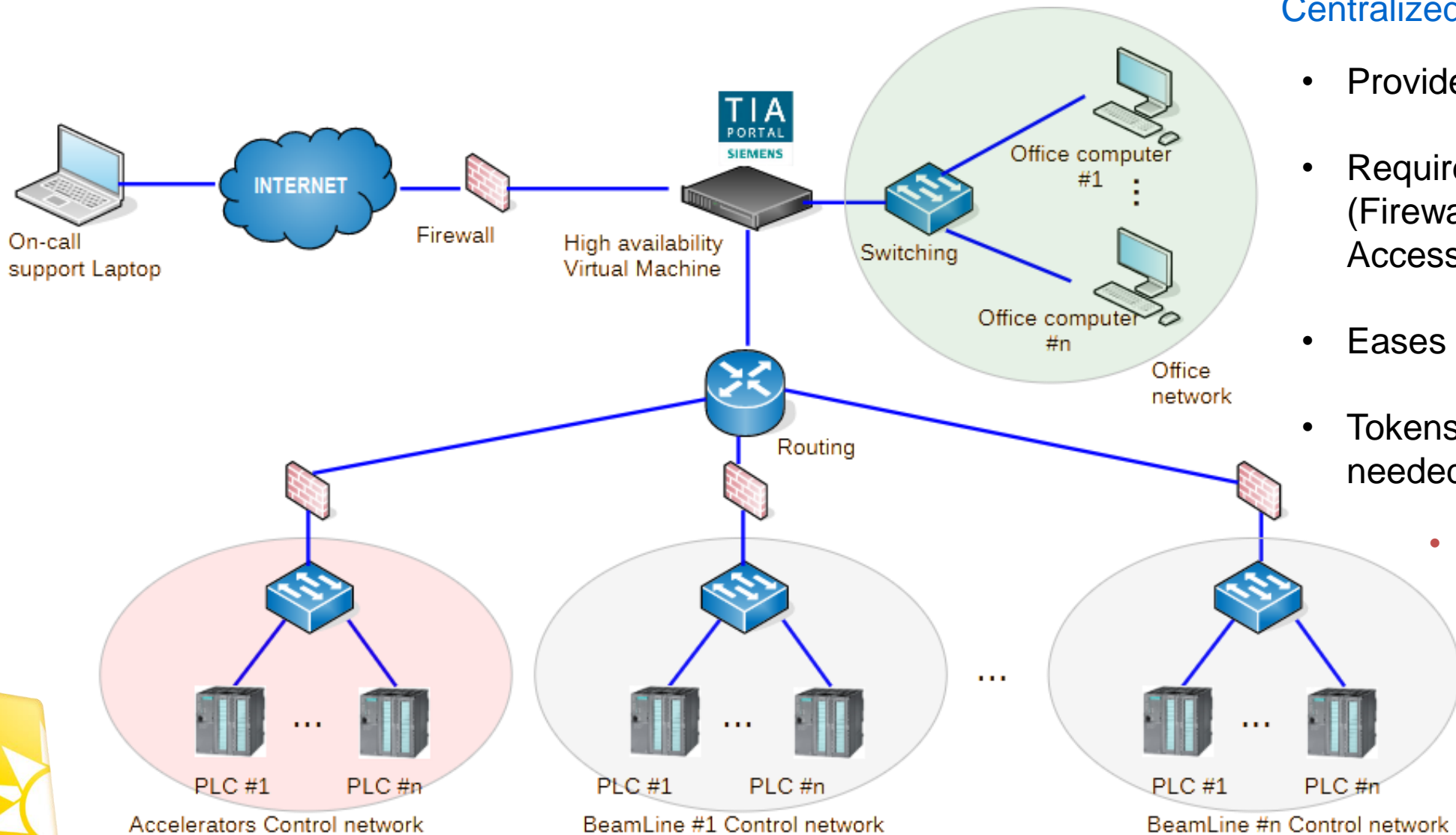


## Conventions used:

- Object oriented design
- Standardized DataBlock internal layout
- Standardized names for mnemonics
- Library of validated FunctionnalBlocks
- Use of CVS repository

## 3-stage object model

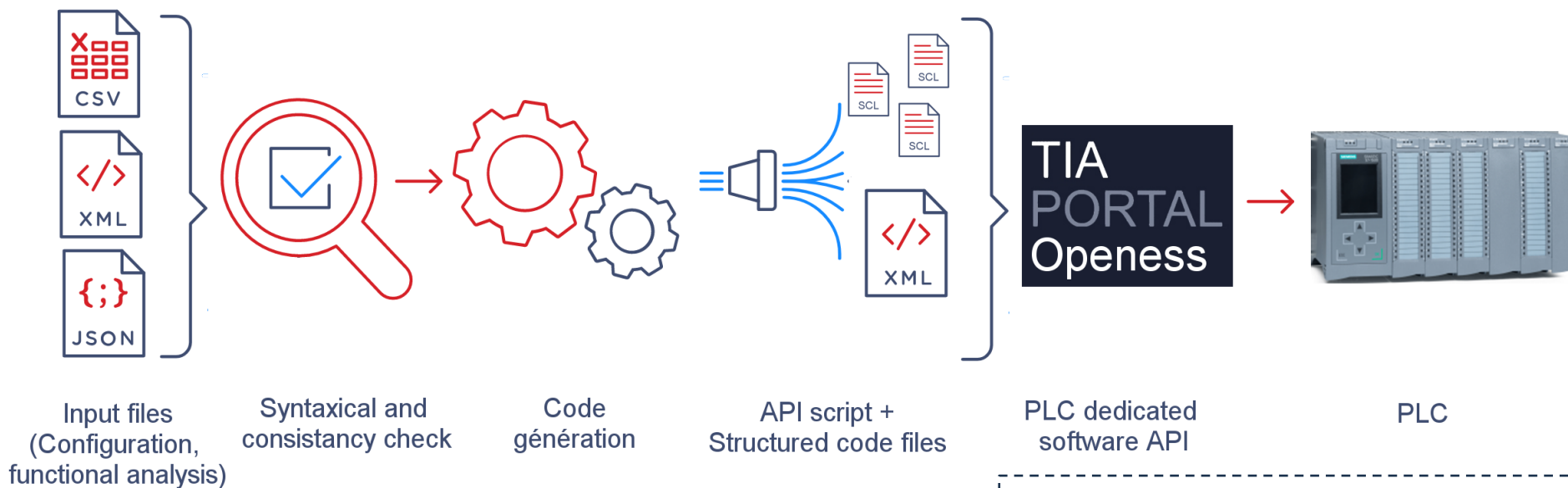




## Centralized programming console

- Provides better accessibility
- Requires more security (Firewall, VPN, Identity & Access management)
- Eases software maintenance
- Tokens reduce number of needed licenses
- May also be used for PLC firmware & upgrade but the SIEMENS Automation Tool doesn't work

## Automatic code generation



### Benefits:

- Provide standardized code
- Reduce programming time

### External solutions:

- **UNICOS** (from CERN) -> Very powerful but complex. Concerns all levels of control systems. No support.
- **PLC2Tango** (from MAX IV) -> Not a PLC code generator but a DS generator
- **PyPLC** from ALBA -> Not tested
- Other (From ELI)?

### Tests

#### Today:

- Tests performed on 3 test benches with fully equipped PLCs in lab
- FAT / SAT

#### To be considered:

- Parts simulators
- Digital Twins

# Monitoring and maintenance tools



Large amount of PLC (~200), still growing = need for monitoring solution

## Requirements:

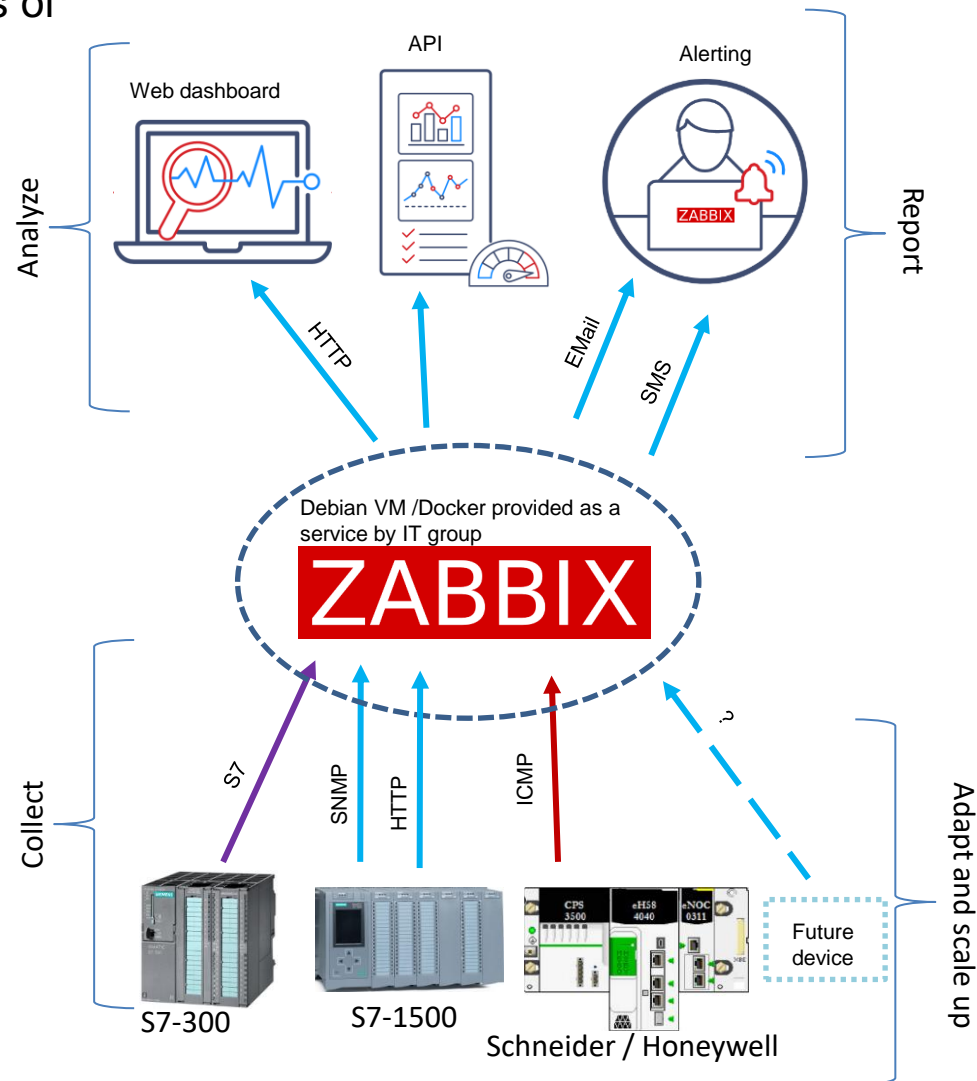
- Able to retrieve data representative of the operating status of the PLC
- User friendly interface

## Solutions:

- Embedded Web server -> Simple but not adapted to multiple PLC
- Proprietary solution -> Not adapted to PLC from other brands
- Network monitoring tool-> Lot of stable and powerful products.  
Good solution: Rely on software already used by IT staff

## Work done:

- Program collecting probes based on various protocols.
- Develop web maps and dashboards





## Multi-level interactive maps

The image displays the ZABBIX monitoring interface, illustrating multi-level interactive maps. On the left, a large circular map shows the overall facility layout with various rooms and equipment labeled. A red dashed line indicates a zoomed-in view of a specific area. On the right, the zoomed-in view shows a detailed floor plan of the 'GT-C05' area, with several server racks and equipment units. The interface includes a sidebar menu with options like Dashboards, Monitoring, Problems, Hosts, Latest data, Maps, Discovery, Services, Inventory, Reports, Data collection, Alerts, Support, Integrations, Help, User settings, and Sign out. The main map area shows various equipment units with status indicators (OK, problem) and labels such as 'RCM Vide Cellule anneau C05', 'RCM Vide Section droite anneau S0L05', 'RCM Vide Section droite anneau S0M06', and 'RCM Mesure temperature Labo Alignement'. The 'Labo Alignement' area is highlighted in red, indicating a problem.

## Single PLC Dashboard

## Email alert & report

From: <zabbix@synchrotron-soleil.fr>  
 To: <liste-zabbix-plc@synchrotron-soleil.fr>  
 Date: Wed, 02 Oct 2024 10:24:06 +0200  
 Subject: Storage ring Vacuum Cell C07 - CPU STOP

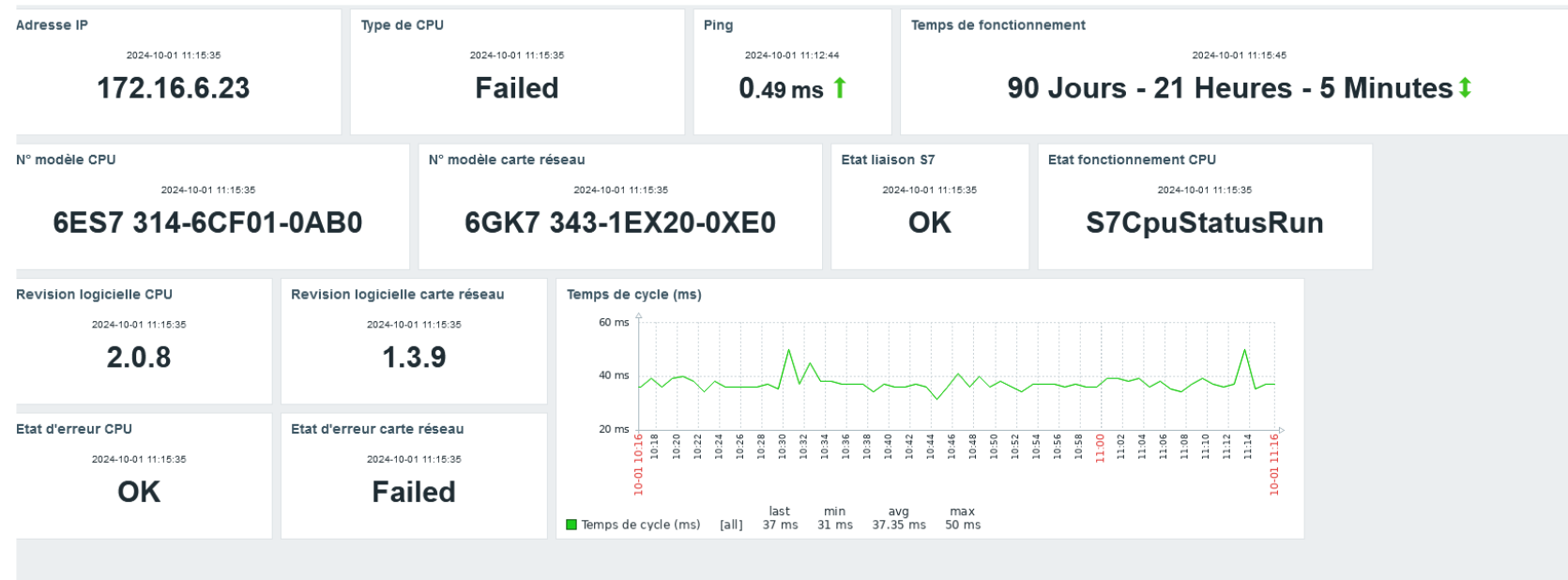
Host : Storage ring Vacuum Cell C07  
 IP Address : 172.17.7.15

Trigger : CPU STOP  
 Trigger description : PLC's CPU has switched to STOP  
 Date : 2024.10.02 10:23:04

Key : CpuState  
 LastValue : S7CpuStatusStop  
 Zabbix link: <https://zabbix.synchrotron-soleil.fr/zabbix/zabbix.php?e=256469>

Configuration details:

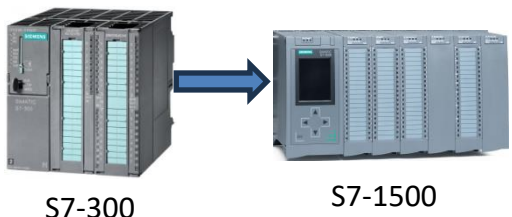
- CPU type: S7-315-2DP
- CPU model: 6ES7 315-2AG10-0AB0
- Hardware revision:
- Software revision: 2.0.1
- Uptime: 22 Days - 1 Hour - 2 Minutes



# Hardware evolutions

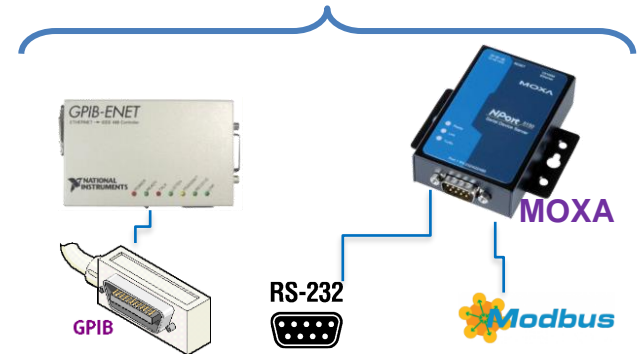


## <1KHz: New generation PLCs

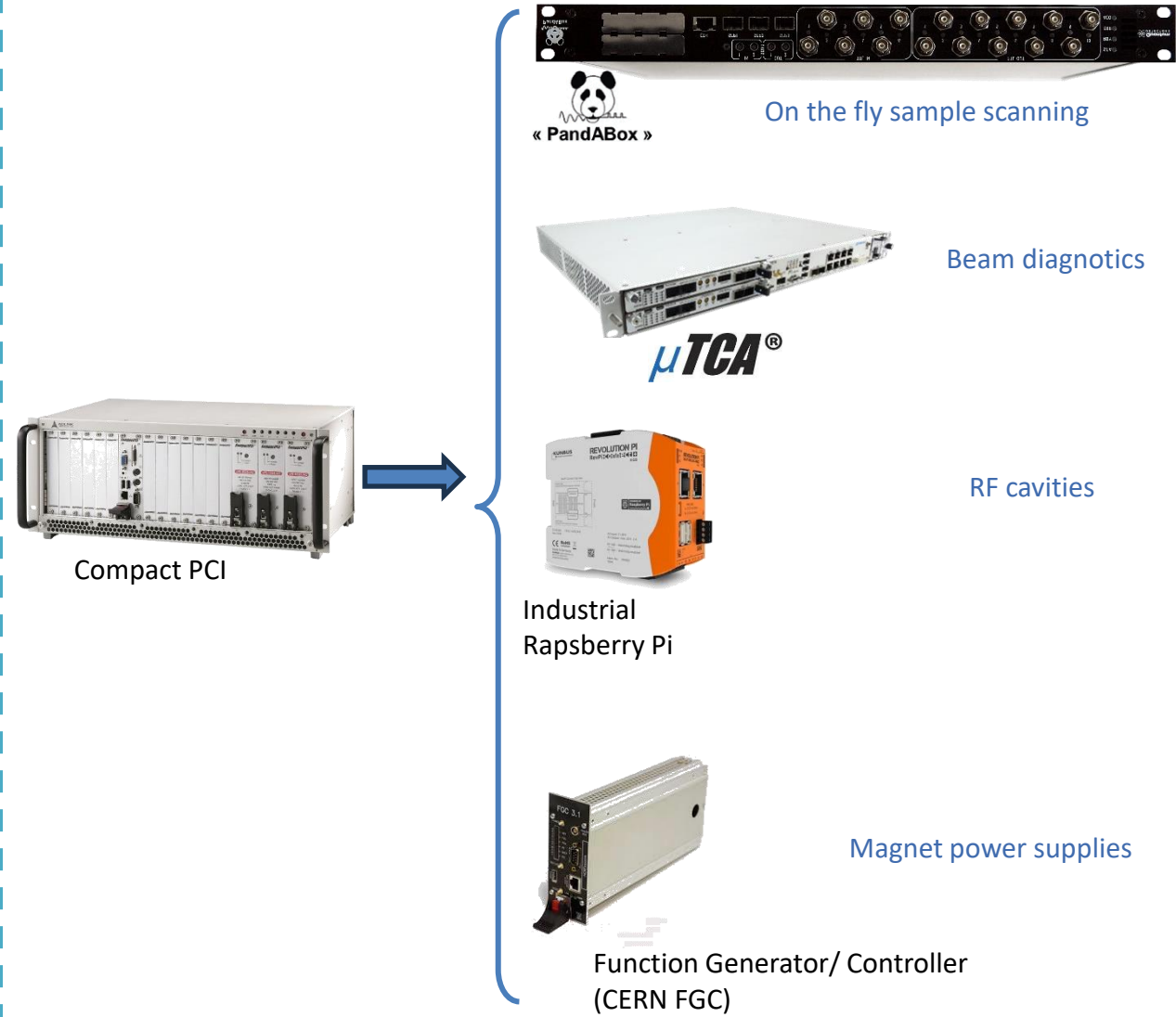


Analog and Digital signals		
Preferred	Also supported	Not supported
<ul style="list-style-type: none"> <li>0-10V / 0-5V</li> <li>4-20mA / 0-20mA</li> <li>24V I/O</li> <li>Dry contacts</li> <li>RTD</li> <li>Thermocouple</li> </ul>	<ul style="list-style-type: none"> <li>Open collector I/O</li> </ul>	<ul style="list-style-type: none"> <li>TTL signals</li> <li>Reed contacts</li> </ul>

Digital Protocols			
Preferred	Also supported		Not supported
Protocols natively supported by SIEMENS PLC	Protocols requiring additional programming work	Protocols requiring gateways and/or programming	Media incompatibility
<ul style="list-style-type: none"> <li>Ethernet-based               <ul style="list-style-type: none"> <li>ProfiNet</li> <li>OPC UA</li> </ul> </li> <li>ProfiBus DP</li> </ul>	<ul style="list-style-type: none"> <li>ModBus TCP</li> <li>ASCII protocols based on TCP/IP frame</li> </ul>	<ul style="list-style-type: none"> <li>EtherCAT</li> <li>CAN</li> <li>ASCII or RTU ModBus on RS232/485</li> </ul>	<ul style="list-style-type: none"> <li>Media incompatibility</li> <li>USB</li> </ul>



## >1KHz: DAQ Hardware

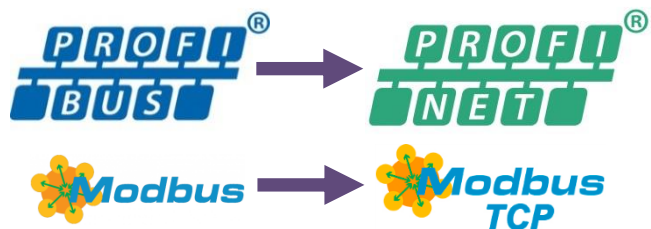




Follow the widespread use of Ethernet in the industrial world

FieldBuses move to FieldNetworks

Examples of fieldbus porting to Ethernet:



New protocols:

**EtherNet/IP™**

**EtherCAT®**

**OPC UA™**

**Numerous advantages:**

- Significant reduction in wiring
- Centralised control of devices
- Richer device data (multivariables, parameters, diagnostics, etc.).
- Greater flexibility in system architecture and design.
- Ease of future extensions and modifications
- IoT
- TSN

**But need to adapt to the specifics of Industrial Ethernet:**

- Switching and routing equipment adapted to harsh environments:
- Special formats for cabinet / DIN rail mounting
- 24VDC power supply
- Rugged connectors



**+ Knowledge of Operational Technology**

- IP & Mask Addressing
- UTP/TCP difference
- Switching & Routing
- ...



# Thank you!



## Backup slides





Front

- 19" rack integration:
- PLC at the top of racks.
  - Industrial cabling elements mounted on rear plate.



Rear

Step	Performer	Remarks
Specifications	Machine or beamline staff	Almost every format accepted, then translated into more formalized documents by automation group.
Wiring scheme	Automation group	Sometimes performed by subcontractors
Cabling and hardware integration	Automation group	Sometimes performed by subcontractors
Software development	Automation group	Now covers also the associated TANGO Device Servers
Testing and commissioning	Machine or beamline staff & Automation group	Site acceptance tests
Maintenance	Automation group	Use of computerized maintenance management system for stocks & elements lifecycle

**OPC Unified Architecture (OPC UA)** is a cross-platform, open-source, IEC62541 standard for developed by the OPC Foundation from the original OPC communications model (Microsoft Windows-only process exchange COM/DCOM)

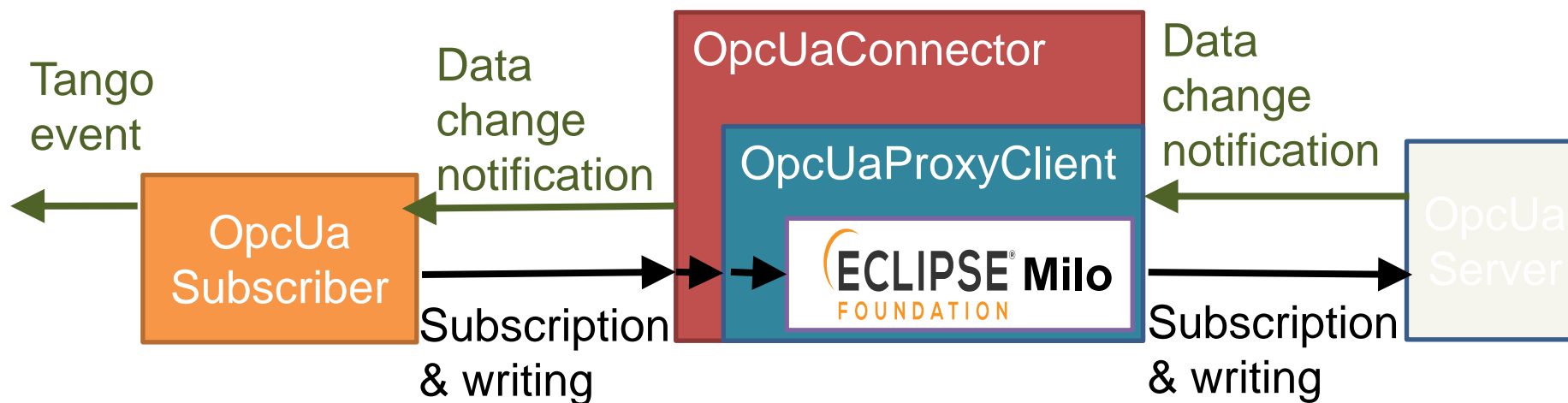


**Interesting features for SOLEIL:**

- **Address Space and information model:** Uses self descriptive data models
- **Security:** Extensible security profiles, including authentication, authorization, encryption and checksums
- **Bandwidth-saving Data Access method:** Support for both client-server and publish-subscribe communication patterns
- **Communication protocol independent:** Mappings to several communication protocols like TCP/IP, UDP/IP, WebSockets, AMQP and MQTT are specified
- **Wide application purpose:** Initially successful in standardized data exchange with industrial equipment and systems for data collection and control, but now also leveraged in building automation, and cloud applications.
- **Open and Free** of charge under redistributable license
- **Cross-platform:** Not tied to one operating system or programming language

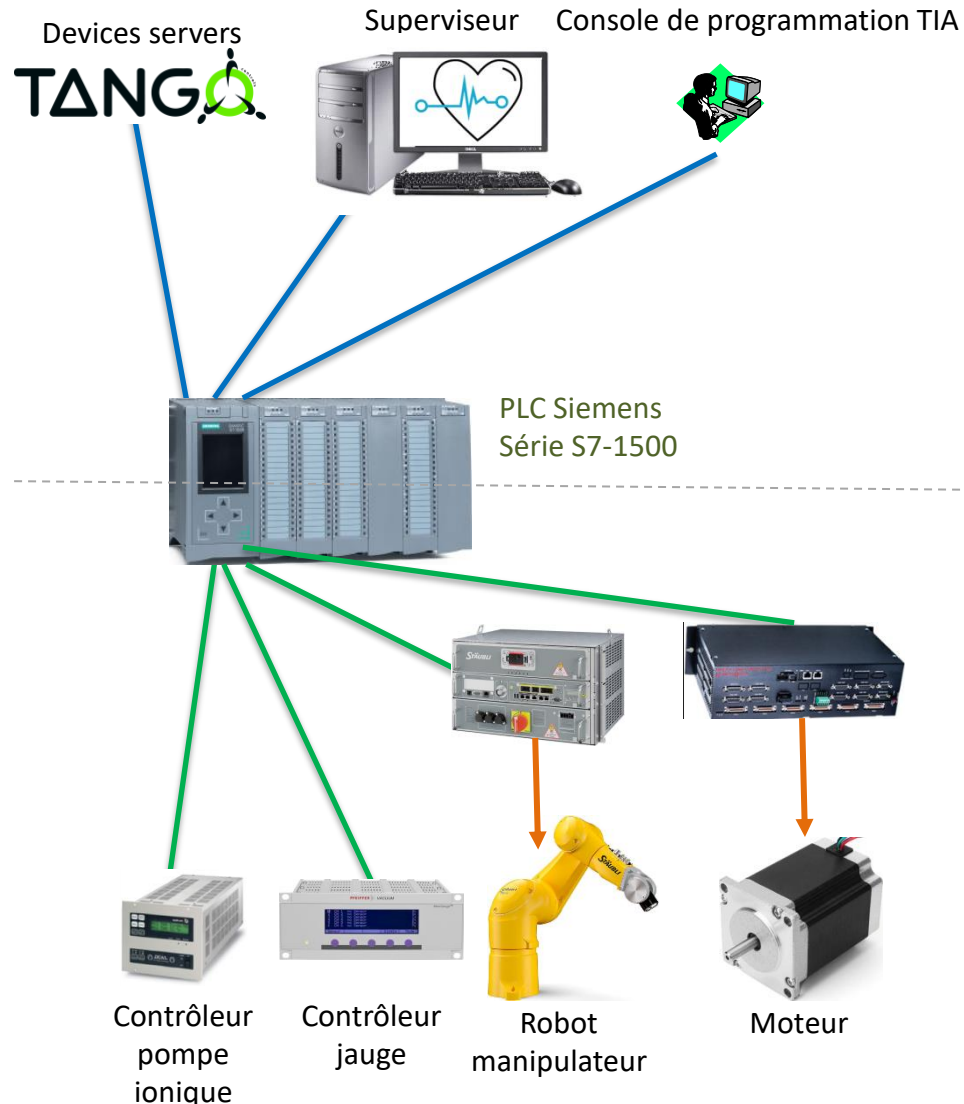
A communication model released in 2015 and currently under study at SOLEIL





- Device OpcUaProxy (using java Milo lib) works as a client, connecting to OpcUa server and providing its data as Tango attributes.
- It creates Tango events (change, archive) at reception of data change notification
- Works on two modes: polling and subscription
- Auto data browsing and converting OpcUa tree data structure to flat data structure in Tango
- Reading/writing given data
- All scalar, 1D and 2D data types are supported.
- Secure connection based on certificates

L'intégration d'automates et des équipements qu'ils pilotent dans les réseaux de terrain crée **2 types de trafics**



## Trafics d'exploitation, de configuration et de surveillance

- Trafic périodique lent (1s à 10s) + Trafic occasionnel
- Couches et ports TCP/UDP classiques (HTTP, NTP, SNMP, S7, ...)
- Non déterministe
- Pas de priorité

## Trafics de processus et d'événements

- Trafic périodique rapide (1us à 100ms) + Trafic occasionnel
- Couches et ports spéciaux
- Déterministe (temps réel)
- Avec priorités (Alarmes, synchro, Time Sensitive Networks)