Industrial Campus Network for Virtualized Programmable Logic Controller (PLC)

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Industry 4.0 and Smart Manufacturing Require More to PLC

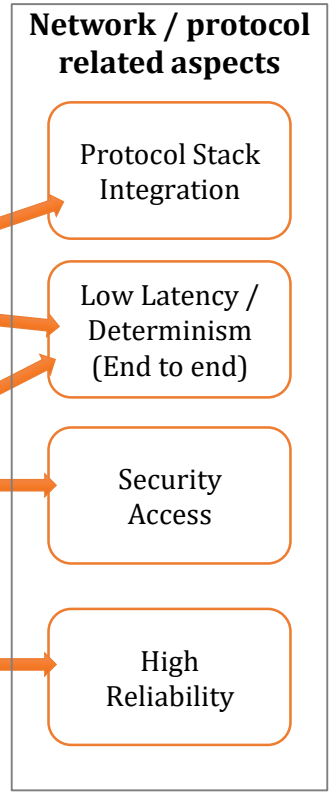
- Industry 4.0 and Smart Manufacturing request competitive production systems for individualized products. PLCs, as the key components of the production systems, new requirements are aroused to PLCs for transformation.
- The transformation approach is the virtualized PLC.

Requirements	Approaches of vPLC
More data to be processed • More data are generated and sent to PLC. • It includes not only logical data, analog data, but also video, image data.	**More computing power to be provided** • The vPLC based on cloud / edge computing could be expanded for more computing power dynamically. • The IT technologies (e.g. AI, big data, etc.) could be introduced in vPLC to process huge amount of data with different types.
More Flexible to adjust • Services or market requirements changing cause procedure flow or data changing. • PLCs are requested to adjust accordingly.	**More ease to verify, update and run vPLC with new functionalities** • There are full maintenance procedures derived from cloud / edge computing. • It's ease and highly efficient to implement verification, update and running vPLC program with new functionalities.
More coordinated to control • There are more factors to be considered to implement the control and manufacturing. • There are more interactions and communications with other devices and systems to optimize decisions based on data.	**Decoupled, more ease to coordinate with the others** • The vPLCs are decoupled from control modules of classic PLCs. • Naturally, it's able to communicate to other vPLCs, I/O modules or other systems conveniently. • More data could be involved into the control progress, it will be more accurate or proper to implement the control capability.

Understanding of Virtualized PLC via Comparison

- Virtualized PLC, that is to decoupling the classic PLC, separates its logical control functionalities and I/O functionalities, standardizes logical control functionalities as modules, deploys and runs the control modules remotely and centrally in virtual environment.

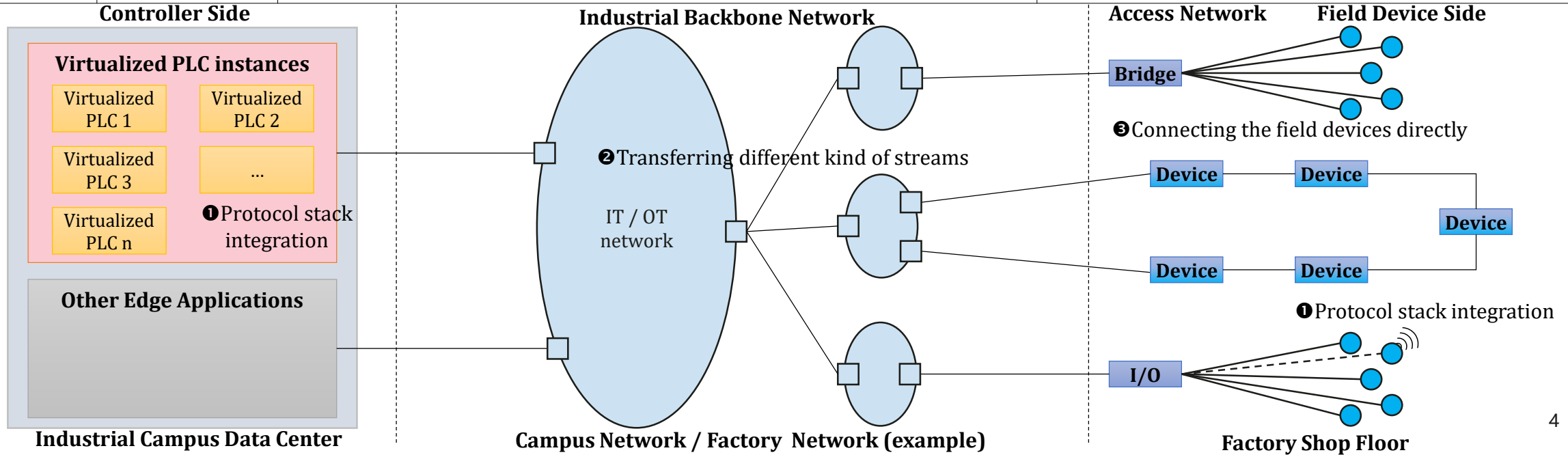
Items \ Category	Hard PLC	Soft PLC	Virtualized PLC
Hardware	Proprietary hardware	Industrial PC	General hardware server
System	Embedded real-time system (hard real-time)	OS with extended real-time features (soft real-time)	**Real-time** OS (RTOS)
Coupling of hardware & software	Completely coupling	Partially decoupling	Completely decoupling
Place of the controller deployed	Field level	Near field level	**Remotely**
Computing power	Limited by the hardware	Expand limitedly	Nearly unlimited
Reliability	High	Medium	**Low (currently)**
Cost	High	Medium	Low



E2E Network / Protocol Involved, from vPLCs to Field Devices, Challenges

- Along the routine from vPLC to Device, the end to end network and protocol stack integration are involved.

Item	Aspects involved	Scenarios	Challenges
Controller Side	❶Protocol stack integration	• Network protocol stack integration with RTOS • vPLCs to access devices with security	• Network ✓ Low latency / determinism ✓ High reliability • Protocol & Access Interface ✓ Ease to integrate protocol stack, avoid influence to device / system ✓ Ease to access, different network, bus, wire or wireless network etc.. ✓ Auto discovery & networking • Security ✓ Access certification, ✓ Risk isolation, etc.
Industrial Backbone Network	❷Transferring different kind of streams	• To transfer different kind of industrial streams, including periodical streams (anticipated) or non-periodical streams (not anticipated, event triggered) • High reliability, fault recovery time not to affect the industrial service	
Access Network	❸Connecting the field devices directly	• Field devices to access different network with different interface	
Field Device Side	❶Protocol stack integration	• Network protocol stack integration with field device • Field devices to be accessed with security	



Possible Aspects for Further Discussion

- The Virtualized PLC is the identified trend, many industry automatic venders are boosting the evolution to vPLC.
- The vPLC will be deployed remotely and centrally. The whole industrial campus network and the protocol integrated by devices / systems might be involved to assure the QoS for the industrial services.
- How the industrial campus network to implement and support the vPLC? There are several points could be analyzed based on such end to end scenarios as followings:
  - Low latency and Determinism
  - High reliability
  - Protocol stack integration
  - Network interface access
  - Security access
  - Etc.

Call for Interest to Discuss and Initiate a Work Item

- Call for interest to discuss about the scenarios and possible technologies evolution.
  - From the end to end routine of industrial campus network which connects vPLCs and filed devices, there are different kind of networks / protocols involved (e.g. TSN, existing industrial field bus based on Ethernet or non-Ethernet, etc.).
  - Based on the current status of the different networks / protocols, how to support to vPLCs scenarios?
  - Is there any gaps respectively for each related network, bus, protocol?
  - There might be possible optimization directions to be studied and analyzed.
- In the fullness to time and discussion, to initiate a new Work Item within Nendica to develop an IEEE 802 Nendica Report.
  - To analyze the end to end industrial campus network / protocol for vPLC.
  - To analyze the challenges of the end to end industrial campus network / protocol to support vPLC.
  - To frame high-level solutions to issues and challenges.
  - Possible standardization considerations.
  - Other aspects, etc..

Thank you.