Smart Factory with Intelligent Edge Control Enabled by Deterministic IP based Networking

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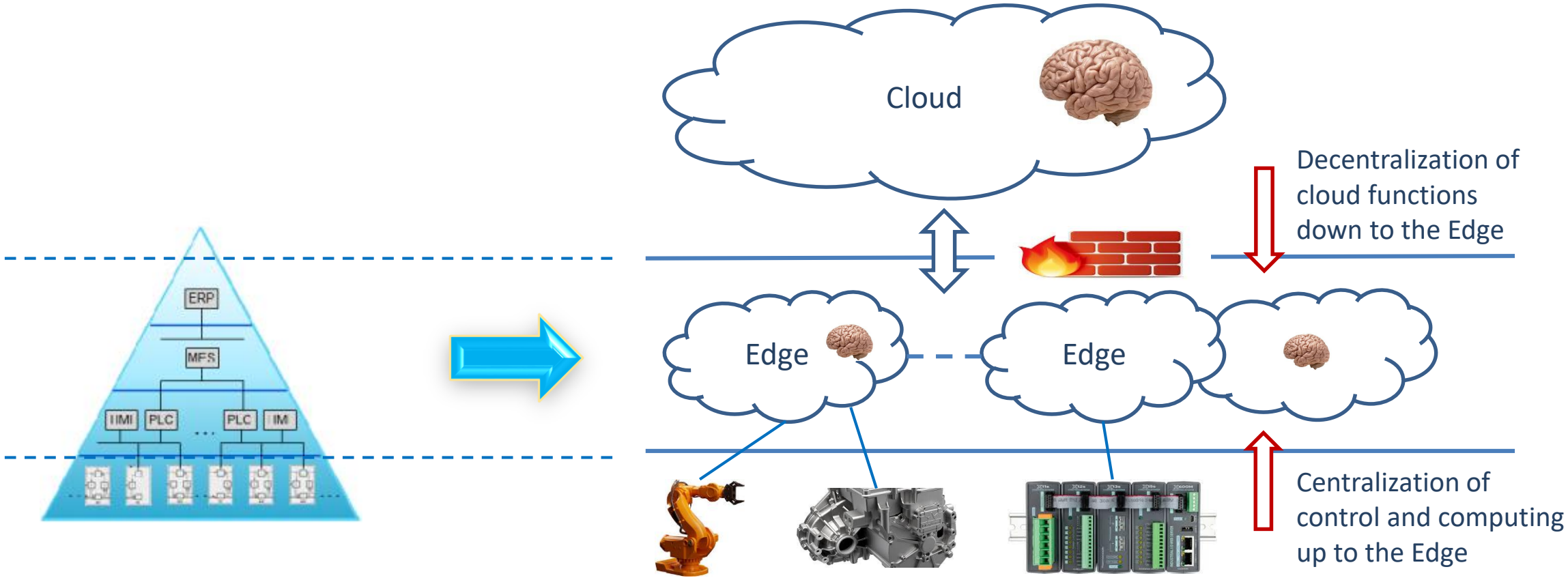
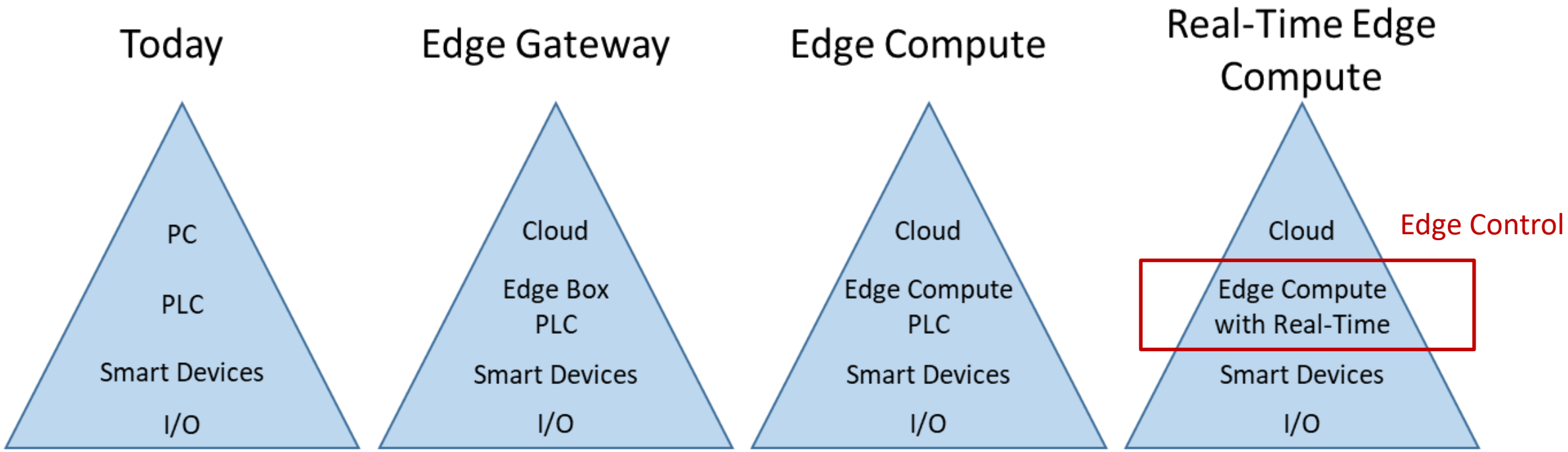
Evolution of Automation Pyramid



Edge Computing Architecture



Classical Pyramid architecture

Edge Box to connect to the cloud

Edge Compute takes over non Real-Time logic from PLC

Edge Compute with Real-Time capabilities

Network Communication Determinism

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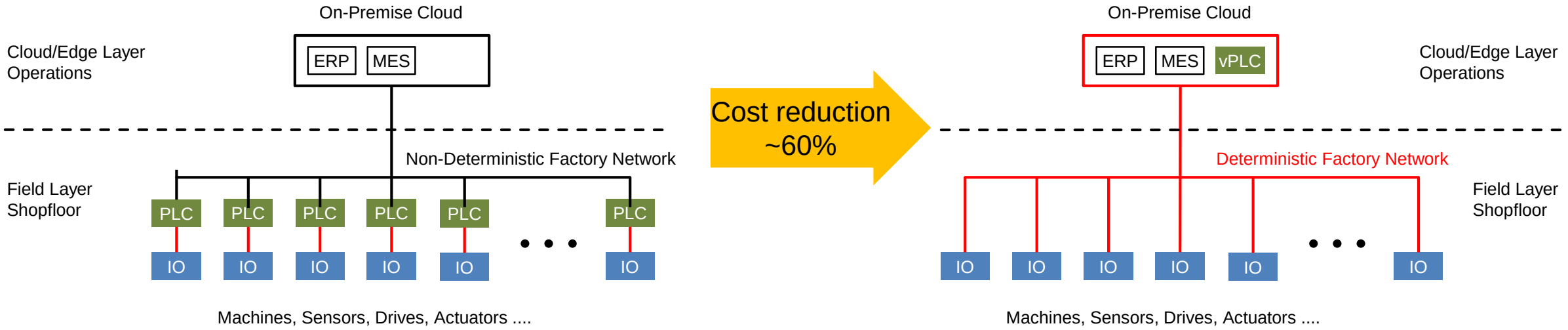
Use Case “Deterministic IP Enabling Intelligent Edge Control”



Benefits for OT Players

- Reduce CAPEX and OPEX
- Increase flexibility: Massive PLC virtualization on edge/cloud infrastructure for flexible, elastic and on-demand automation.
- Eable machine learning and (real-time) big data analysis

Network Requirements

- Transparent to existing Industrial Ethernet communication protocols
- Work seamless with 5G
- Support IT&OT convergence: It can carry control, video, data and other heterogenous traffic in one network
- Support large-scale deterministic communication

Ethernet Based Deterministic Networking Technologies

OSI Layer 3 Technology

Deterministic IP for large-scale Deterministic Network

– Beyond hop-limit, adapt to large scale networking

– Performance: 10μs latency per hop, 20μs jitter E2E

– Being standardized in IETF DetNet workgroup

Suitable for large-scale network

OSI Layer 2 Technology

TSN (Time-Sensitive Networking) and Industrial Ethernet Tech.

– Performance: 1-5μs low latency, <1μs jitter E2E

– Well recognized and accepted among OT players

– Standardized in IEEE 802.1

Good for small-scale network

OSI Layer 1.5 Technology

XE (X-Ethernet)

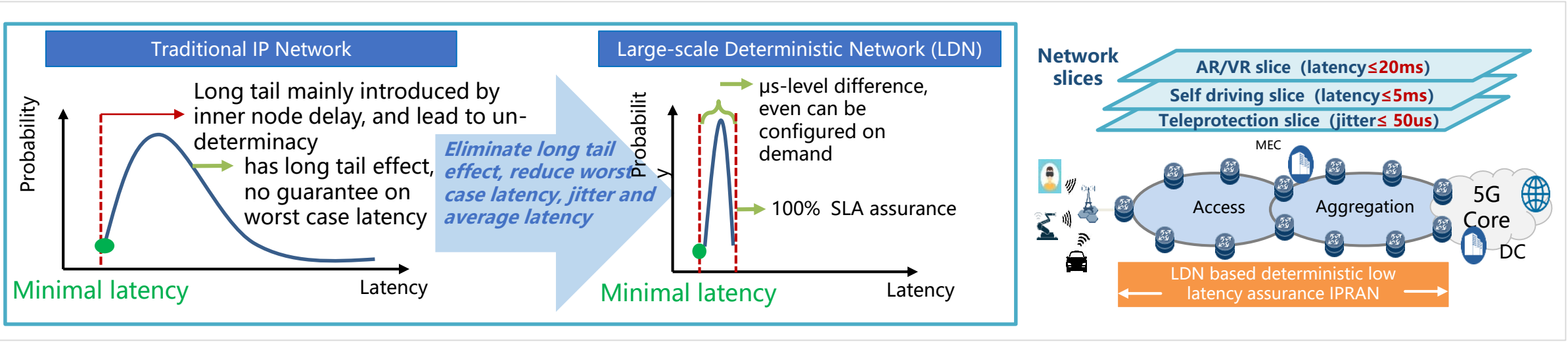
– Work on layer between PHY and MAC, bit-block exchange

– Performance: 1-2μs ultra low latency, 50ns ultra low jitter

– Capable of carrying industrial Ethernet protocols transparently, such as industrial Ethernet implement, PROFINET, EtherCAT, EtherNet/IP

Large-scale Deterministic Networking

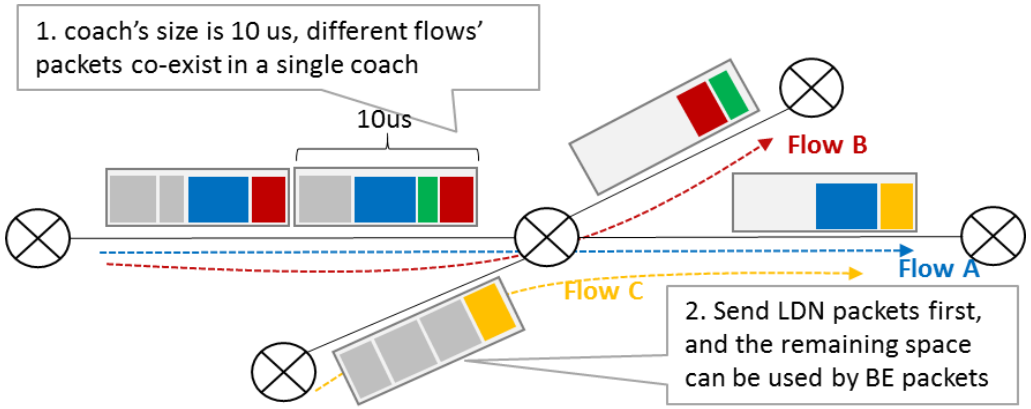
The large-scale deterministic networking focuses on deterministic data paths that operate over Layer 2 bridged and Layer 3 routed segments, where such paths can provide bounds on latency, loss, and packet delay variation (jitter), and high reliability.



It supports massive nodes to achieve deterministic forwarding jitter at microsecond level. It is being standardized in IETF, and compatible with 5G seamlessly.

Technology Details

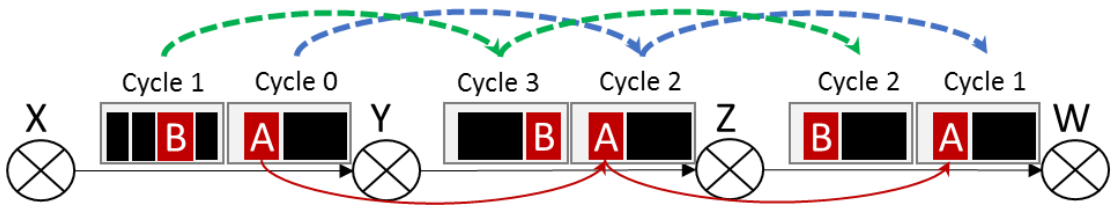
① Dispatcher divides time into same length “coaches”, and send out packets in cyclic coaches



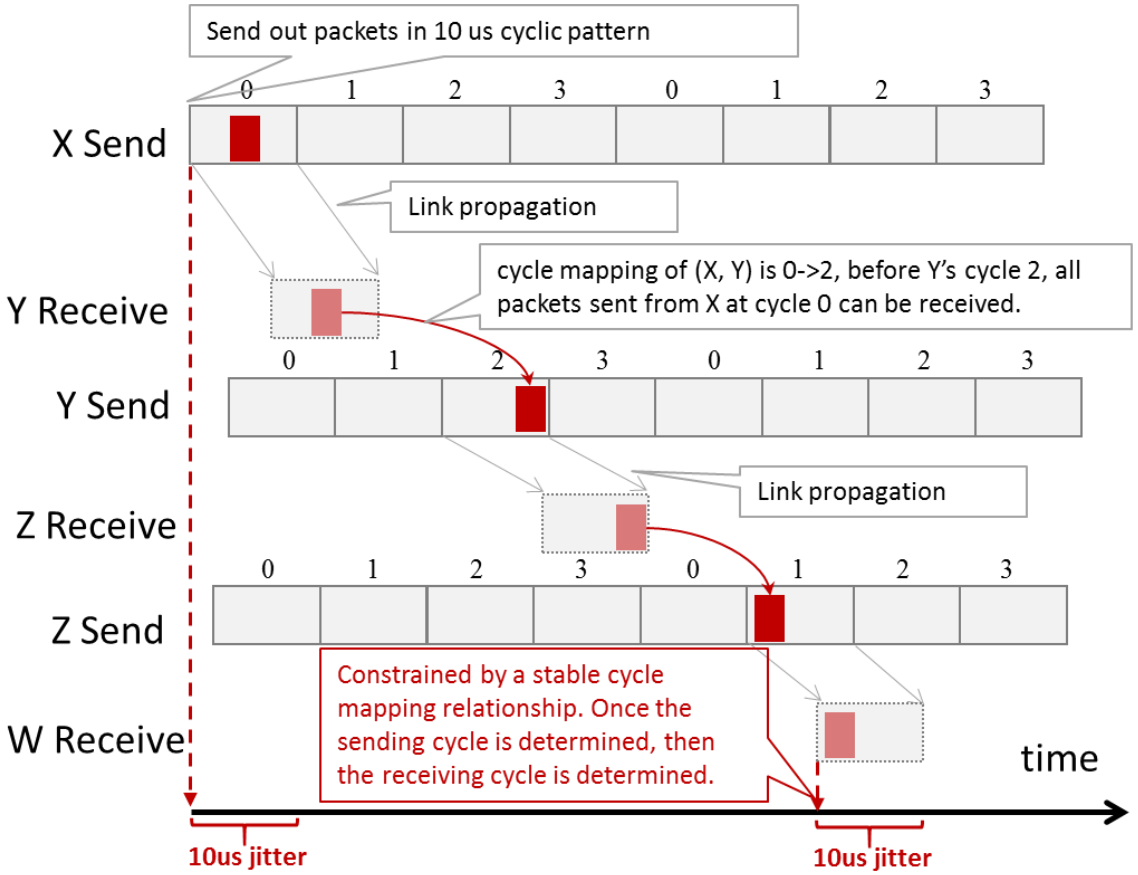
② Each pair of nodes have a stable cycle mapping relationship, which determines packets forwarding time

(X, Y)’s cycle mapping is 0→ 2

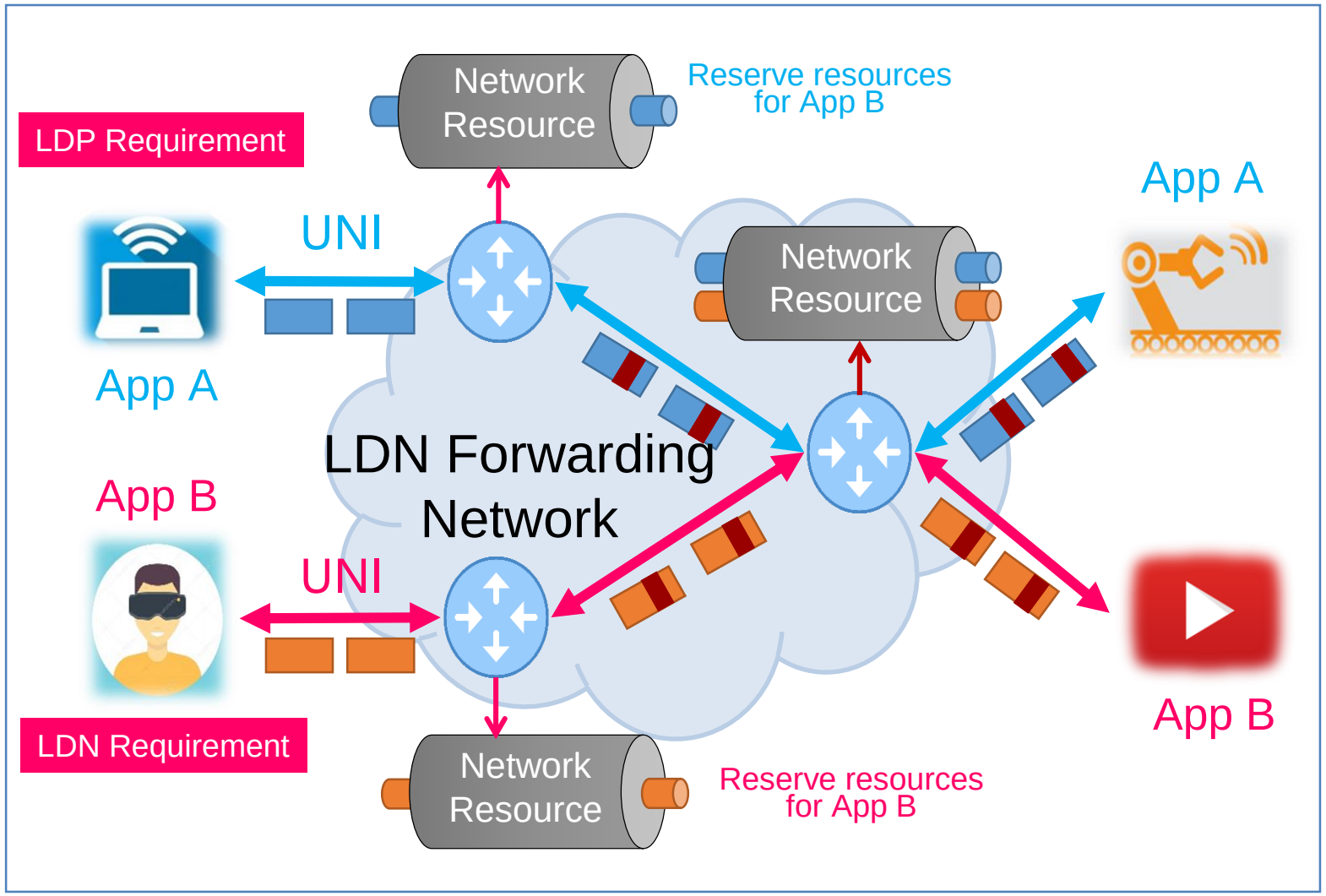
Accordingly, cycle 1’s packets of X will map to cycle 3 of Y



③ Once the sending cycle at X is determined, according to a serials of cycle mapping relationship, then the receiving cycle at W is determined. E2E jitter < variance in sending cycle + variance in receiving cycle = 20 us



Large-scale Deterministic Network Solution Overview



Four Functional Components:

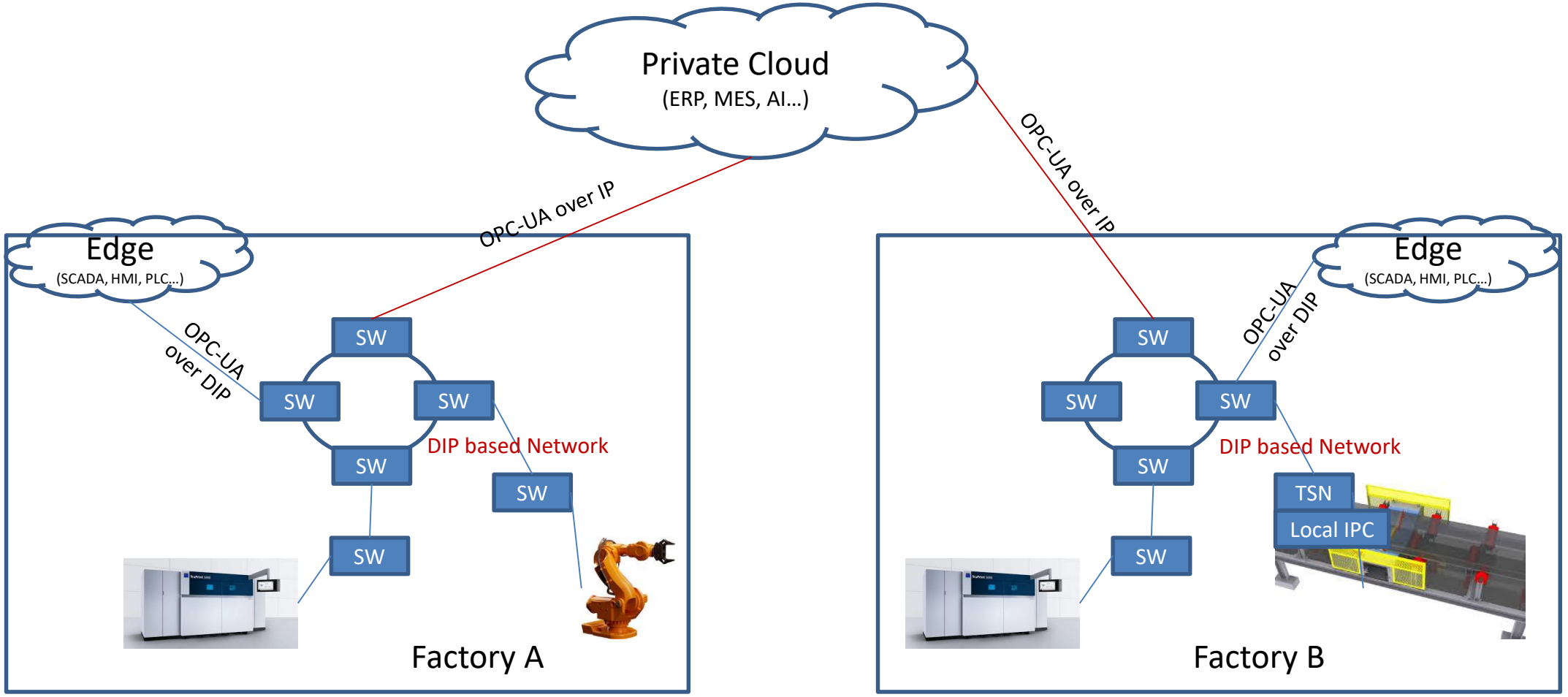
I. UNI-describe users' deterministic service requirements to network

II. Reservation Signaling-reserve resources for deterministic applications

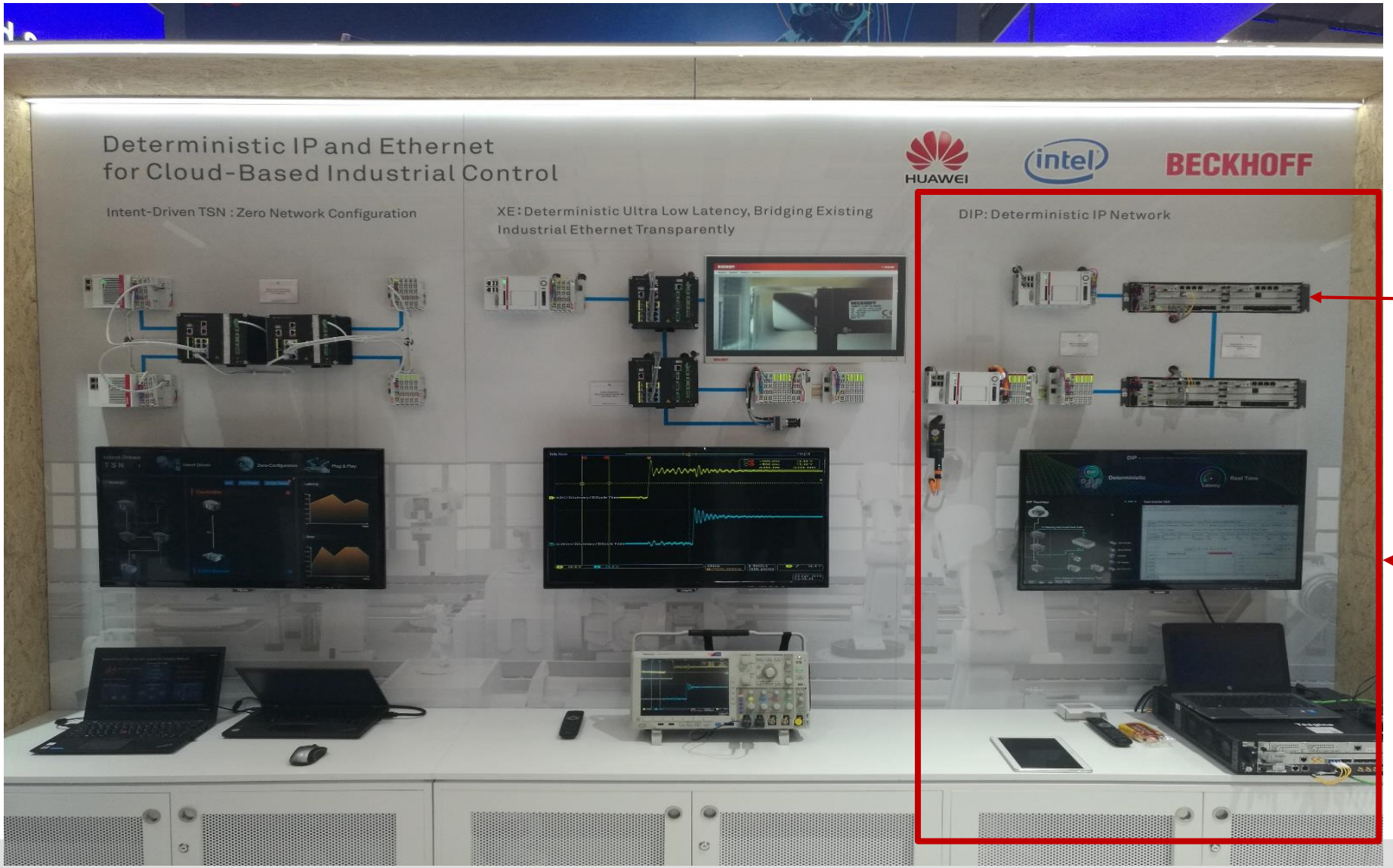
III. LDN Forwarding-provide IP based deterministic service

IV. OAM-a fine-grained visualization OAM toolset provided for user

Smart Factory Vision Enabled by Deterministic IP based Network



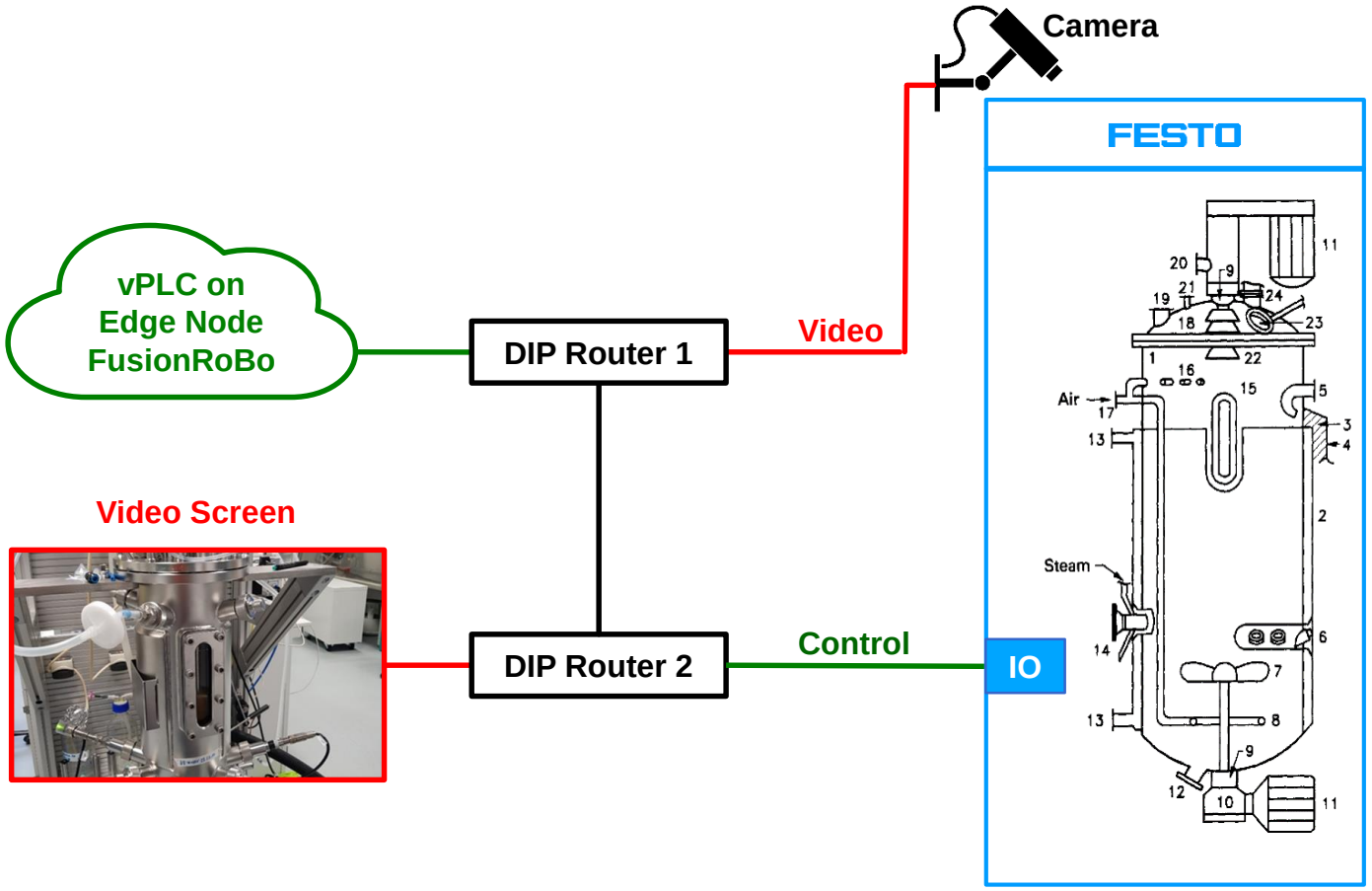
Collaboration with Beckhoff – HMI 2018



DIP Router

Beckhoff IPC controls a servo motor at a cycle time of 2ms over a deterministic IP network (emulated by 2 DIP routers)

Huawei Connect Europe 2019: Joint Demonstration with FESTO



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Any Questions?
Thank You !