LNI 4.0 Approach for Production Lines

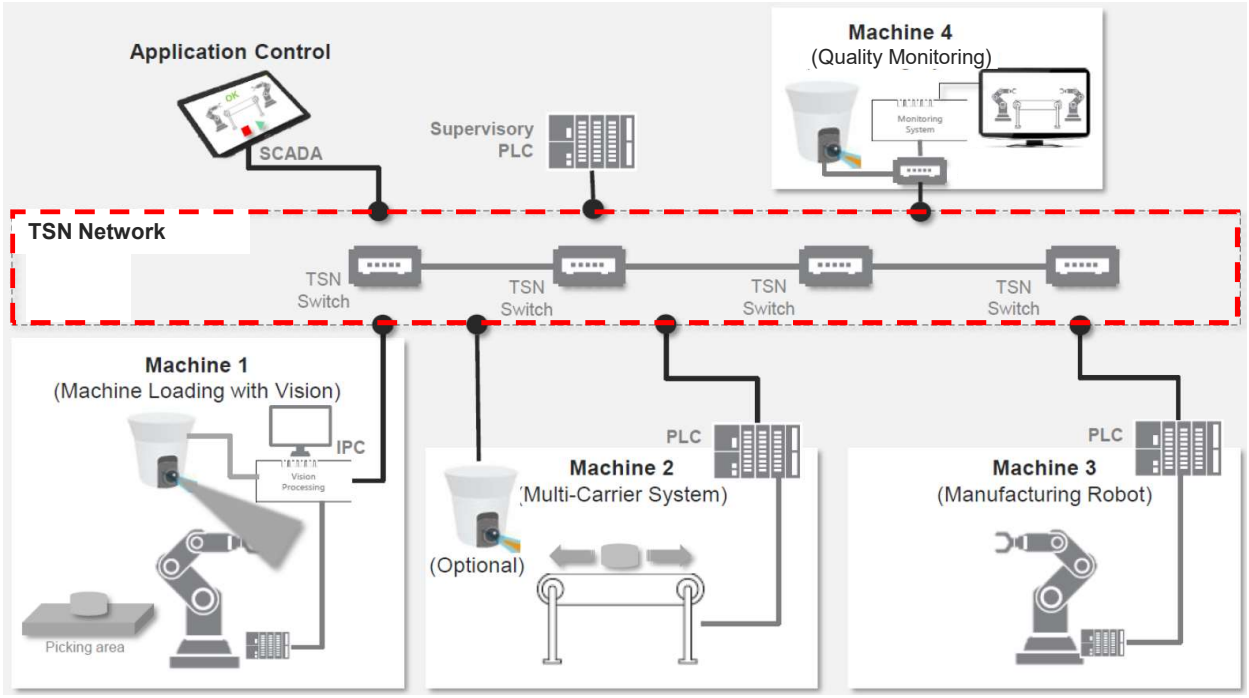
June 2021

Introduction

- This presentation describes the LNI 4.0 approach for production lines which represent a broad market potential
- Our goal is to create understanding for low-expenditure solutions
- The support of the LNI 4.0 approach in the IEC/IEEE 60802 Industrial Profile is important
- Refer also to https://www.ieee802.org/1/files/public/docs2021/60802-Weber-MMinteract-0521-v02.pdf which describes the interactions in a production line from an application's point of view

Production Line with TSN

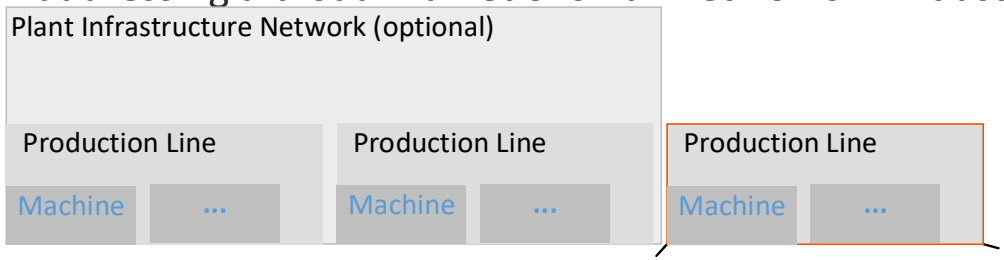
Taken from LNI 4.0 Demonstrator



Pick & Place → Circulation System → Production Step

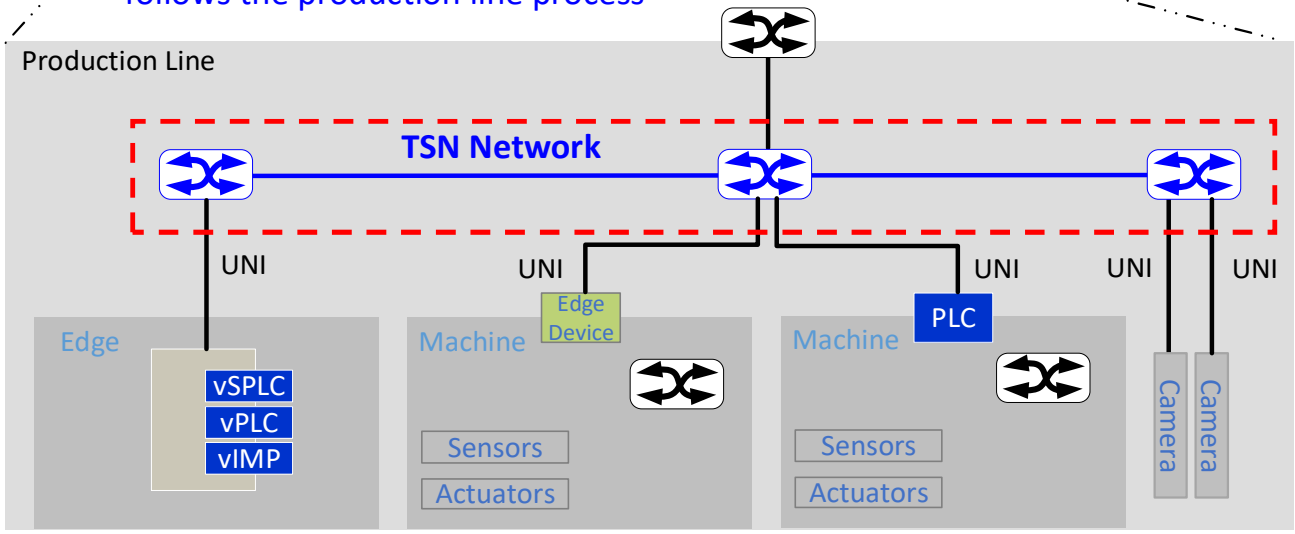
Where to locate Production Lines?

… addressing a broad Market of small networks in Industry



A production line network can operate stand alone or be part of an overall plant infrastructure network

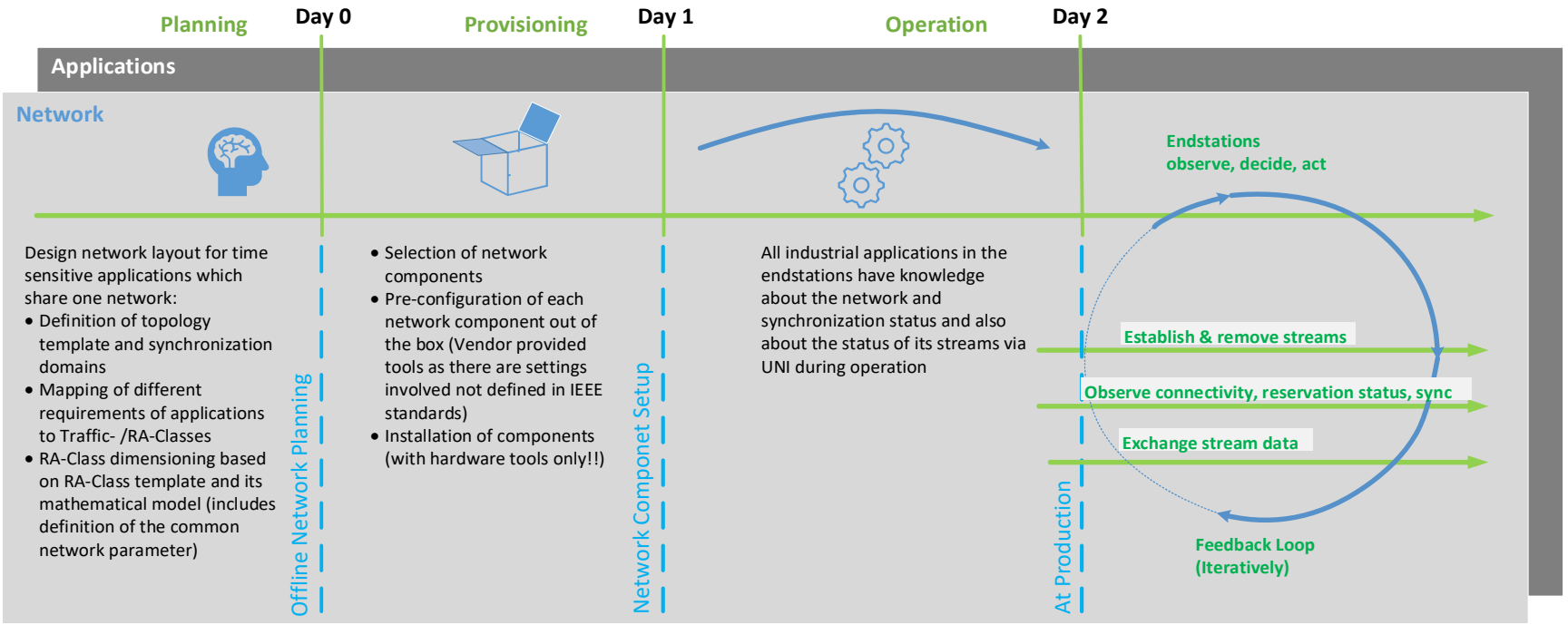
The topology of a production line network follows the production line process



vSPLC: Virtualized Supervisor Programmable Logic Controller
vPLC: Virtualized Programmable Logic Controller
vIMP: Virtualized Image Processing
UNI: User Network Interface based on LRP/RAP

Production Line Network Lifecycle

Focus on system integration in production lines



Design of future Production Lines

General Requirements

As of today:

- OT personal is in charge of production
  -> Avoid extra cost for specialists, e.g. network operator
- Production rate has to be met
  -> Begin design with sequence of actions with time constraints
- Stepwise commissioning of machines to be supported
  -> Start with partial network in operation
- Downtime has to be minimized to increase Overall Equipment Effectiveness
  -> Limit the effects of failures, avoid dependencies to components not needed in production
  -> Minimize dependencies between connected machines

New:

- Multiple applications have to be supported on a single network
  -> Integrate formerly dedicated connections:
  Eliminate discrete cabling, additional interfaces, installation and associated error sources
  -> Make machine data accessible for Smart Manufacturing:
  Avoid to re-program machines to get access to useful data

LNI 4.0 Offerings

Simplifying the Production Line Use Case

- Guidance for time-sensitive applications:
  Each RA-Class template includes a mathematical model for the dimensioning of required bandwidth, per-hop max latency and network resources based on LNI 4.0 topology
- Stepwise commissioning & production line failures:
  Network fragments work autonomously and can join automatically
- Dynamic E2E stream allocation for “plug&produce”:
  Applications can establish or remove streams from the network via UNI inside the designed “guard rails” at runtime
- Exposure of stream diagnostics via UNI:
  Applications can adapt to the actual network status through E2E stream diagnostics
- Leverage existing production line networking technology for real time:
  Streams use any given active network topology even shared with non-real time, no need for traffic engineering.
- No need for topology discovery and explicit path computing:
  In line or ring topologies, loop prevention protocols like RSTP or IEC62439 MRP are sufficient.
- Support for Minimum Viable Solutions:
  Enhancing the existing protocol stack by a single stream reservation protocol used by all time sensitive applications on a converged network is a lightweight approach which meets the application requirements.

LNI 4.0 Outlook

While the first LNI 4.0 approach is a good starting point, further enhancements are visible on the horizon:

- Participate at OPC UA Pub/Sub TSN prototyping with LNI 4.0 model
- Further reduce the entry barrier with an “unshaped” strict priority based RA-Class opening up real time support for a wide range of existing hardware
- Contribute LNI 4.0 RA-Class template proposals to IEEE P802.1Qdd RAP as part of our liaison
- Support ring topologies for high availability
- Support integration of centralized/virtualized with decentralized stream reservation
- Leverage coming RAP coordinated shared reservation to aggregate a huge number of small streams for optimizing e.g. supervisory use case
- Introduce edge device with proxy functionality to integrate legacy components or subnetworks for transparent E2E real time connectivity
- Integration of LNI 4.0 in DetNet

Summary: LNI 4.0 Highlights

LNI 4.0 promotes a simple approach for production lines, fostering smooth stepwise collaboration between automation system integrators and machine builders:

- Production line network technologies with its simple topologies are enhanced for real time.
- Automation together with network design can be verified from the start through mathematical modelling.
- All devices from different applications share the same UNI based on LRP/RAP.
- During provisioning or even in case of failures, parts of the production line continue to work self-sufficient.
- During operation, the TSN network operates autonomously providing diagnostics and reservation states to it’s users.

Thank You