

LNI 4.0 Testbed TSN

hosted by BMWi* Mittelstand 4.0 – Kompetenzzentrum Augsburg

Labs Network Industrie 4.0 e.V.
and
BMWi Competence Center 4.0 Augsburg

Mittelstand-
Digital

 **Mittelstand 4.0**
Kompetenzzentrum
Augsburg

 **Fraunhofer**
IGCV

September 2018



*German Federal Ministry for Economic Affairs and Energy

unrestricted



Introduction to LNI 4.0 e.V. and BMW i Competence Center 4.0 Augsburg

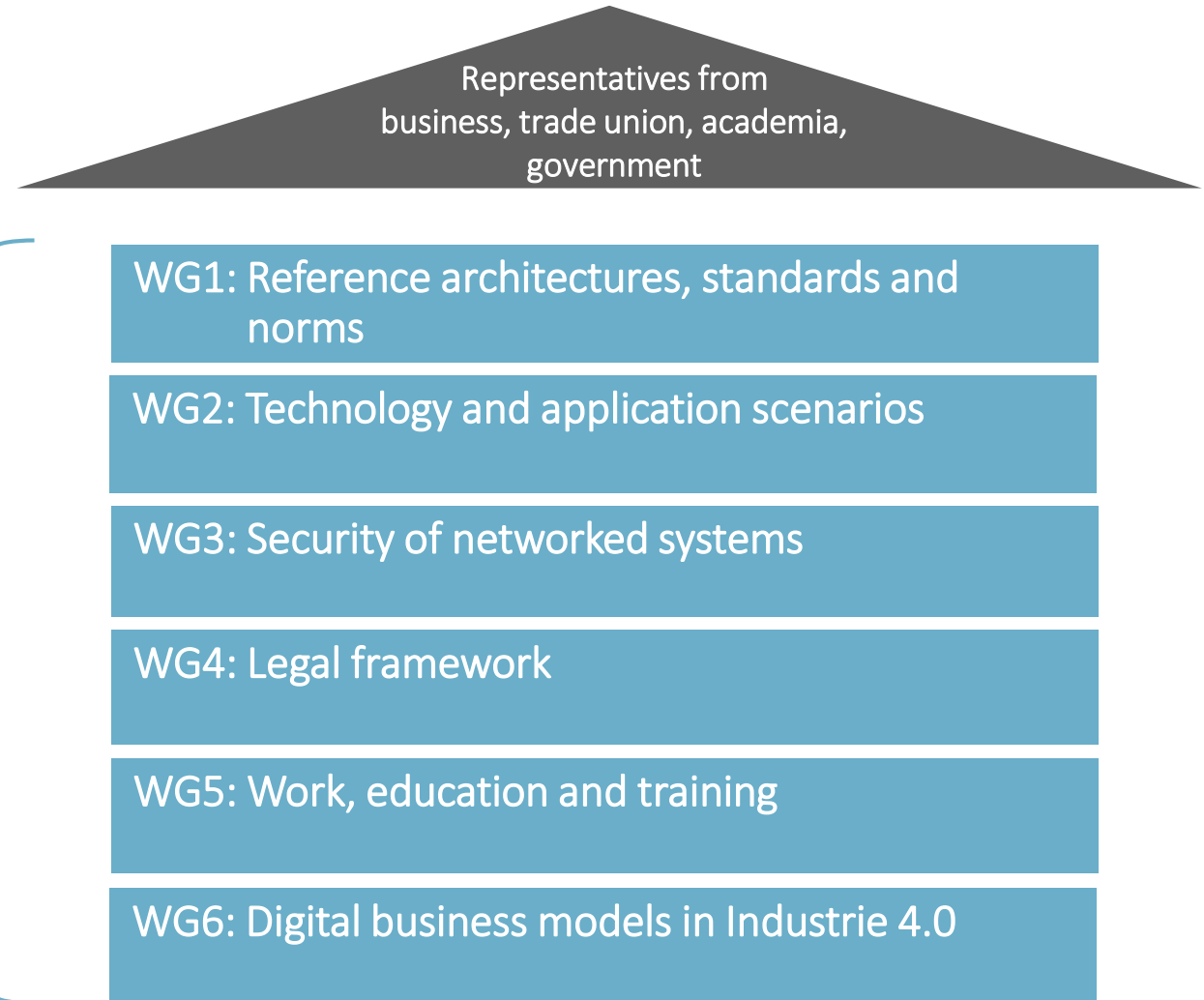
Plattform Industrie 4.0 in Germany



Working groups



- 400 participants
- Relevant stakeholders in Germany
- No legal entity



LNI4.0 founders, Nov. 2015



Dr. Klaus Mittelbach
Treasurer



Thomas Hahn
Chairman



Dr. Christian Schläger
Vice Chairman



Hartmut Rauen



Dr. Hans Jörg Stotz



Prof. Dr. Peter Post



Sven Zehl



Dr. Heinrich Arnold

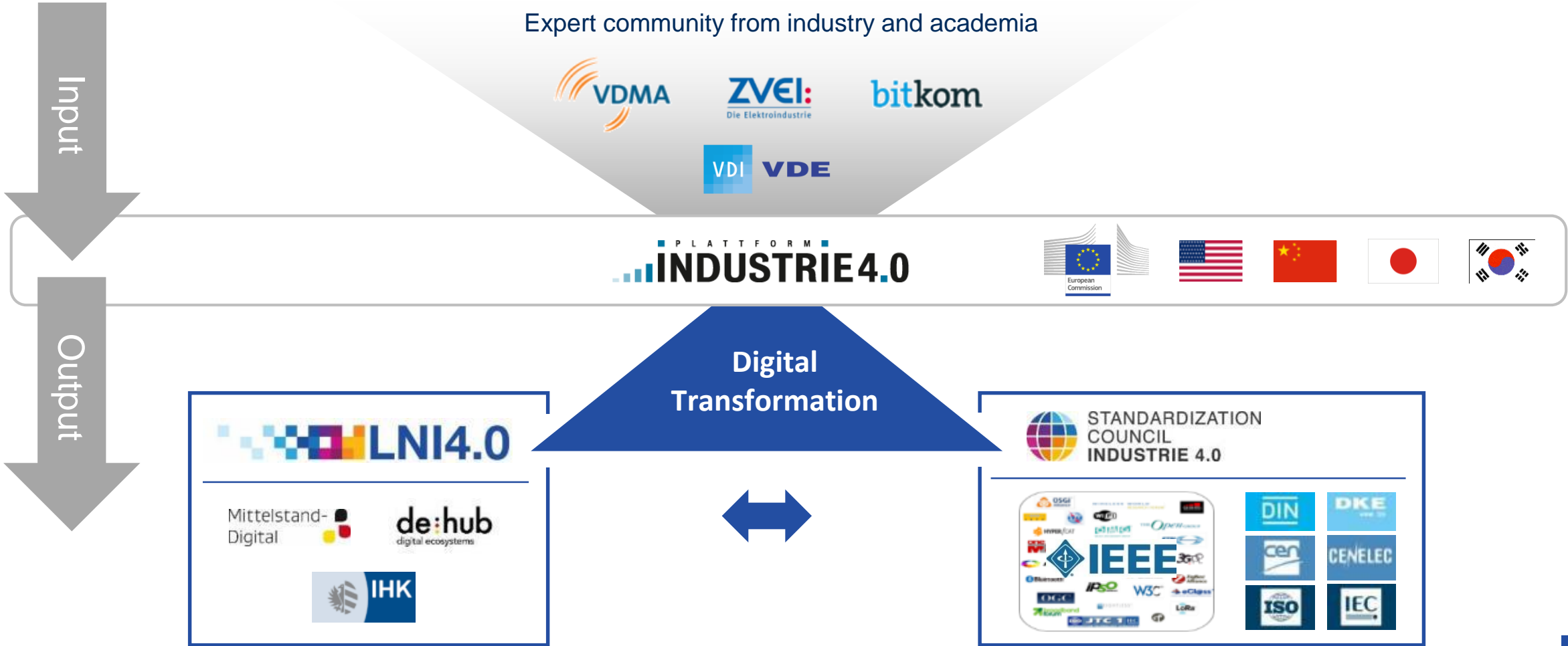
Member providing personal



In cooperation with: PLATTFORM INDUSTRIE4.0



Industrie 4.0 Stakeholders



Testlabs cooperation (>40)



BMWi Kompetenzzentren 4.0

A collection of logos for BMWi Kompetenzzentren 4.0. The logos include: Mittelstand-Digital, HESSEN DIGITAL Kompetenzzentrum für den Mittelstand, Leibniz Universität Hannover, mit uns digital! Das Zentrum für Niedersachsen und Bremen, Technische Universität Braunschweig, Fraunhofer IGV, Fraunhofer IPA, Fraunhofer AISEC, Fraunhofer ESK, Digital in NRW DAS KOMPETENZZENTRUM FÜR DEN MITTELSTAND, FIR InnovationLabs, OTTO VON GUERICKE UNIVERSITÄT MAGDEBURG, smartFactory^{KL}, DEMOFABRIK AACHEN, Fraunhofer ESK, Fraunhofer AISEC, and CIP.

DIGITAL HUBS

A collection of logos for Digital Hubs. The logos include: unternehmertum TUM and de:hub digital ecosystems.

INDUSTRIE 4.0 TESTLABS

A collection of logos for Industrie 4.0 Testlabs. The logos include: FH MÜNSTER University of Applied Sciences, SAP Co-Innovation Lab, VIRTUAL DIMENSION CENTER, ARENA2036, WILDAU, IHK, Fraunhofer IGV, Fraunhofer IPA, Fraunhofer AISEC, Fraunhofer ESK, Lufthansa Industry Solutions, CETECOM, DHBW Duale Hochschule Baden-Württemberg Mosbach, SCHMERSAL, FZI, tec.nicum excellence in safety, FAU FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG, Smart Data Innovation Lab, TWENTY54LABS, evosoft, UniTransferKlinik Lübeck, HSD Hochschule Düsseldorf University of Applied Sciences, Universität Potsdam, Smart Electronic Factory, UNIKASSEL VERSITÄT, and Fraunhofer IOSB.

LNI 4.0 Use Case Synergies

ASSET ADMINISTRATION SHELL

VALIDATION OF THE CONCEPT OF INDUSTRIE 4.0 COMPONENTS



- Administration shell for Industrie 4.0 components
- Validated at a flexible transportation system and a virtualized production plant



Industrial Testbed OPC UA over TSN

LNI 4.0 Testbed TSN partners (30, 9 SME) LNI4.0 LABS NETWORK INDUSTRIE 4.0



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Overall LNI 4.0 Testbed TSN Goals

- Industrial testbed based on several SME usecases
- Continuous plug-festival (3rd May, 22nd August, 25th October 2018)
- TSN product development and interoperability validation of each company in protected environment on neutral ground (BMW i Competence Center 4.0 Augsburg)
- TSN testbed creates input and validation for standardization (SCI4.0)  STANDARDIZATION COUNCIL INDUSTRIE 4.0
- Usecases covered: machine to machine communication over OPC UA over TSN
- Cooperation with major testbeds (IIC and Fraunhofer FOKUS)

BMWi Mittelstand 4.0 – Kompetenzzentrum



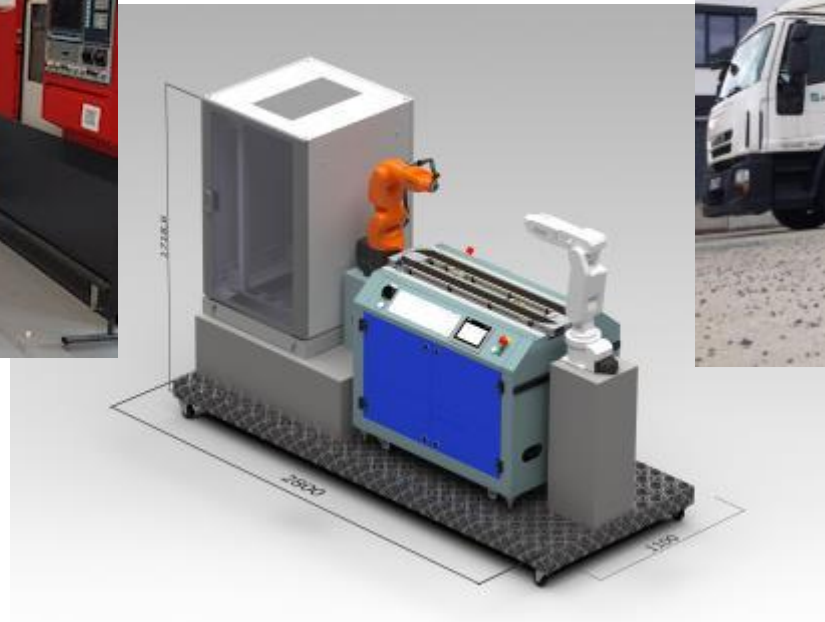
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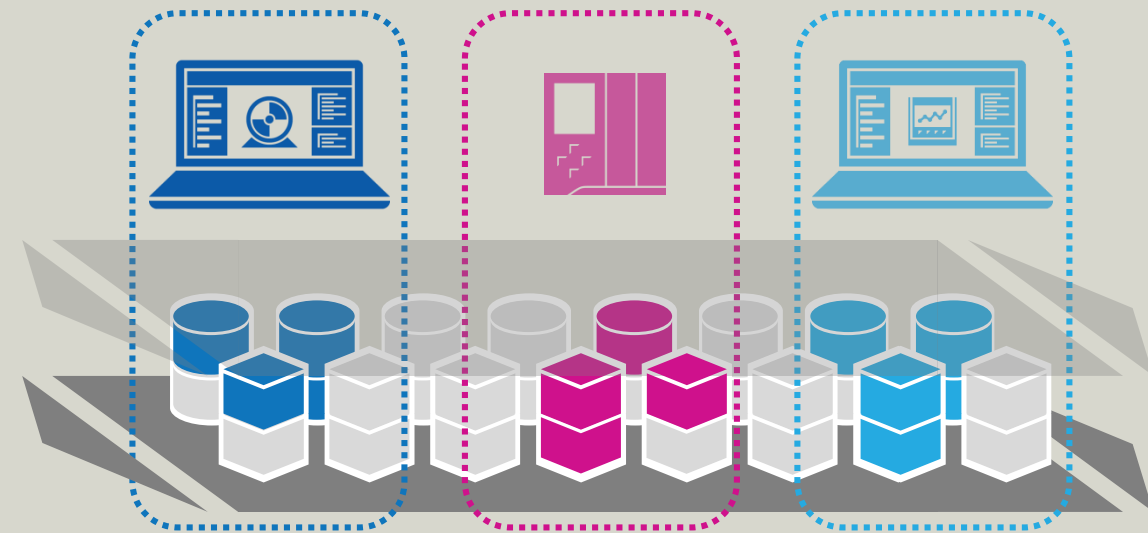
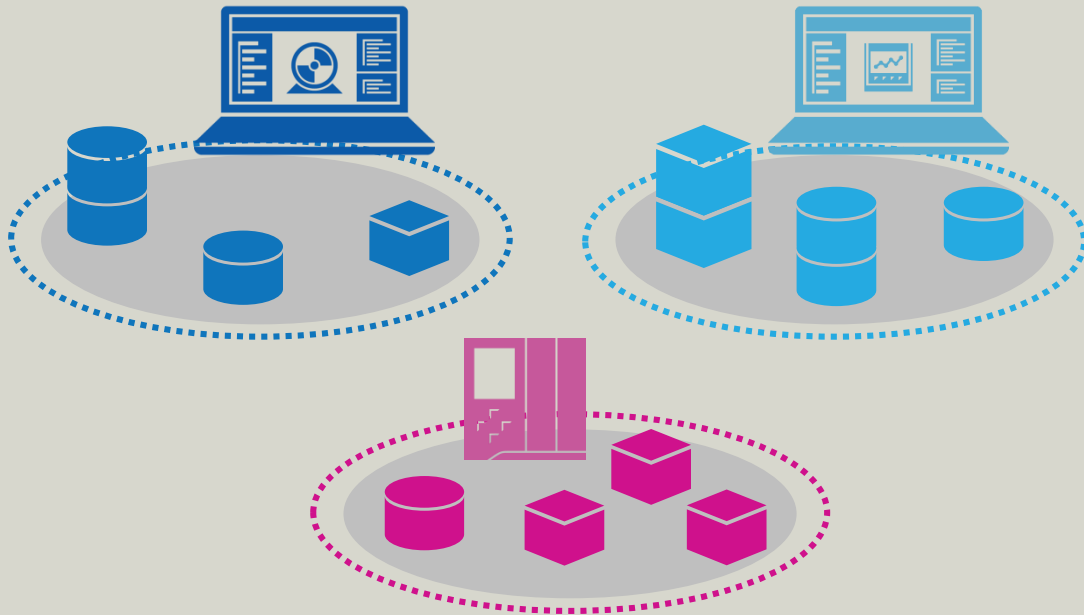
TSN Testbed Organization

- Group 1: Robotics
- Group 2: Controllers
- Group 3: Network, Architecture
- Group 4: Cloud (passive)
- Group 5: SME use case pipeline

Towards a Converged Network Infrastructure ... LABS NETWORK INDUSTRIE 4.0

From physically isolated networks ...

... to logically isolated networks



TSN Configuration Models

System Configuration IEEE 802.1Qcc

LNI Testbed

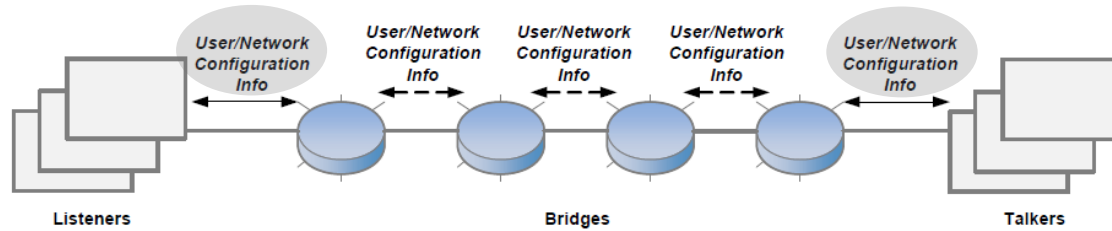


Figure 99-1 — Fully Distributed Model

IIC Testbed

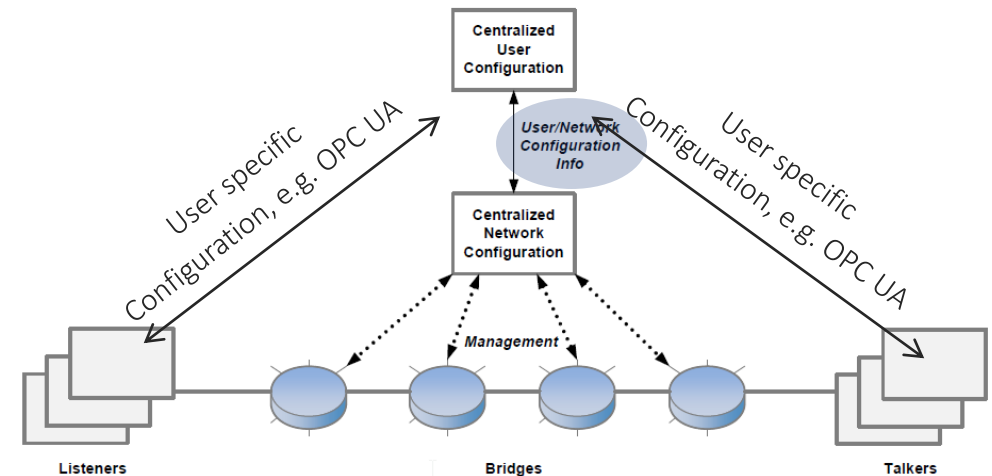


Figure 99-3 — Fully Centralized Model

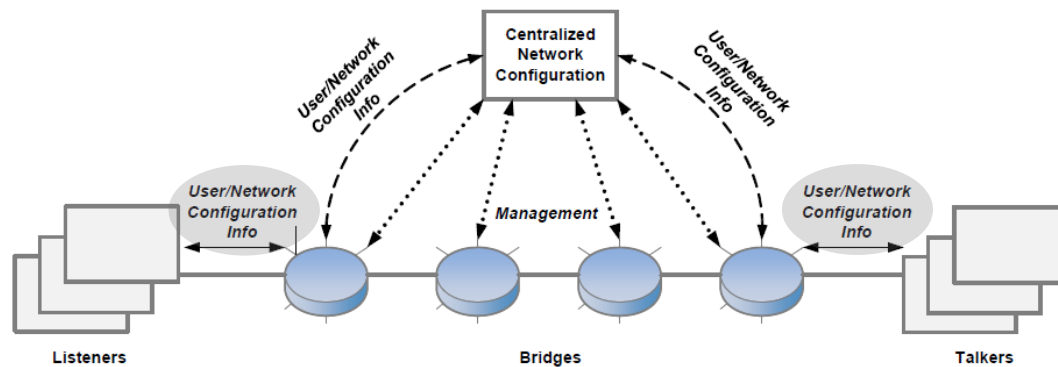


Figure 99-2 — Centralized Network / Distributed User Model

Fully Distributed Model, or
Centralized Network / Distributed User Model :
UNI interface located at network edge to hide internal network.

UNI = User-Network Interface

Fully Centralized Model:
UNI interface located between CUC and CNC

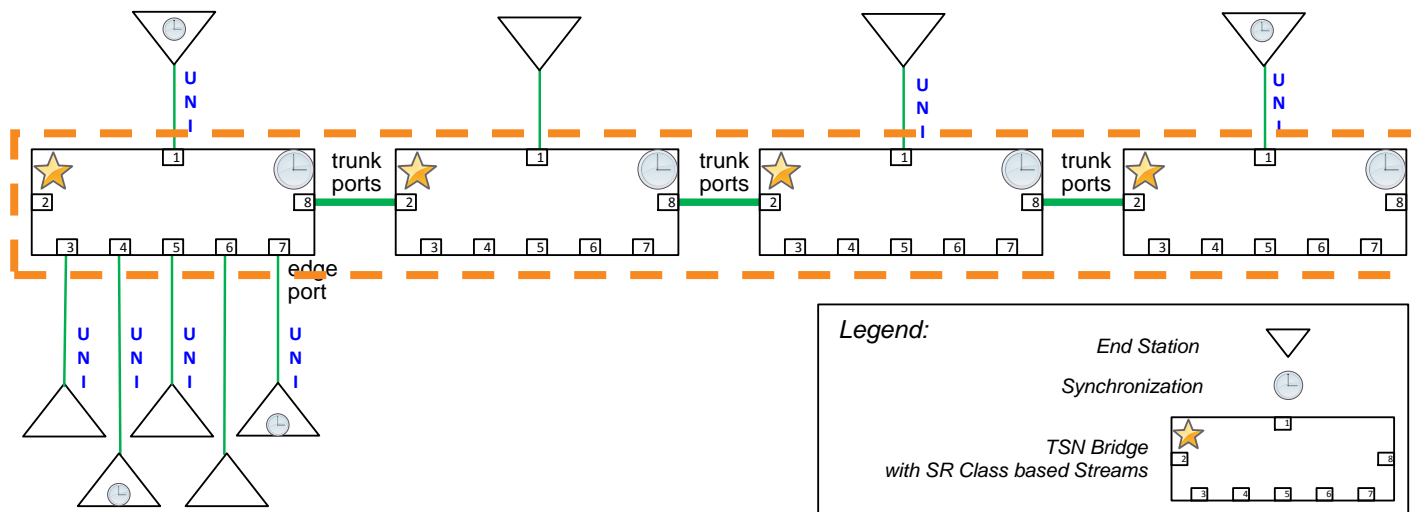
Technology Selection

- Stream Reservation Protocol (SRP)
 - Provides main part of User Network Interface (UNI)
 - Performs stream configuration in distributed configuration model
 - Protects SR Class from overbooking
- Enhancements for scheduled Traffic (Time Aware Scheduler, TAS)
 - Guarantees bounded latency for control data streams
- Precision Time Synchronization
 - Synchronized Gating Cycles IEEE 802.1AS-Rev

Stream reservation and scheduled traffic

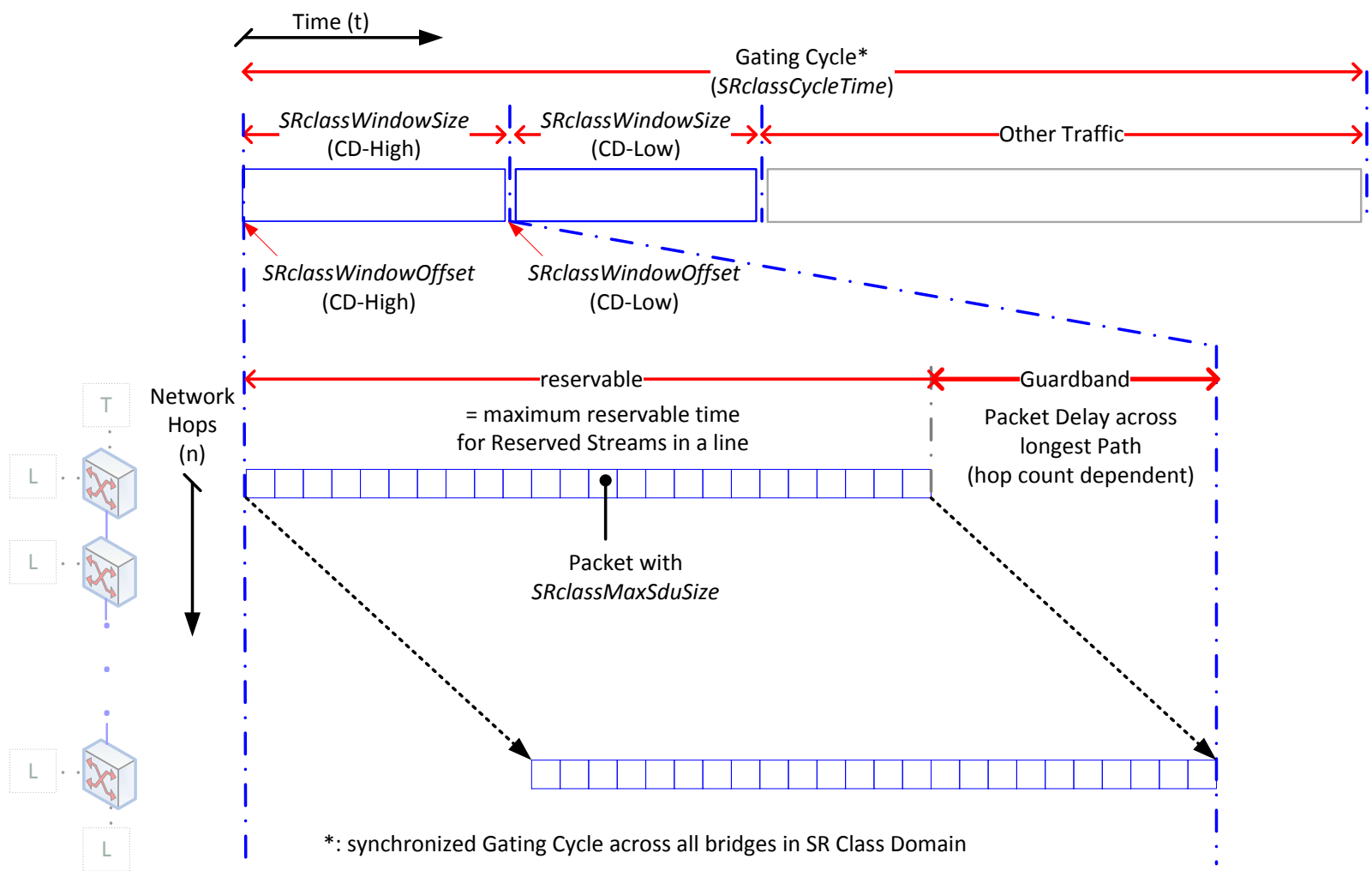
How do they fit together?

- They fit under constraints:
 - Restricted bridge diameter
 - Consider the set of bridges as one virtual bridge from the point of reservation
 - TAS is used to bound the latency for the set of bridges



MSRP++ Domain Model

Enhanced Domain Attribute for SR Class – TAS - Combination



- SRclassDomainAttributeEnhanced:**
- *SRclassID, SRclassVID, SRclassPriority:* SR Class identifier, assigned VLAN identifier and data frame priority (attribute types from MSRP)
 - *SRclassMaxSduSize:* Maximum payload size
 - *SRclassCycleTime:* Interval which is applied for SR class streams
 - *SRclassWindowOffset:* Offset within the SRclassCycleTime interval which is applied as start offset for SR class streams
 - *SRclassWindowSize:* Size of the window which is applied for SR class stream packets
 - *SRclassMaxLatency:* Maximum end-to-end latency for SR Class stream packets
 - *SRclassTransmissionMode:* Transmission selection algorithm for the SR class
 - Periodical unsynchronized
 - Time coordinated synchronized
 - *SRclassReservationMode:* Bandwidth reservation method for the SR Class (MSRP++ method)
- Within an SR Class domain, the domain attribute values between peers must be identical.

Conclusion LNI 4.0 Testbed TSN

- Industrial Testbed driven by Industrie 4.0 SME usecases
- TSN network convergence in focus (protocols, configuration)
- Plug&Work @ TSN (dynamic use cases enabled)
- SME can access testbed without obstacles (member fees,...)
- Direct access to SCI 4.0 and associations (VDMA, ZVEI, BITKOM,...)
- Synergy effects with already ongoing LNI4.0 usecases
- Liaison with IEEE 802.1 and OPC Foundation is planned
- Link to fieldbus organizations implicitly given by partners



Thank you!

