

# Architectural Design of a TSN to SDN Gateway in the Context of Industry 4.0

17.05.18 – 23. ITG Fachtagung Mobilkommunikation

Martin Böhm, Jannis Ohms, Olaf Gebauer and Diederich Wermser

Funded by:

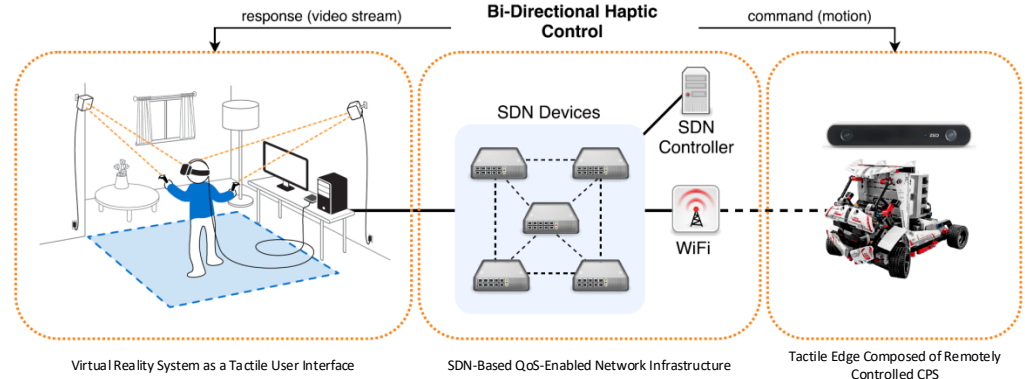
- SecuRIn (Security Referenzmodell Industrie 4.0, Nds. MWK, FKZ: VWZN3224)
- MONAT (Modellbasierte und bedarfsgerechte Netzwerkkonfiguration für Netzwerke der Automatisierung und Telekommunikation, BMBF, FKZ: 16KIS0782)
- INAASCA (Integrated Network as a Service Solution as Part of Cloud IT Application Portfolio, BMWi, FKZ: ZF4113601HB5)

# Agenda

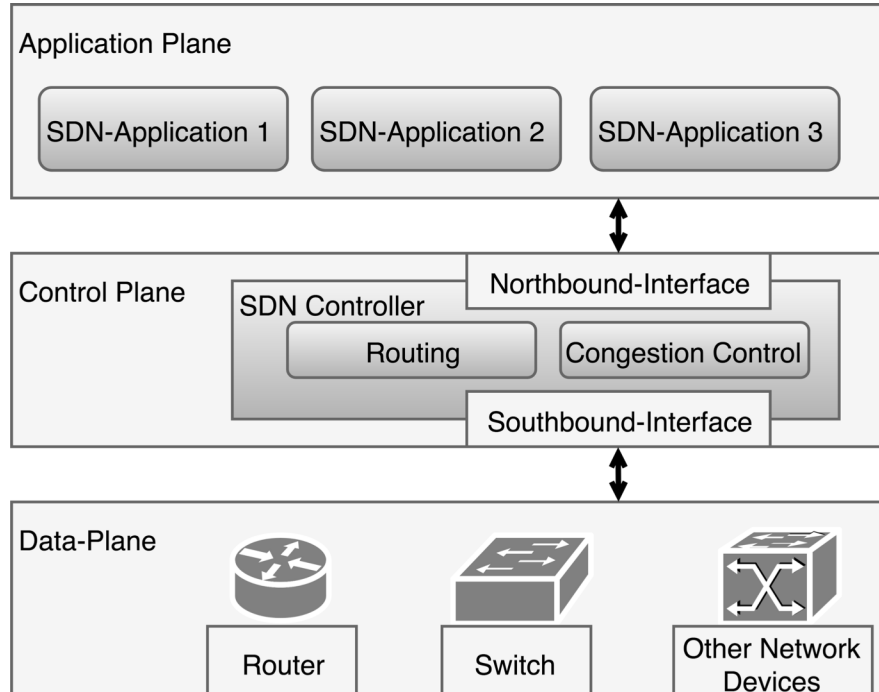
1. Introduction
2. Software-Defined Networking
3. Time-Sensitive Networking
4. Industry 4.0
5. TSN/SDN Gateway
6. Conclusion/Future Work

# Introduction

- Internet-of-Things (IoT)
- Industrial Internet-of-Things (IIoT)
  
- Powerful Networks
- Demand Driven Communication
  - Quality of Service (QoS)
  - Multipath
- Real-time Communication
  - Ensure max Transfer Time, Jitter, ...

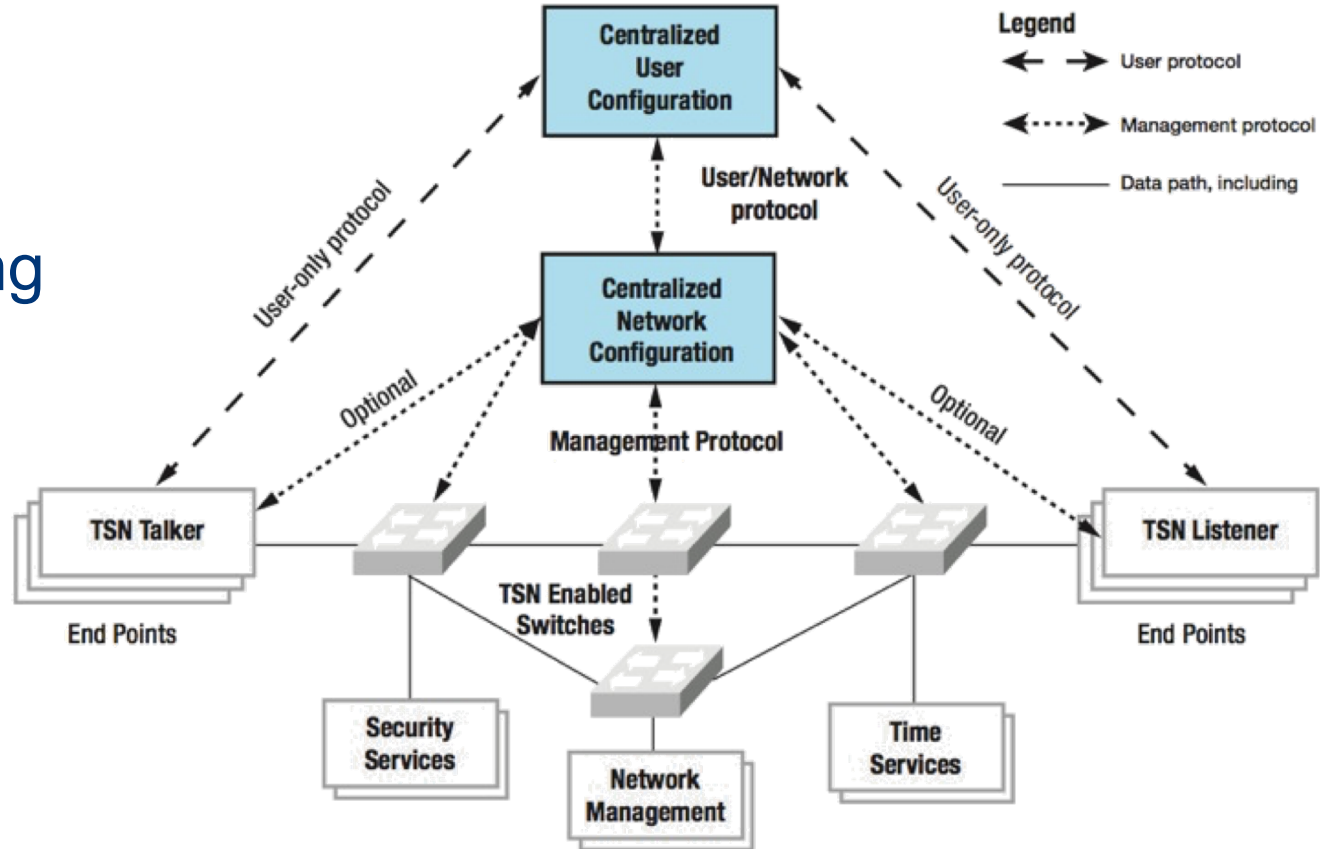


# Software-Defined Networking



# Time-Sensitive Networking

## Roles in the TSN System



# Current Status of TSN Standards

Standard	Title	Status	Last Update
802.1AS-Rev	Timing and Synchronization for Time-Sensitive Applications	Draft 6.0	13. Mar. 2018
802.1Qbu	Frame Preemption	Final	30. Aug. 2016
802.1Qbv	Enhancements for Scheduled Traffic	Final	18. Mar. 2016
802.1Qca	Path Control and Reservation	Final	11. Mar. 2016
802.1CB	Frame Replication and Elimination for Reliability	Final	27. Oct. 2017
802.1Qcc	Stream Reservation Protocol (SRP) Enhancements and Performance Improvements	Draft 2.1	15. Feb. 2018
802.1Qch	Cyclic Queuing and Forwarding	Final	28. Jun. 2017
802.1Qci	Per-Stream Filtering and Policing	Final	28. Aug. 2017
802.1CM	Time-Sensitive Networking for Fronthaul	Draft 2.0	19. Jan. 2018
802.1Qcr	Asynchronous Traffic Shaping	Draft 0.3	26. Jan. 2018
802.1Qcp	Bridges and Bridged Networks Amendment: YANG Data Model	Draft 2.1	06. Mar. 2018
802.1Qcj	Automatic Attachment to Provider Backbone Bridging (PBB) services	Draft 0.1	07. Mar. 2016
802.1Qcw	YANG Data Models for Scheduled Traffic, Frame Preemption, and Per-Stream Filtering and Policing	Draft 0.0	15. Dec. 2017
802.1Qcx	YANG Data Model for Connectivity Fault Management	Draft 0.2	09. Mar. 2018

# Current Status of TSN Standards

<b>Standard</b>	<b>Title</b>	<b>Status</b>	<b>Last Update</b>
802.1AS-Rev	Timing and Synchronization for Time-Sensitive Applications	Draft 6.0	13. Mar. 2018
802.1Qbu	Frame Preemption	Final	30. Aug. 2016
802.1Qbv	Enhancements for Scheduled Traffic	Final	18. Mar. 2016
802.1Qca	Path Control and Reservation	Final	11. Mar. 2016
802.1CB	Frame Replication and Elimination for Reliability	Final	27. Oct. 2017
802.1Qcc	Stream Reservation Protocol (SRP) Enhancements and Performance Improvements	Draft 2.1	15. Feb. 2018
802.1Qch	Cyclic Queuing and Forwarding	Final	28. Jun. 2017
802.1Qci	Per-Stream Filtering and Policing	Final	28. Aug. 2017
802.1CM	Time-Sensitive Networking for Fronthaul	Draft 2.0	19. Jan. 2018
802.1Qcr	Asynchronous Traffic Shaping	Draft 0.3	26. Jan. 2018
802.1Qcp	Bridges and Bridged Networks Amendment: YANG Data Model	Draft 2.1	06. Mar. 2018
802.1Qcj	Automatic Attachment to Provider Backbone Bridging (PBB) services	Draft 0.1	07. Mar. 2016
802.1Qcw	YANG Data Models for Scheduled Traffic, Frame Preemption, and Per-Stream Filtering and Policing	Draft 0.0	15. Dec. 2017
802.1Qcx	YANG Data Model for Connectivity Fault Management	Draft 0.2	09. Mar. 2018

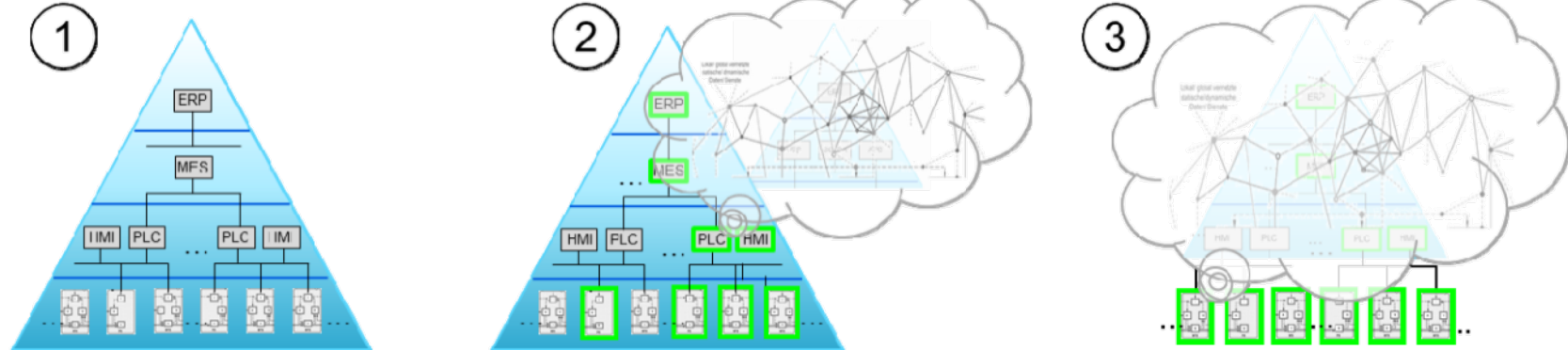
# Current Status of TSN Standards

Standard	Title	Status	Last Update
802.1AS-Rev	Timing and Synchronization for Time-Sensitive Applications	Draft 6.0	13. Mar. 2018
802.1Obu	Frame Preemption	Final	30. Aug. 2016
802.1Qbv	Enhancements for Scheduled Traffic	Final	18. Mar. 2016
802.1Qca	Path Control and Reservation	Final	11. Mar. 2016
802.1CB	Frame Replication and Elimination for Reliability	Final	27. Oct. 2017
802.1Qcc	Stream Reservation Protocol (SRP) Enhancements and Performance Improvements	Draft 2.1	15. Feb. 2018
802.1Qch	Cyclic Queuing and Forwarding	Final	28. Jun. 2017
802.1Qci	Per-Stream Filtering and Policing	Final	28. Aug. 2017
802.1CM	Time-Sensitive Networking for Fronthaul	Draft 2.0	19. Jan. 2018
802.1Qcr	Asynchronous Traffic Shaping	Draft 0.3	26. Jan. 2018
802.1Qcp	Bridges and Bridged Networks Amendment: YANG Data Model	Draft 2.1	06. Mar. 2018
802.1Qcj	Automatic Attachment to Provider Backbone Bridging (PBB) services	Draft 0.1	07. Mar. 2016
802.1Qcw	YANG Data Models for Scheduled Traffic, Frame Preemption, and Per-Stream Filtering and Policing	Draft 0.0	15. Dec. 2017
802.1Qcx	YANG Data Model for Connectivity Fault Management	Draft 0.2	09. Mar. 2018

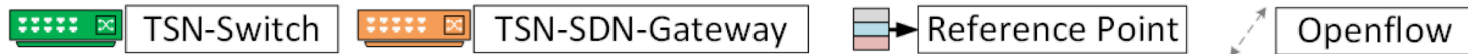
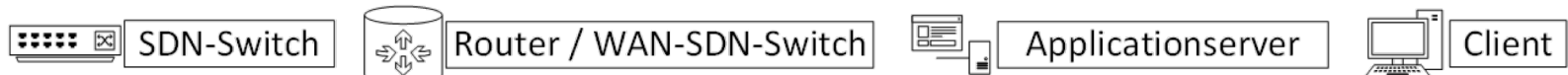
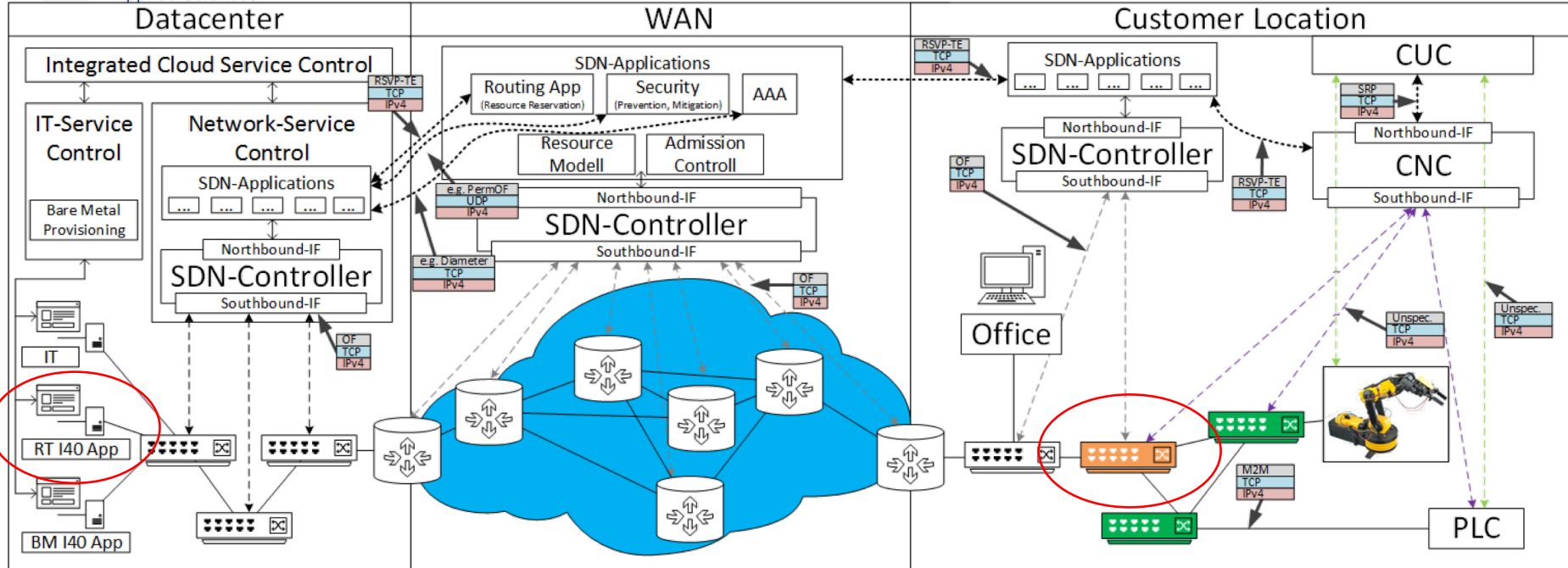


# Industry 4.0

- Connected Cyber-Physical-Systems (CPS)
- Information Available in Real-time
- Analyse Data
  - Improve Performance and Availability
- Move Services to the Cloud



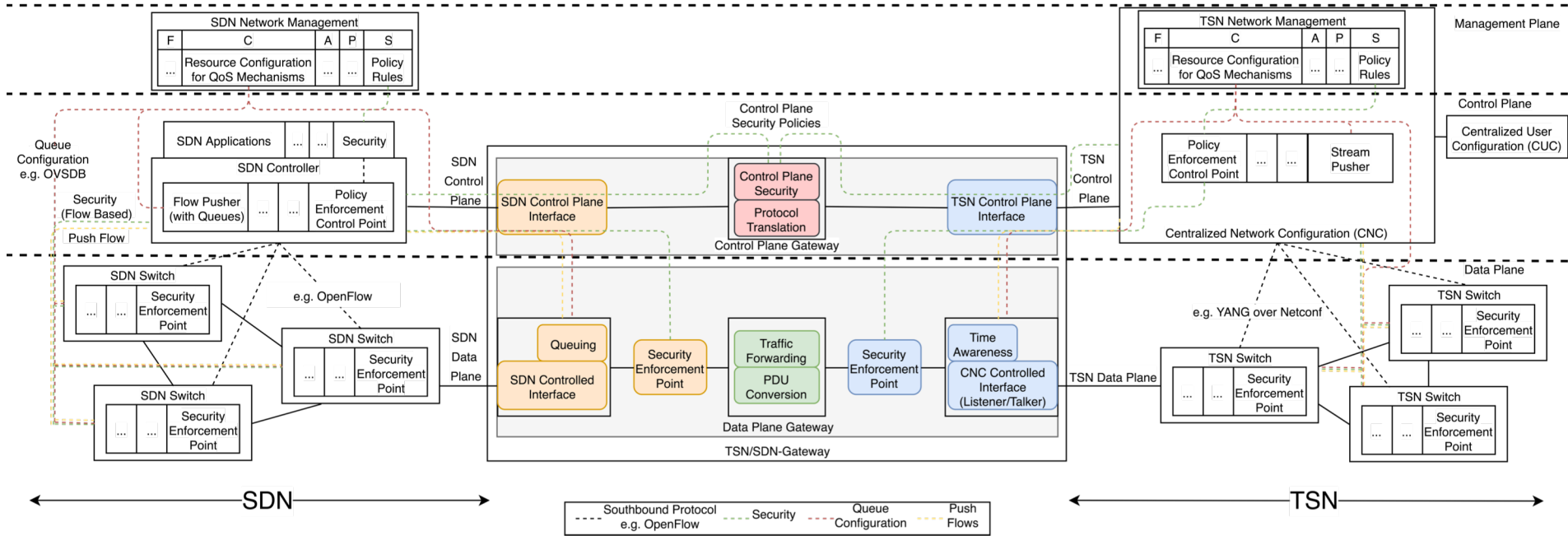
# I40 Anwendungen aus der Cloud



# Need of Connecting both Network Technologies

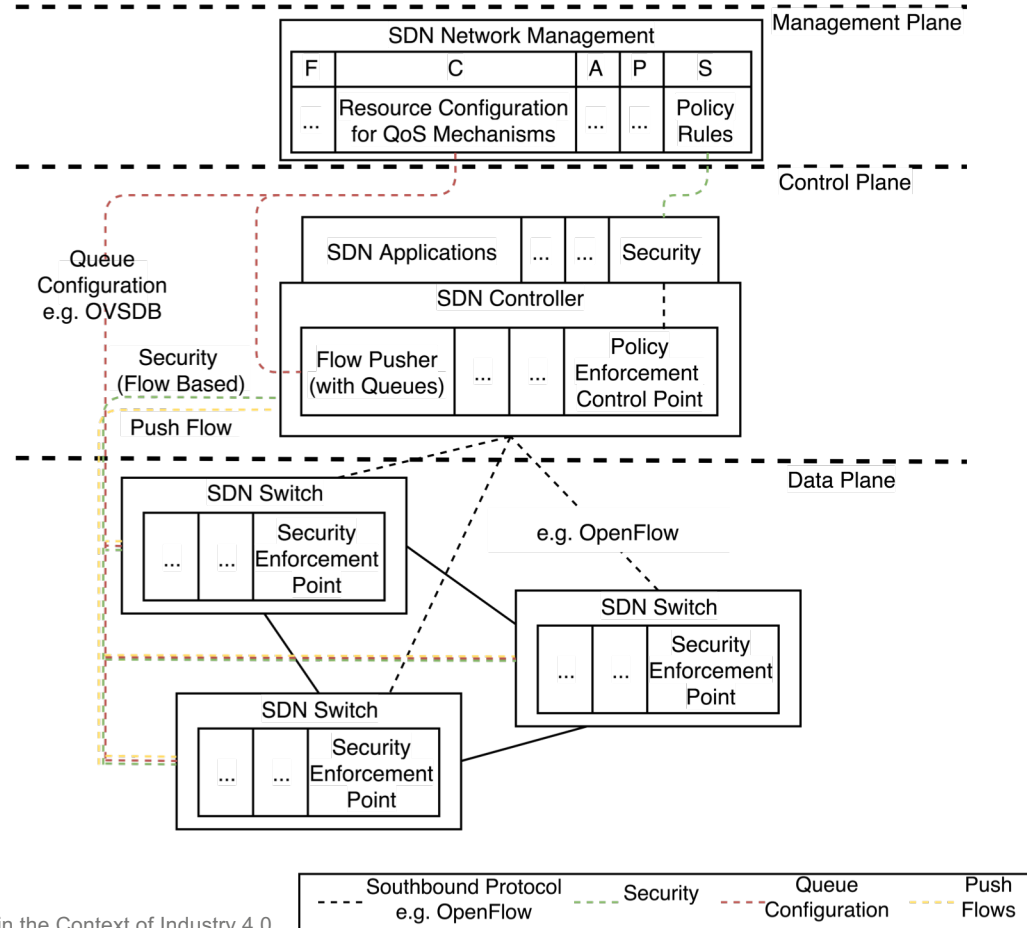
- TSN offers Real-time Capabilities
- SDN offers WAN Capabilities (incl. QoS)
- Both are Software-Defined
  - Dynamical Reconfiguration
- Most Important
  - Security
  - Real-time/QoS

# TSN/SDN Gateway View on Security/QoS



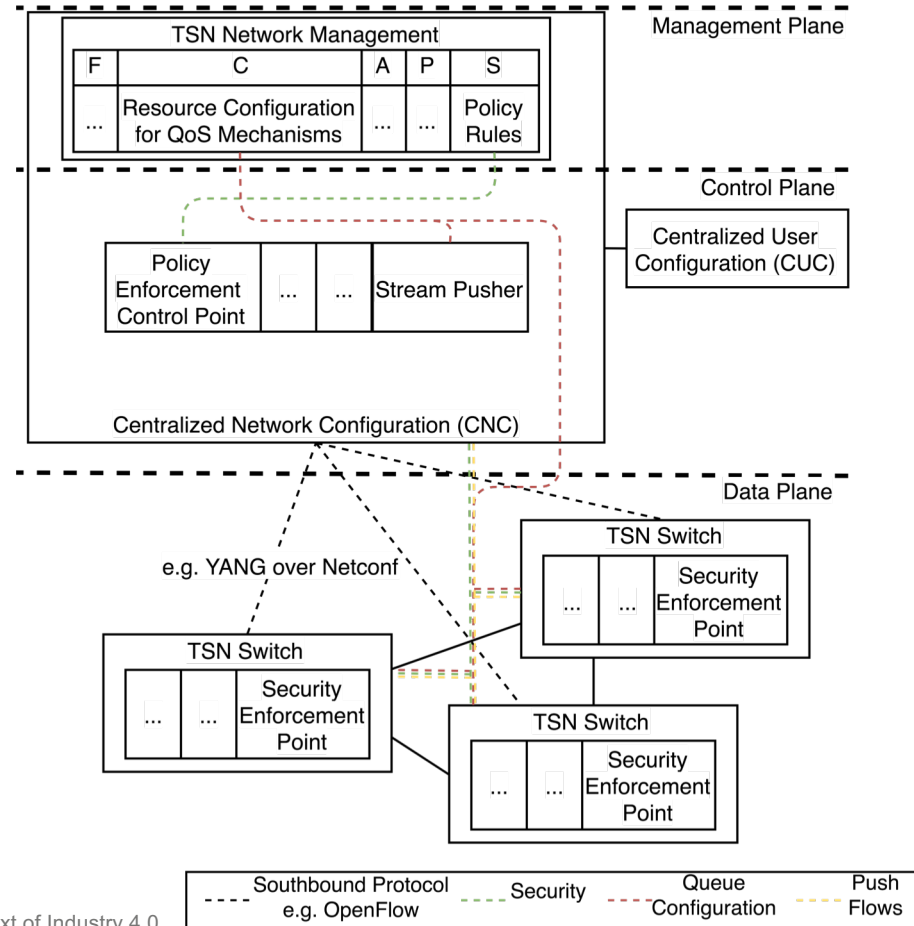
# SDN View on Security/QoS

- Management Plane: FCAPS
  - Fault Management
  - **Configuration Management**
    - Queue Configuration
  - Accounting Management
  - Performance Management
  - **Security Management**
    - Policy Rules



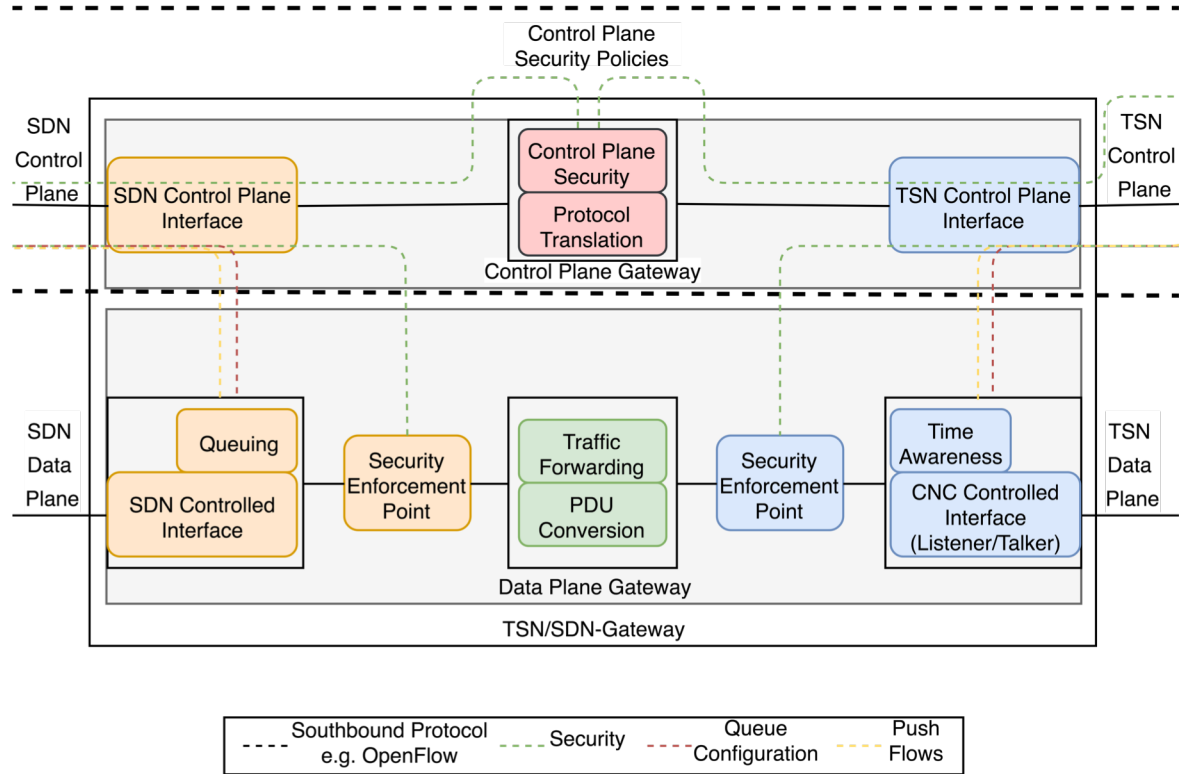
# TSN View on Security/QoS

- Management Plane: FCAPS
  - Fault Management
  - **Configuration Management**
    - Queue Configuration
  - Accounting Management
  - Performance Management
  - **Security Management**
    - Policy Rules



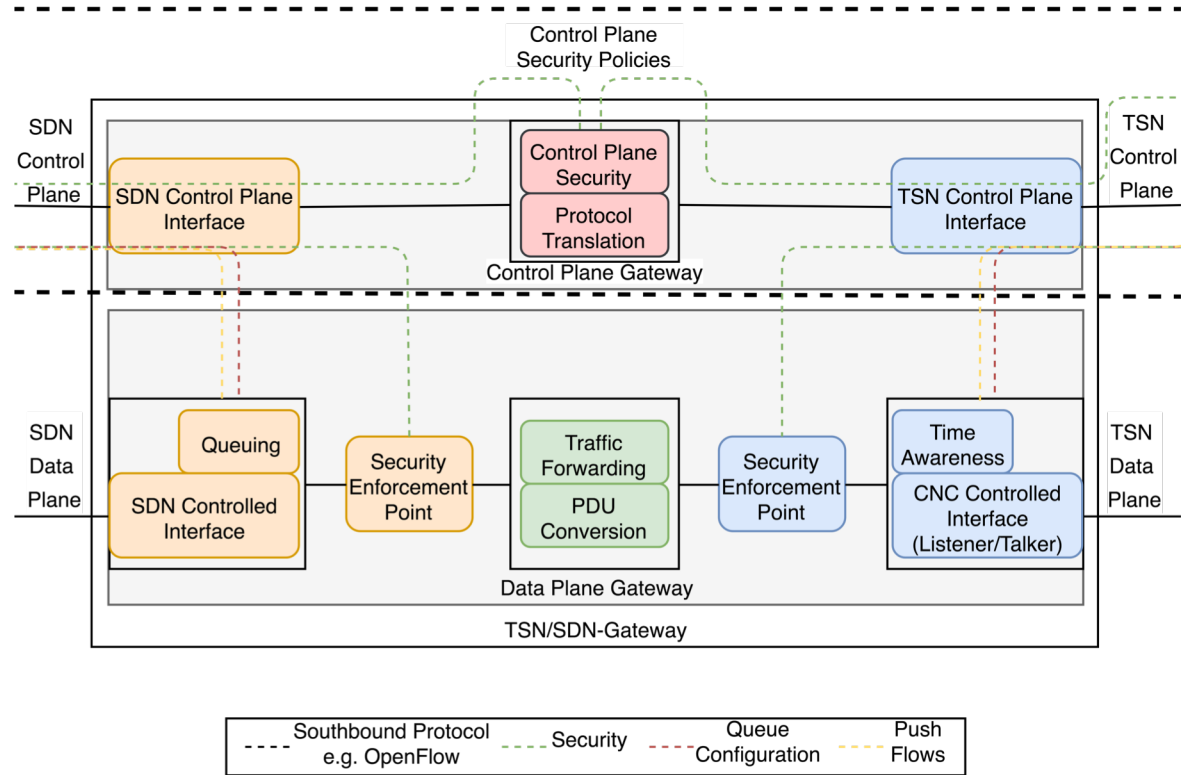
# Gateway – SDN-side

- Control Plane
  - Security Policies from Management
- Data Plane
  - Queues
  - Security Enforcement Point
    - Applies Policies from Management



# Gateway – TSN-side

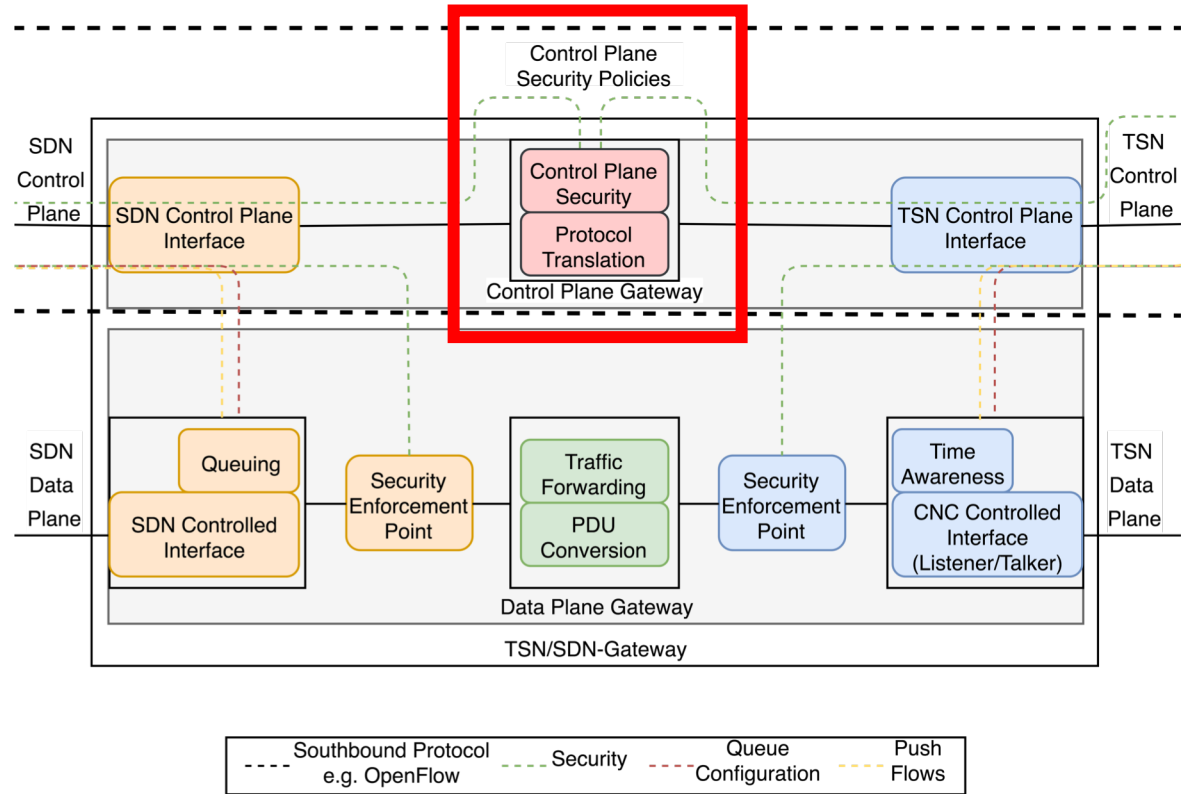
- Control Plane
  - Security Policies from Management
- Data Plane
  - Queues
  - **Time-Awareness**
  - Security Enforcement Point
    - Applies Policies from Management





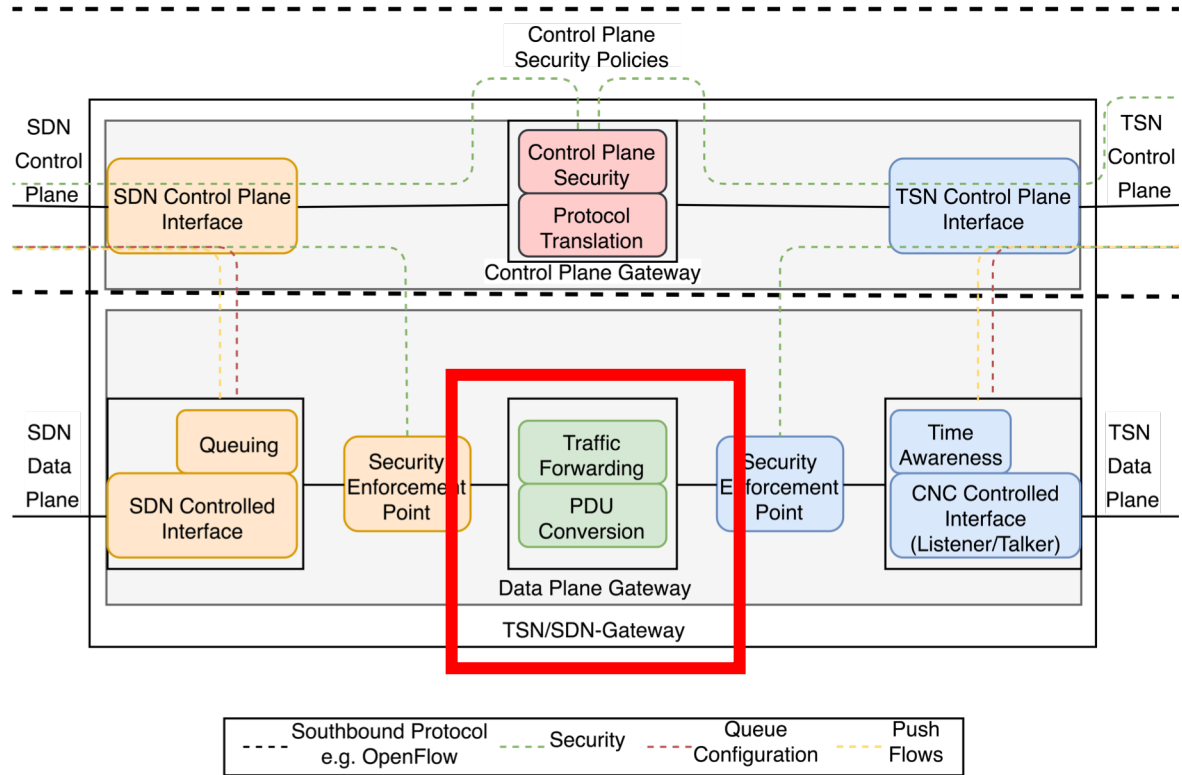
# Gateway – Control-Plane

- Security Rules
- Translates Control Plane Protocols
  - E.g. OpenFlow to Netconf



# Gateway – Data-Plane

- Forward Traffic
- Convert PDU
  - Add/Remove VLAN
- Security Check before and after PDU Conversion



# Conclusion/Future Work

- TSN Specifications are not Finally Finished
  - TSN-side of Gateway needs to be reworked according to progress in TSN architecture standardization
- Elaboration and Validation of the Architecture
  - Sequence Diagrams etc.
- Proof-of-Concept Implementation
- Future Considerations
  - L4 Interactions?
  - M2M Protocol Interactions?