Harmonization of TSN parameter modelling with automotive design flows

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Introduction

Ethernet in automotive: Use case

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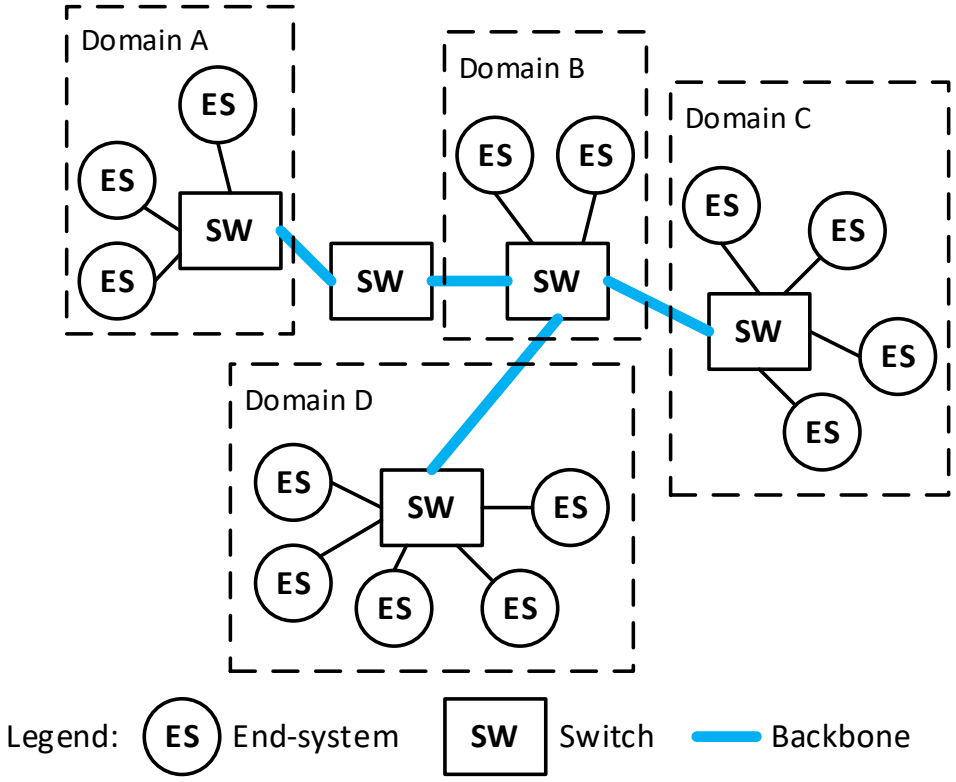
Network on vehicle

- Variable topology
- Different domains connected by Ethernet links
- High utilization on central/backbone links



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Mixed traffic profile

Use cases	Requirement
Control	- Timely behavior is critical (bounded low latency and jitter) - Delivery must be guaranteed - Configuration must be validated by design
Streaming	- Timely behavior is important (bounded latency and jitter) - Delivery must satisfy a QoS - Configuration must be validated by design
Best-effort	- No time guarantees needed - No guarantees for delivery - No configuration required

IEEE 802.1 Time Sensitive Networking (TSN)

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✓ Adds real-time capabilities to switched Ethernet

Time Synchronization

IEEE 802.1AS: Time Synchronization
P802.1AS-Rev: Time Synchronization Redundancy

Latency

IEEE 802.1Qav: Credit Based Shaper
IEEE 802.1Qbu: Frame Preemption
IEEE 802.1Qbv: Scheduled Traffic
IEEE 802.1Qch: Cyclic Queuing and Forwarding
P802.1Qcr: Asynchronous Time Shaping

Reliability

IEEE 802.1CB: Frame Replication and Elimination
IEEE 802.1Qca: Path Control
IEEE 802.1Qci: Per-Stream Filtering and Policing
P802.1AS-Rev: Time Synchronization Redundancy

Management

IEEE 802.1Qat: Stream Reservation Protocol
IEEE 802.1Qcc: Network Management
IEEE 802.1Qcp: YANG Data Model
P802.1CS: Link-local Reservation Protocol

First steps towards a TSN Automotive Profile

(PAR expected to be approved in Nov)

TSN Automotive Profile has the following benefits:

- TSN Customers: easier specification of requirements
- TSN Vendors: easier implementations

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IEEE 802.1 TSN Approach to Configuration

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Configuration models (IEEE 802.1Qcc)

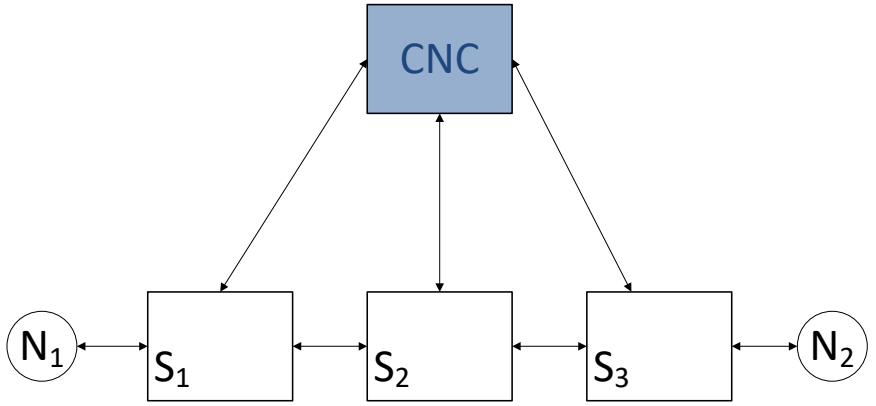
Distributed model:

- Configuration decisions are made locally in every node

→ In automotive: dynamic behavior replaced by a centralized static configuration

Centralized model:

- Configuration decisions are made in the CNC (Centralized Network Configuration)
- CNC has a global view of the network
- CNC can be located outside the vehicle (in a backend network) or inside as a trusted node
- CNC can reconfigure the network during operation time



Configuration Entities are called *Managed objects*

Managed objects :

- specify configurable parameters of TSN mechanisms → modeled using YANG (Modelling Language)
- can be read and modified using configuration protocols → Definition of protocols not part of TSN
- used for static and dynamic configuration

- Examples:

Standard	Name	Description
IEEE 802.1AS	initialLogSyncInterval	Initial value of the of synchronization messages.
IEEE 802.1Qci	AdminControlList	Administrative version of the gate control list (ingress).
IEEE 802.1 Qbv	AdminControlList	Administrative version of the gate control list (egress).

Configuration: YANG Data Models

Ongoing effort to model the TSN managed objects with YANG

https://github.com/YangModels/yang/tree/master/standard/ieee/802.1/draft

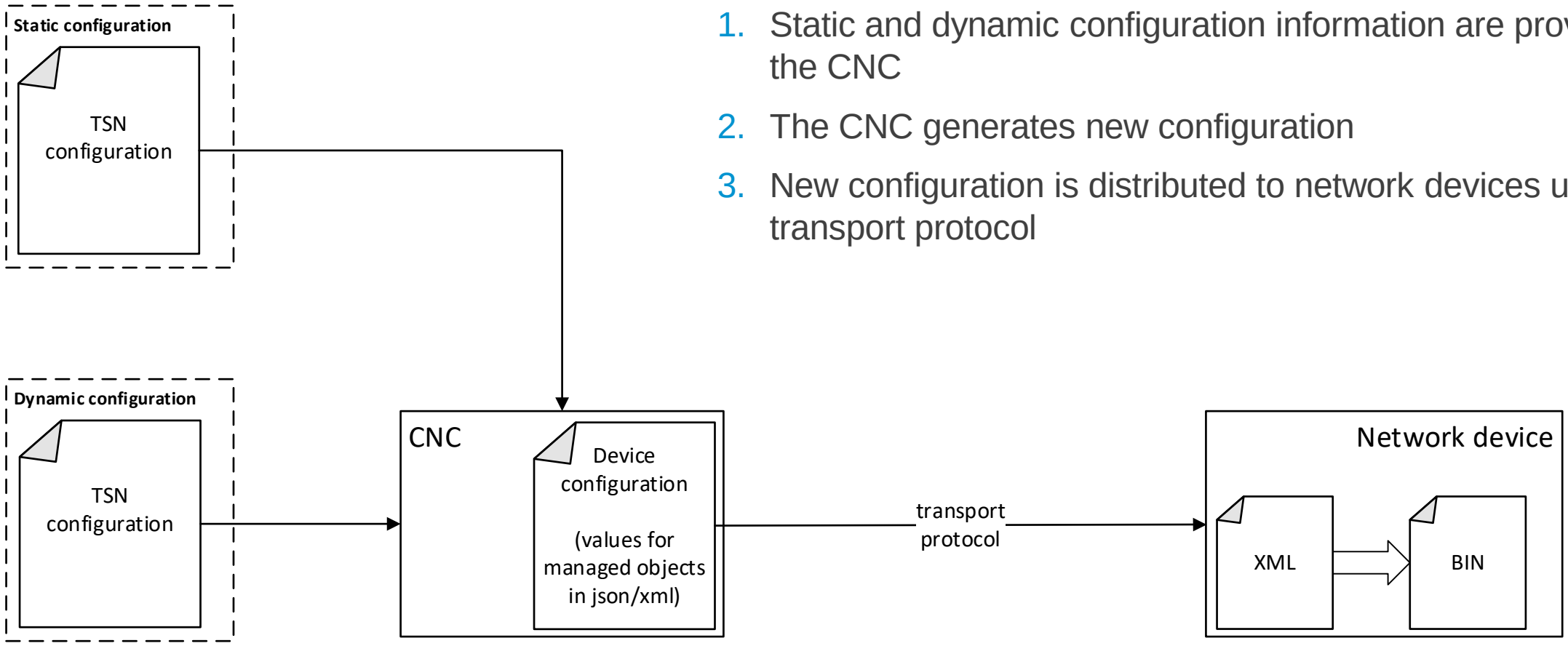
Advantages of YANG:

- Human readable, and easy to learn representation
- Hierarchical configuration data models
- Formal constraints for configuration validation
- Well defined versioning rules

- Instantiations of the model can be encoded in XML or JSON

```
189      container gate-parameters {
190        description
191          "A table (list) that contains the per-port
192          managable parameters for traffic scheduling.
193          For a given Port, an entry in the table exists.
194          All writable objects in this table must be
195          persistent over power up restart/reboot.";
196        reference
197          "IEEE Std 802.1Qbv-2015: 8.6.8.4, 8.6.9, 12.29.1";
198
199        leaf gate-enabled {
200          type boolean;
201          description
202            "The GateEnabled parameter determines whether traffic
203            scheduling is active (true) or inactive (false).
204            The value must be retained across
205            reinitializations of the management system.";
206          reference
207            "IEEE Std 802.1Qbv-2015: 8.6.8.2, 8.6.9.4.14, 12.29.1";
208        }
209        leaf admin-gate-states {
210          type uint8;
211          description
212            "AdminGateStates is the administrative value of the
213            initial gate states for the Port.
214            The bits of the octet represent the gate states for the
215            corresponding traffic classes; the most-significant bit
216            corresponds to traffic class 7, the least-significant bit
217            to traffic class 0. A bit value of 0 indicates closed; a
218            bit value of 1 indicates open.
219            The value must be retained across
220            reinitializations of the management system.";
```

Configuration workflow



1. Static and dynamic configuration information are provided to the CNC
2. The CNC generates new configuration
3. New configuration is distributed to network devices using a transport protocol

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Automotive Approach to Configuration

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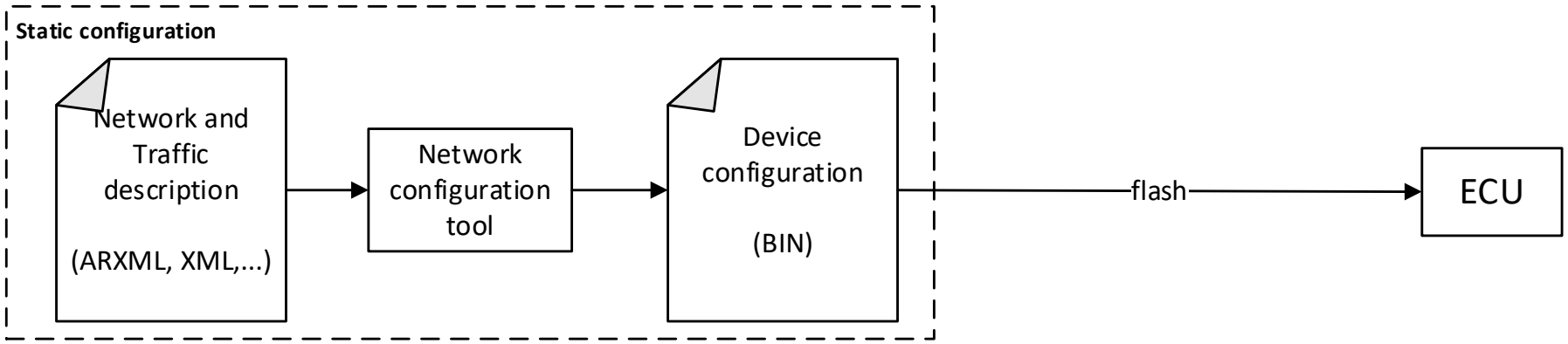
Configuration workflow

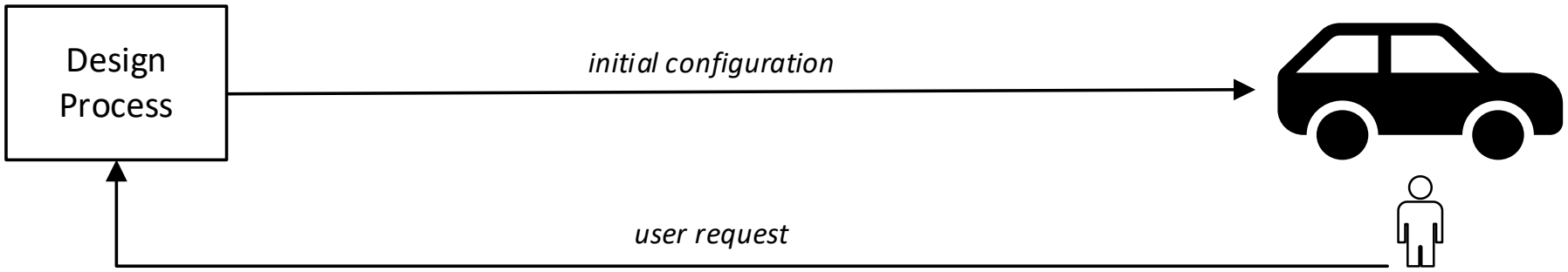
AUTOSAR modules and its ecosystem are well established in the industry

1. Static configuration is provided to a network configuration tool in arxml format
2. The Network configuration tool produces device specific configuration
3. Configuration is flashed to the ECU



Static configuration

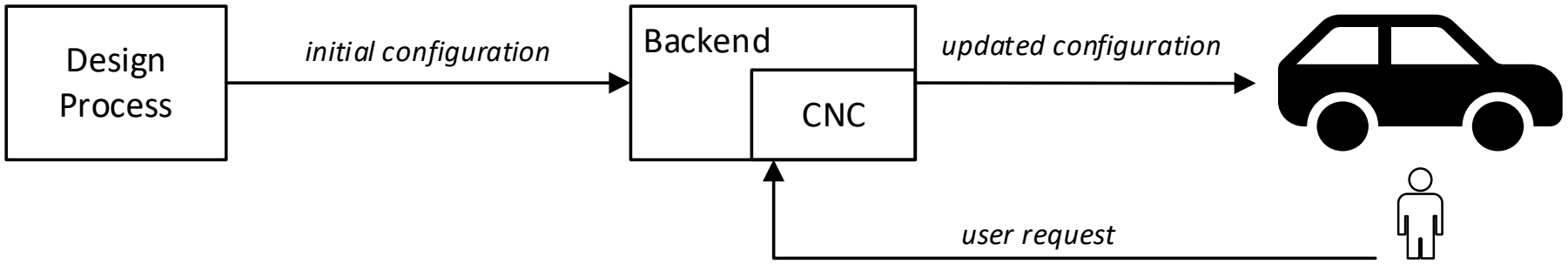
- Initial configuration produced during the design process
- Upon a user request, a configuration update takes years



Dynamic configuration

Option 1:

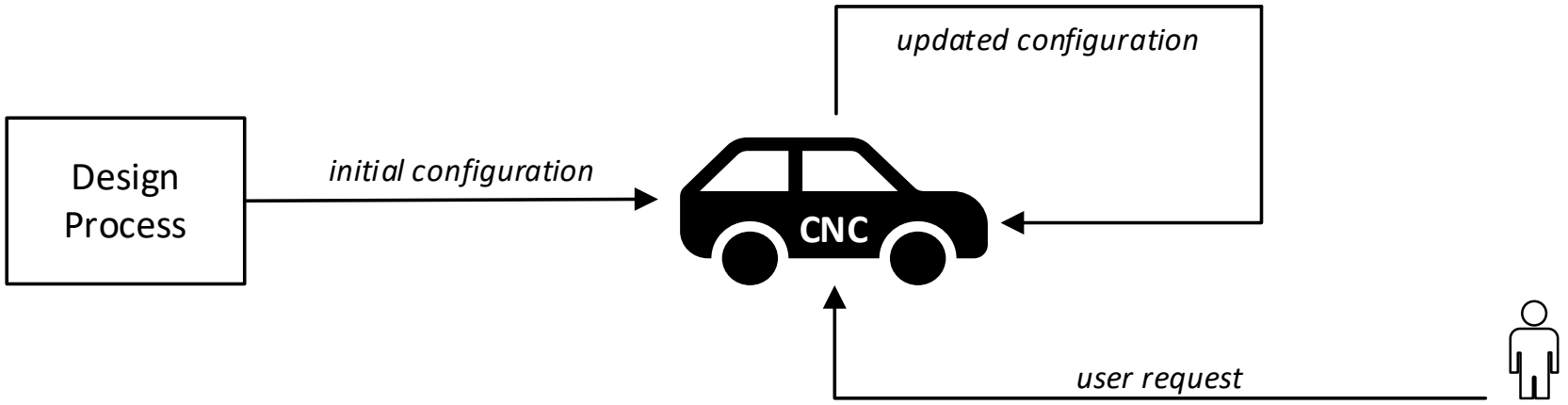
- User request is handled by the CNC in the back-end → Configuration update takes hours



Dynamic configuration

Option 2:

- User request is handled by the CNC in the vehicle → Configuration update takes seconds!



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Proposed Harmonization of TSN and Automotive Configuration Approaches

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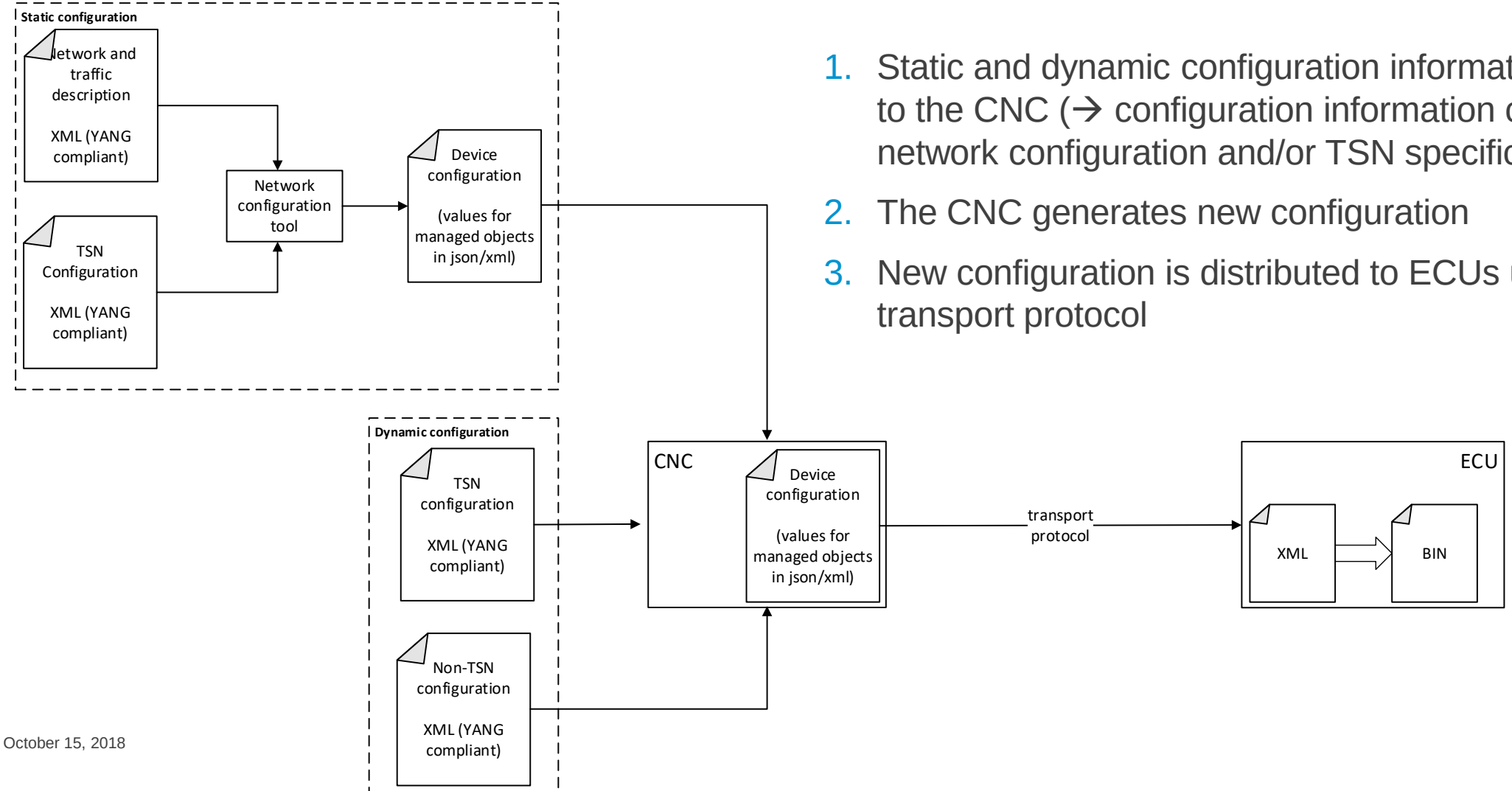
TSN Automotive configuration workflow



1. Static and dynamic configuration information is provided to the CNC (→ configuration information can be general network configuration and/or TSN specific)
2. The CNC generates new configuration
3. New configuration is distributed to ECUs using a transport protocol

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Efforts needed

Parameters:

- Incorporate TSN parameters to existing network configuration tools
- Automotive specific parameters needed in/for the CNC

Interfaces:

- Automotive standardization activities to consider harmonization with YANG data models
- CNC to merge general network configuration and TSN specific configuration

Transport protocol:

- A transport protocol should be defined / chosen, considering security aspects

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Conclusion

Conclusions

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Automotive design flows

- Well established for static configuration
- Upcoming need for dynamic reconfiguration

TSN standards

- Satisfy automotive requirements (automotive profile on the making)
- Already defines dynamic reconfiguration process

Automotive - TSN harmonization

- Will align OEMs requirements with Tier1s configuration and Tier2s features
- And facilitate the use of TSN in automotive networks…

→ thus providing an already established process for dynamic reconfiguration

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