



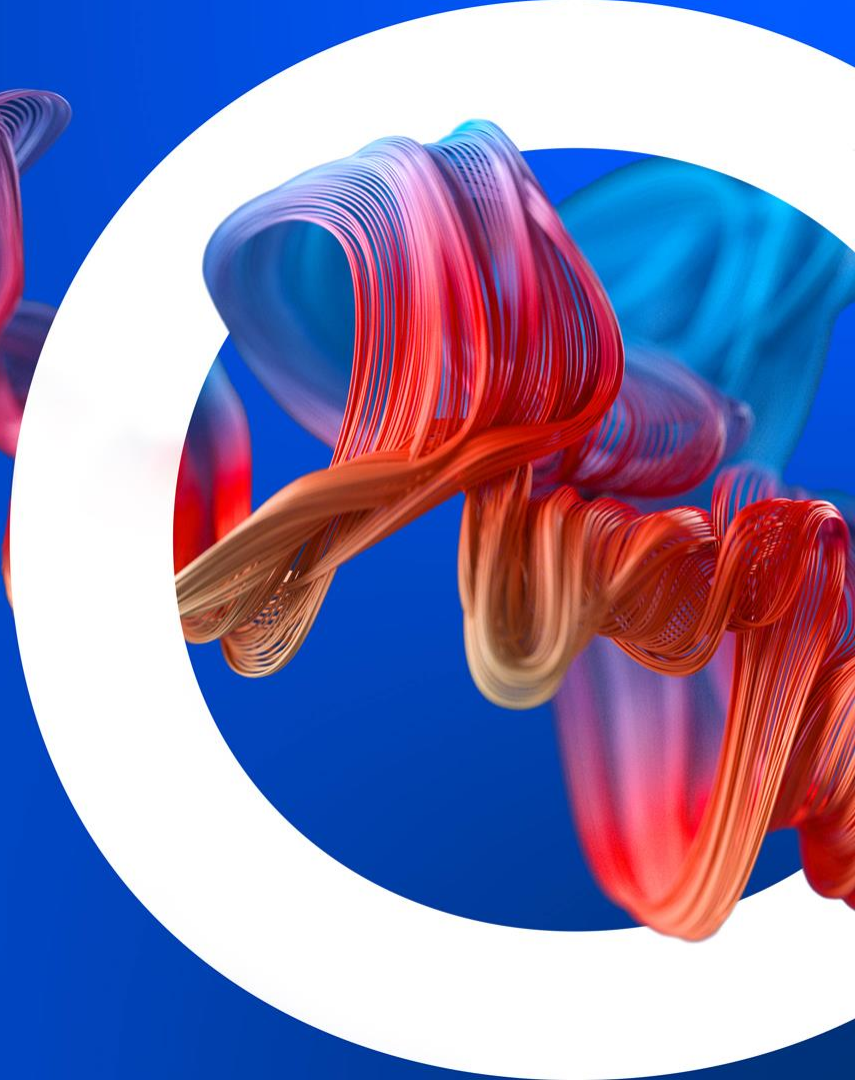
Fiber broadband for future in-vehicle connectivity?

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Trends in automotive create increasingly demanding requirements for in-vehicle networking

Trends	
	Electrification
	Software-defined car
	Autonomous driving



Networking requirements	
	Immune to electromagnetic interference
	Minimize weight
	Support increasing data rates

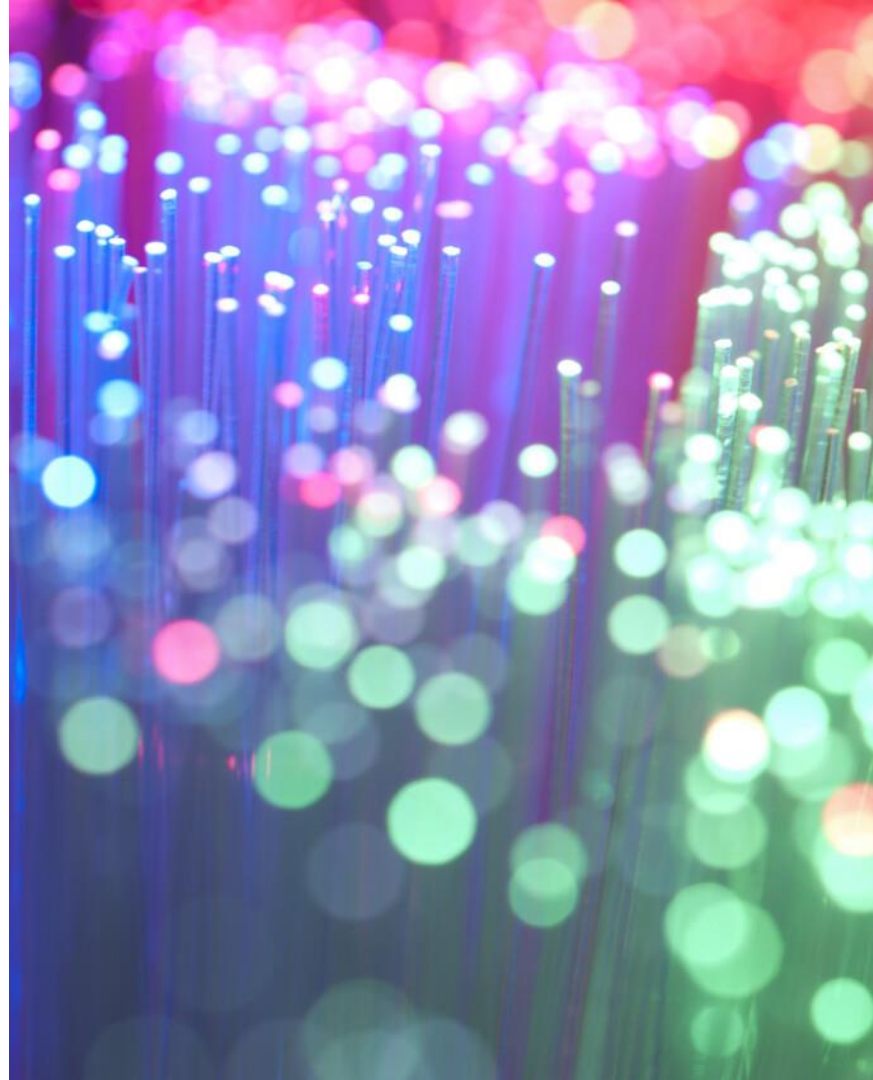
Optical fiber resonates very well with these requirements

Optical fiber:

- Not susceptible to electromagnetic interference
- Easily achieves high data rates
- Significant weight advantage vs. copper
- **Mature technology for broadband connectivity**



Can we leverage fiber broadband technology for future in-vehicle networks?



Fiber broadband technology maturity

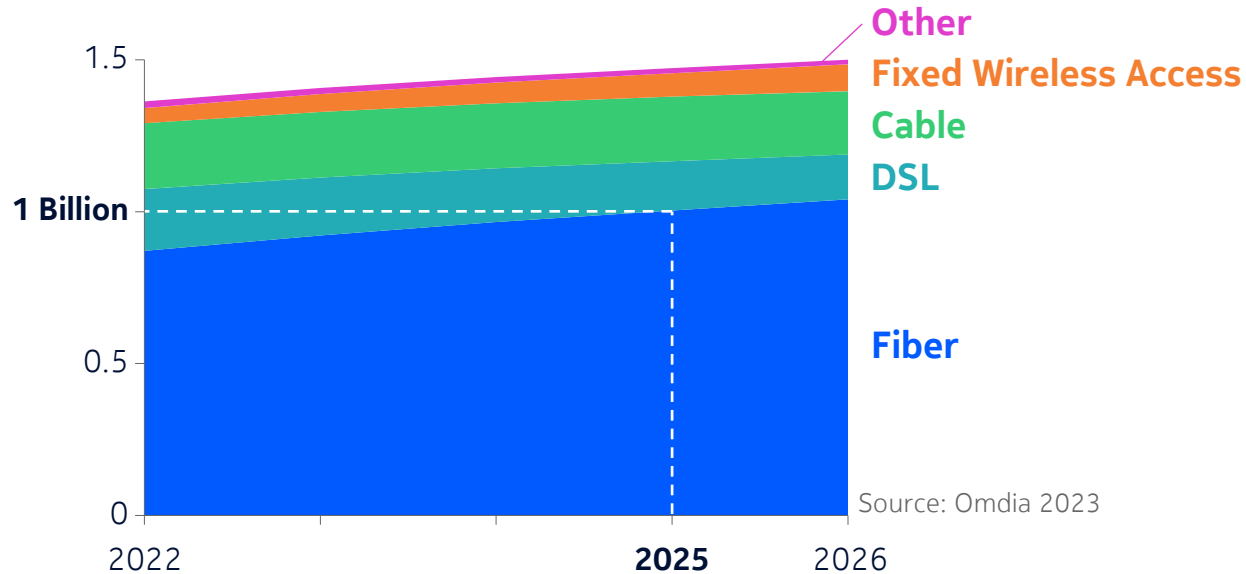
Technical characteristics

Matching to automotive requirements

Fiber networks are a mature solution for broadband connectivity

More than one billion users will have fiber broadband by 2025

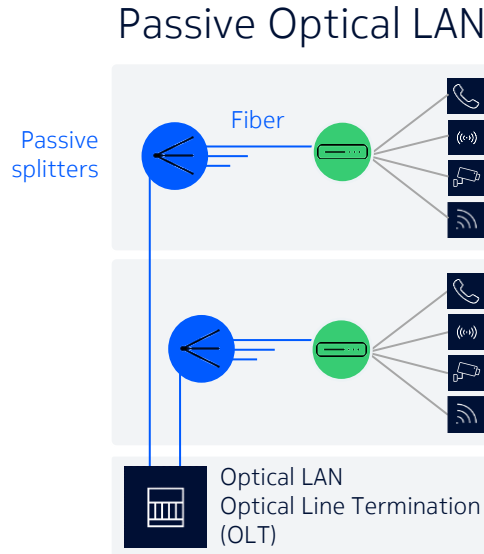
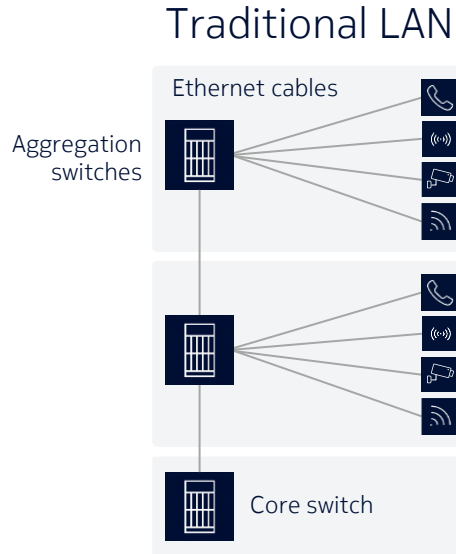
Worldwide broadband subscriptions



Source: Omdia 2023

Fiber is also increasingly adopted for enterprise networks

Under the umbrella of “Passive Optical LAN”



- Lower power
- Less equipment/floorspace
- Cost-efficient upgrades
- Carrier-grade reliability
- Military-grade security

Fiber broadband technology maturity

Technical characteristics

Matching to automotive requirements

Fiber broadband can effortlessly support high data rates

The most recent commercially available flavor runs at 25 Gigabits/second

2.5G

GPON*

Massively
deployed

10G

XGS-PON*

Ongoing mass
deployments

25G

25GS-PON*

Deployments
started

50G

50G-PON*/G.hsp

Trials

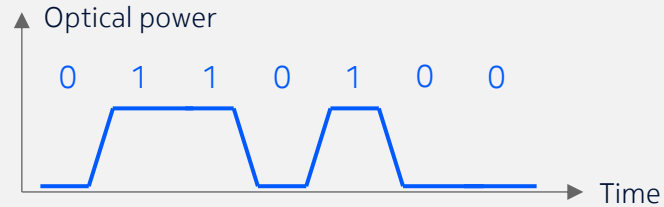
* PON = Passive Optical Network

Cost is always a prime consideration for fiber broadband

And it therefore uses cost-efficient techniques

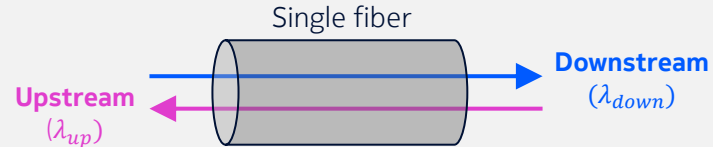
Simple modulation

- On/off-Keying
- Used by all PON generations so far



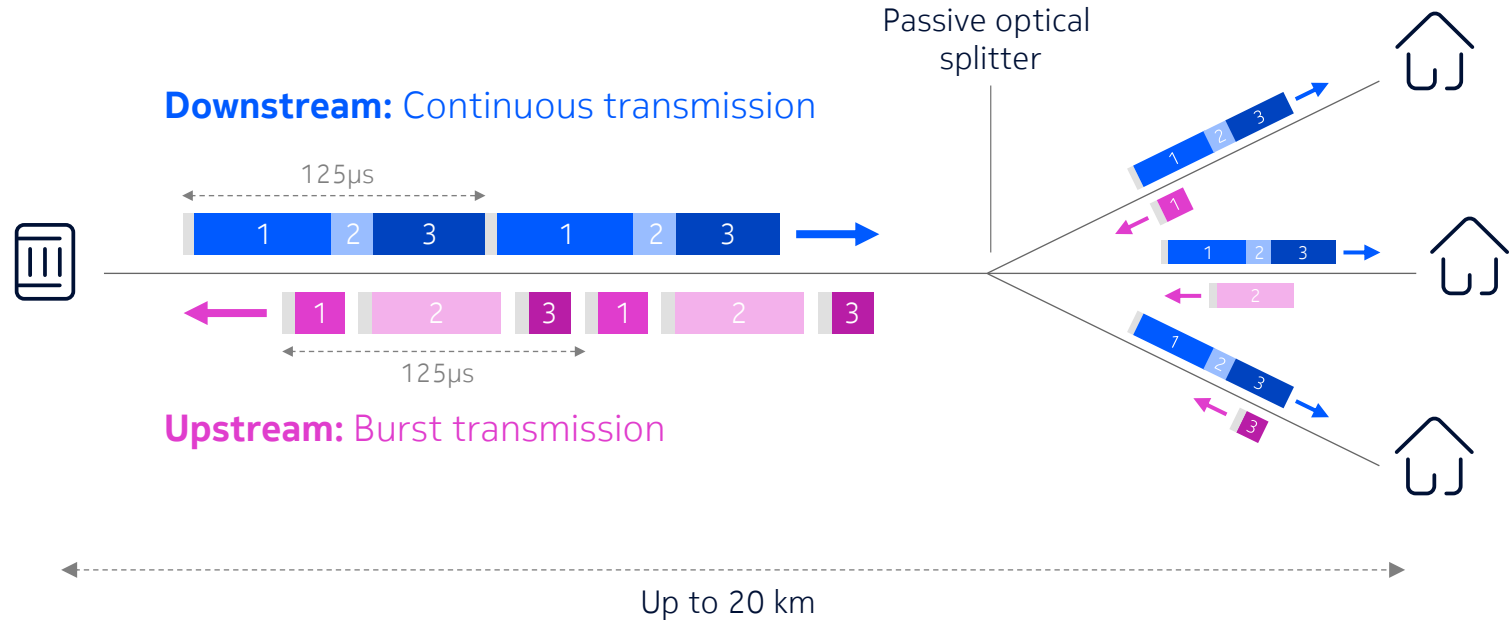
Bidirectional communication over a single fiber

Upstream and downstream at different wavelengths on the same fiber



A passive optical network is a point-to-multi-point network

Only containing passive optical power splitters



A point-to-multipoint architecture has its benefits

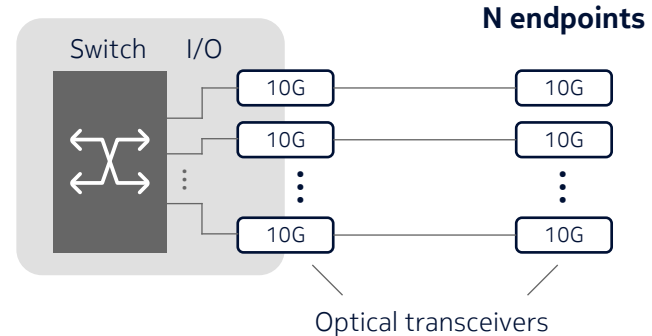
A lower number of transceivers and lower switch capacity requirements

Point-to-point

More optical transceivers

└ Fully redundant: $4N$

Higher switching requirements



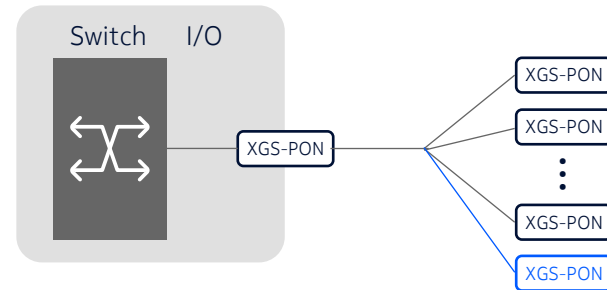
Point-to-multipoint

Less optical transceivers

└ Fully redundant: $2N+2$

Lower switching requirements

Easily expandable



Fiber broadband technology maturity

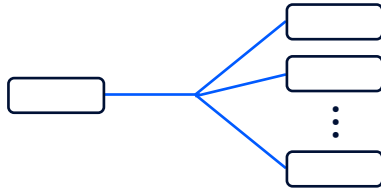
Technical characteristics

Matching to automotive requirements

PON could be made cheaper by tailoring to automotive

Similar to ongoing efforts at ITU-T for developing a standard for “Fiber In Premises”

Maximum fiber length



Broadband

20 km

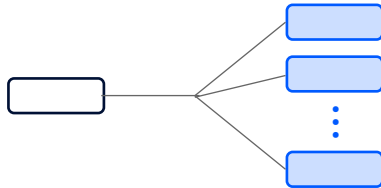


Automotive

40 m*

Enables use of cheaper optics and fiber

Number of endpoints



Broadband

256



Automotive

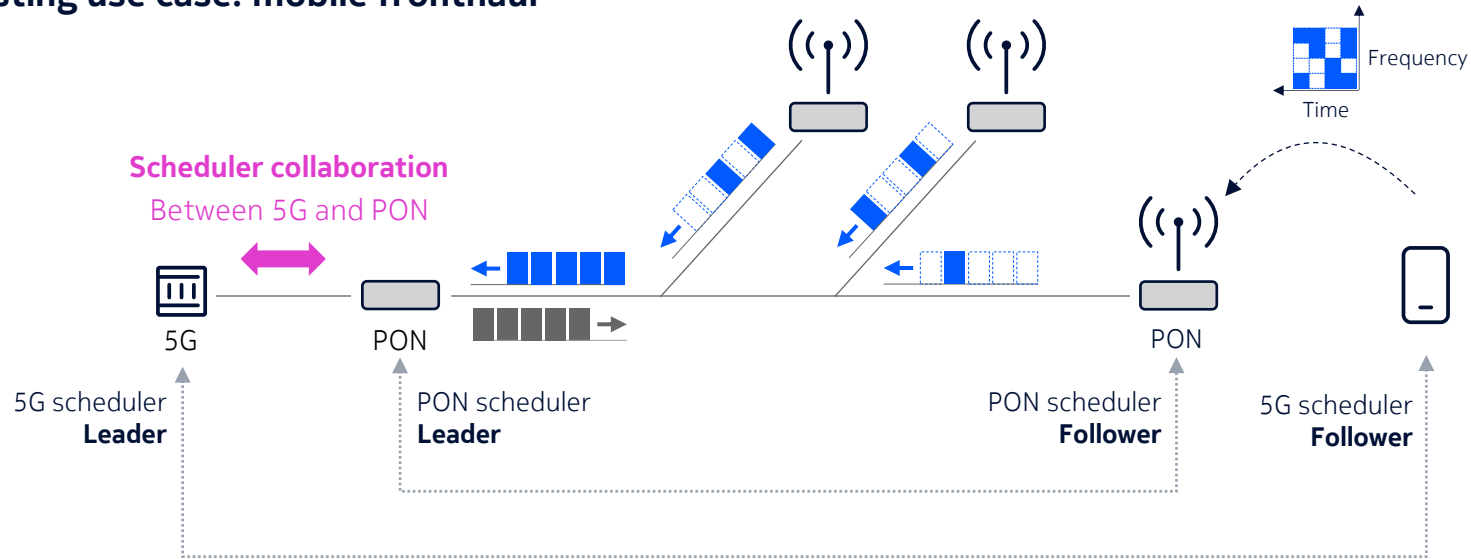
4-16?

Enables simplification and speed-up of Medium Access Control

* Current specification for optical automotive Ethernet

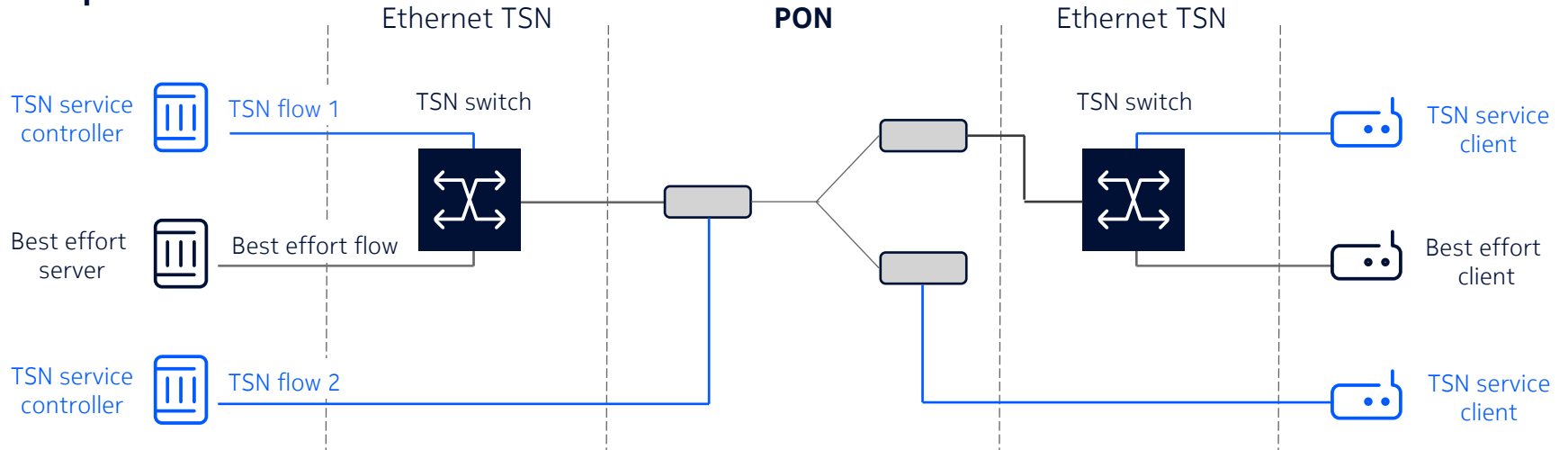
PON can support deterministic timing by properly coordinating the time-based scheduling on the fiber

Existing use case: mobile fronthaul



Proofpoint: Nokia Bell Labs' Time Sensitive Networking over PON

Setup



Demonstration:

- Co-scheduling of PON and TSN switches
- Combination of TSN traffic and best-effort traffic on the same system

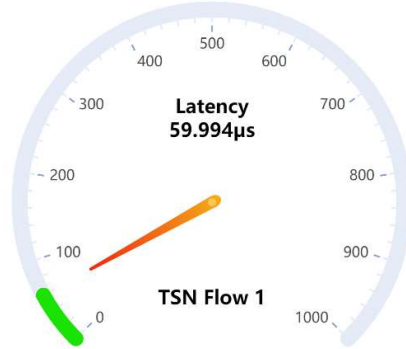
Proofpoint: Nokia Bell Labs' Time Sensitive Networking over PON

Shows how jitter on PON can be kept below one microsecond

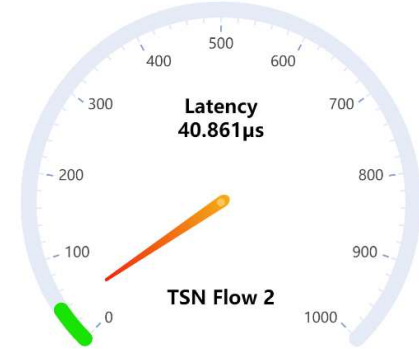
NOKIA



Jitter: 864.047µs



Jitter: 0.590µs



Jitter: 0.212µs

S. Das, P. Dom, R. Bonk, J. Maes, "Low latency Low-Jitter Bandwidth-Efficient PON for Industry applications", in Proc. ECOC, 2024.

Summary

Future requirements for In-Vehicle Networks align well with capabilities of optical fiber

Electromagnetic interference, data rate, weight

Fiber is a mature solution for broadband connectivity

Nearly one billion users today

Potential role for passive optical networks in future vehicles?

[Reach out to us to explore!](#)

NOKIA