10 Mbps Single Pair Ethernet (10SPE – 10 BASE-T1S)

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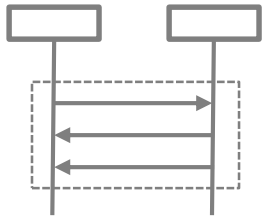
Motivation

- **Ethernet/IP-based Network everywhere**
  - WWW, IT, Automation, IoT, Cars etc.
  - Scalable bandwidth, various PHY layer options, proven SW stacks

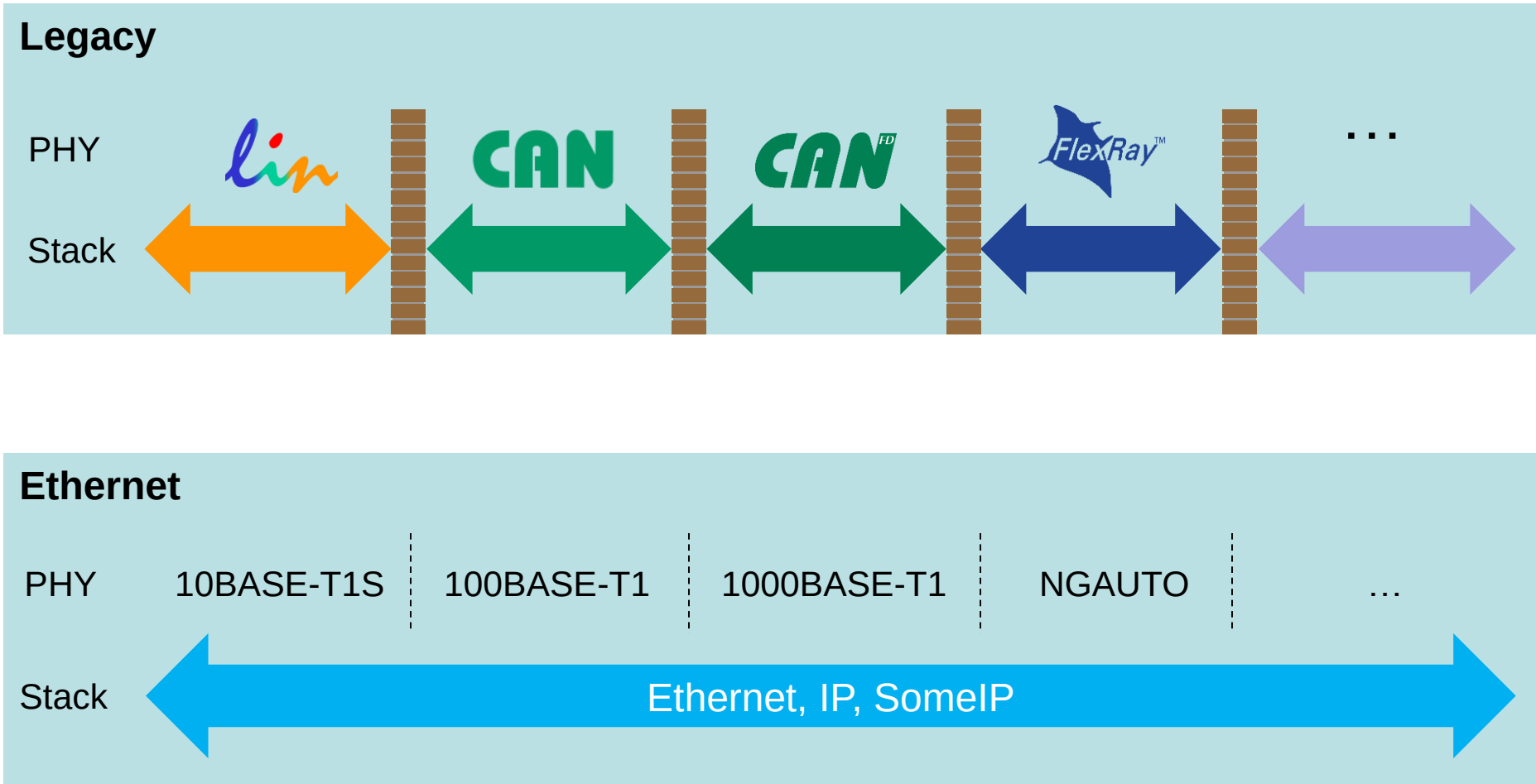
- **Security and safety are essential**
  - Security framework
  - Safety framework

- **Service-oriented architecture manages complexity**
  - Encapsulation of functions and data
  - Unifies communication
  - Re-usability and movability of services



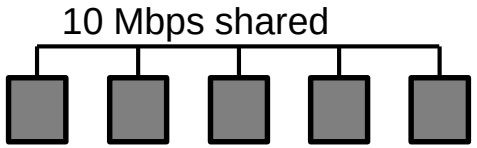
- **Innovative applications drive data rates**
  - Legacy implementations run out of steam

Why is Ethernet needed?



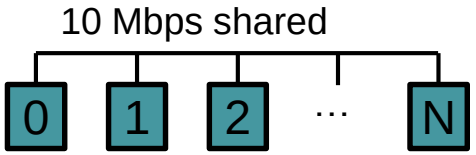
Why not 100BASE-T1?

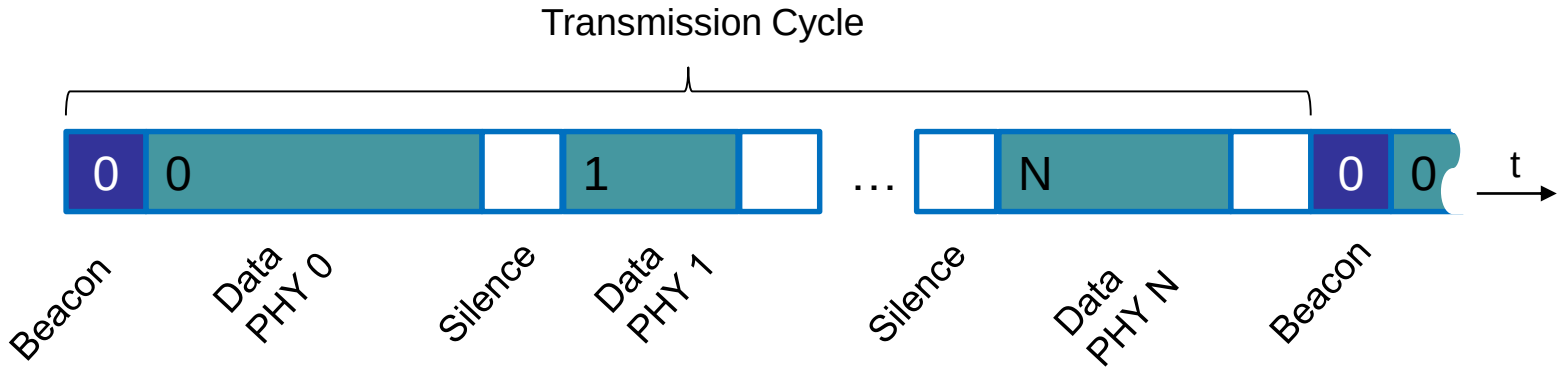
- **10BASE-T1S enables multi-drop (bus line)**
  - No switches
  - Less cables
  - 10 Mbps shared
  - Half-duplex
  - Up to at least 8 nodes
  - Up to at least 25 m
  - Stubs up to 10 cm
  - Arbitration scheme for optimized data throughput and transmission latency



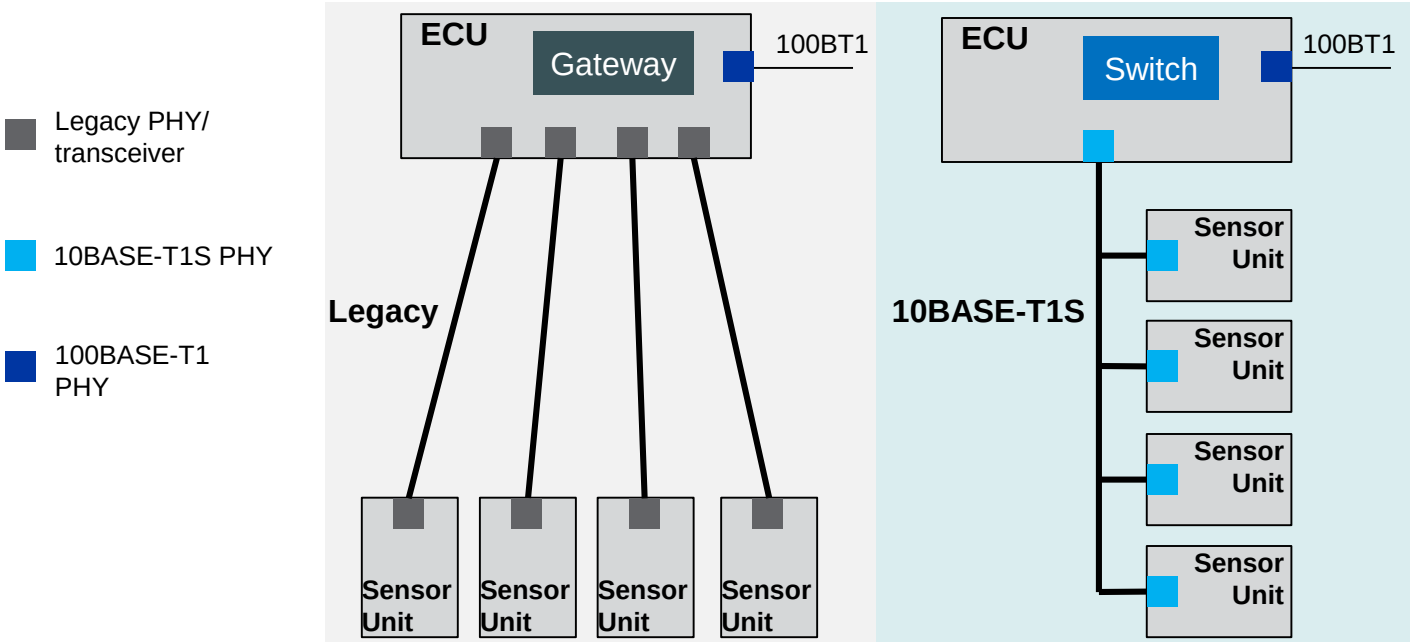
Optimized data throughput on the bus line

- **Goals**
  - Full bandwidth utilization
  - Reduce latency
  - Quality of Service (QoS)
- **Principle**
  - Avoid physical collisions on the medium by organizing the media access
    - Called Physical Layer Collision Avoidance (PLCA)
- **How it is done**
  - Only the PHY that owns a transmit opportunity is allowed to send data
  - Transmit opportunities are given in a round robin manner
  - A new cycle of transmit opportunities is started when the master node sends a BEACON
  - Works on top of Carrier Sense Multiple Access/Collision Detection (CSMA/CD)





Impact on Cabling

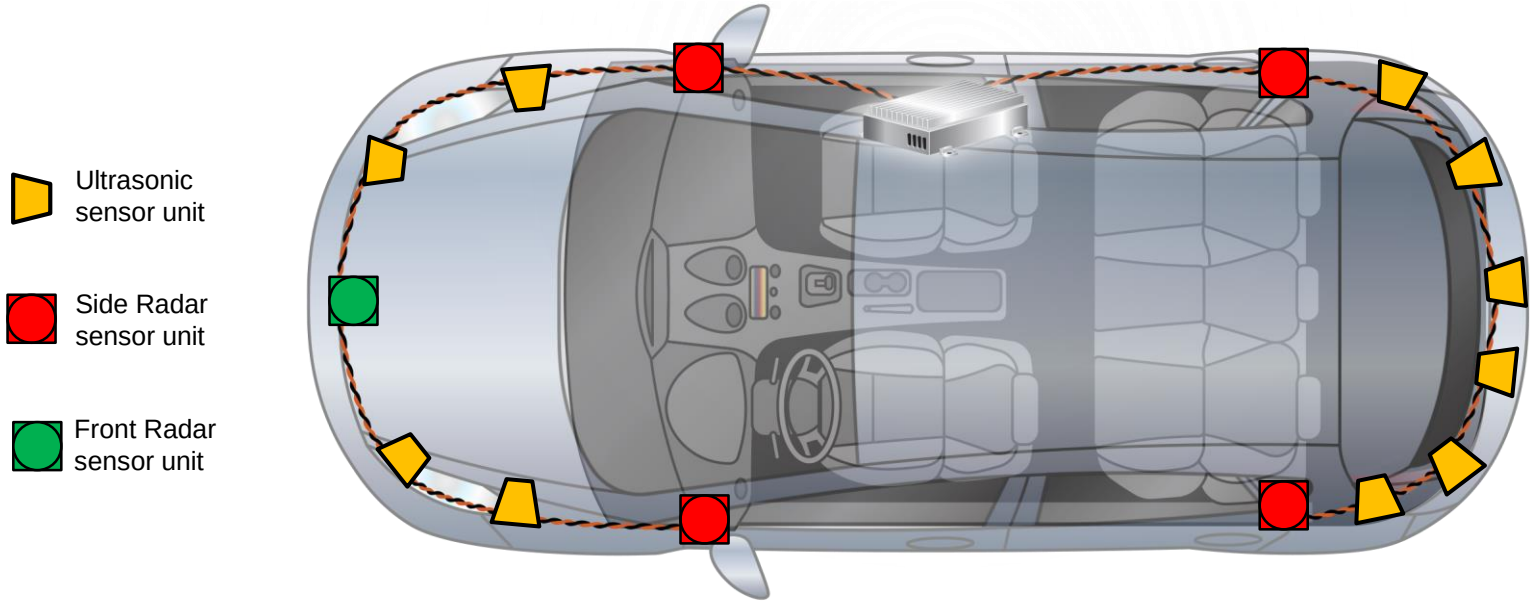


			Benefits of 10BASE-T1S
# PHYs	8	5	Fewer PHYs
# Connectors ECU	4	1	Fewer connectors and less connector space on ECU
Cabling	4 cables	1 bus line	Less cabling, extendability, scalability
Bandwidth	< 10 Mbps	10 Mbps	More bandwidth
Ethernet-based network	no	yes	Seamless integration into overall Ethernet architecture
Gateways	yes	no	Eliminates need to translate messages

Scalability

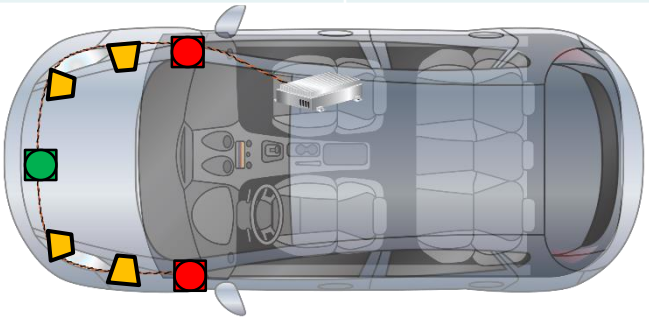
- Minimum required connector space at ECU
- Bus line can be expanded by additional sensor units
- Assembly options don’t change central ECU

Example: Ultrasonic and Short Range Radar



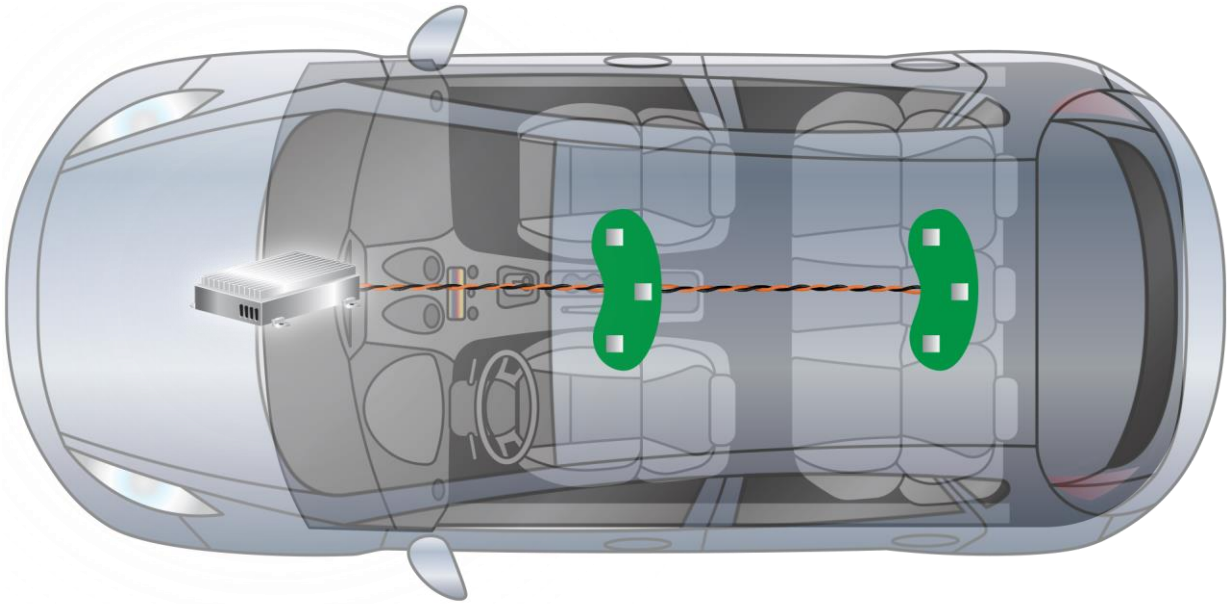
Example Radar/Ultrasonic

	Ultrasonic	Side Radar	Front Radar
# Sensors	4	2	1
Bandwidth	0.3 Mbps	1.5 Mbps	3.5 Mbps
L1 Packet Length	84	148	148
# Packets per Sensor per Second	446	1267	2956
Latency	624 us	624 us	624 us



Example: Hands Free Microphones

- Three Sensors on one PCB
- Two PCBs connected to an ECU
- 1722 AVTP as transmission protocol



Example: Hands Free Microphones

	Per PCB	Total
# Sensors	3	6
Sample Frequency	48 kHz	48 kHz
Samples per Packet	3*24	3*24
L1 Packet Length	206	206
# Packets per second	48 kHz / 24 = 2000	4000
Latency (= sample collection + packet transmission)	500 us + 2 * 165 us = 830 us	830 us
Bandwidth	3.3 Mbps	6.6 Mbps

Application Overview

- Hands free microphones
- Active speakers
- Noise vibration harshness
- Parking ECU
  - Radar
  - Ultrasonic
- Engine ECU
- Body ECU
- Active suspension
- Steering/braking system
- Charging units for electric cars
- Traffic sign recognition

Conclusion

- **Key Features**
  - Multi-drop
  - No collisions
  - Deterministic low latency

- **Enabling expansion of Ethernet technology to many additional applications**

Thank you!