

In-Vehicle Networking

Lecture 1 Introduction to in-vehicle networking
BAE 5030 - 003
Fall 2008
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Oklahoma State University

January 7, 2008

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1

Goals for Class Today

- Introduce class
 - Goals of the class
 - Teaching style / expectations of students
 - Grading process
 - Content
- Introduce the topic of in-vehicle networks
 - Clarify the focus
 - Set the scope of study
- Introduce the ISO Open System Interconnection model
- Conduct a laboratory exercise to demonstrate
 - Media access control
 - Addressing
 - CSMA/CD
 - Token ring

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2

Class introduction

- Prerequisites
 - BAE 5413, MAE 4733 or equivalent experience
- Course Objectives
 - The objective of this course is to provide students with a working knowledge of in-vehicle network systems and exposure to aspects of design, development, application, and performance issues associated with those systems.
- Syllabus on D2L
 - All handout material, reading materials, assignments will be posted on the web at <https://oc.okstate.edu/>
- Student Deliverables
 - In-class presentation 25%
 - Class notebook 25%
 - Quizzes 25%
 - Final exam 25%

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3

Class subject outline

- Introduction to OSI and network descriptive structures and network functionality.
- Network technologies
 - LIN
 - SAE J1850
 - SAE J1587/1708
 - CAN
 - SAE J1939/ISO 11783/NMEA2000
 - Flexray
 - MOST
 - Ethernet
 - Future network technologies
- Software development of embedded distributed systems

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4

In-Vehicle Network technologies

Technology	Speed	Uses	Advantages	Devices
LIN	20 kbits/s	Body	Low cost	Sensors, switches
CAN	1 Mbit/s	Body	Fault tolerant	Controls
FlexRay	10 Mbits/s	Body, chassis, powertrain, X-by-wire	High performance, fault tolerant, deterministic	Engine, brakes, steering
MOST	50 Mbits/s	Entertainment, driver information	High performance, simple network	DVD playback, radio, Bluetooth, amplifier
IDB-1394	400 Mbits/s	Driver information, individual passenger entertainment, camera network	High speed, single network for multiple use, multiple choice of physical layer, isochronous transfer	Navigation, multiple DVD playback, intelligent monitors, exterior/interior cameras, amplifier, customer-convenient port

- W. Wong. Multimedia Automotive Networks. Electronics Design, ED Online ID #14995, March 29,2007.

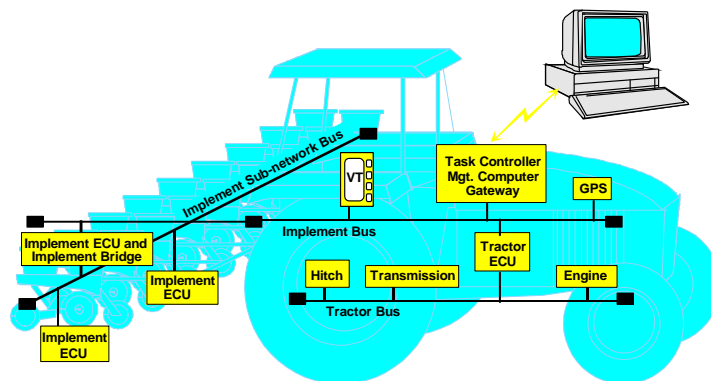
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5

In-Vehicle Networks

- What are they?
 - A system of physical and logical interconnection enabling communication between components inside a vehicle and between components outside the vehicle and the inside components.



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6

In-Vehicle Networks

- What constitutes a network
 - Distributed computing
 - Communications among distributed components
 - Interconnection via:
 - wiring
 - fiber optics
 - radio
 - other?
 - Must include in-vehicle components
 - Shared communications media = multiplexing
 - Method of allocation of access to media
- Vehicles
 - For our purposes – mobile equipment
 - Ag and construction equipment
 - Mining equipment, trucks and buses, automobiles, ships, aircraft etc.

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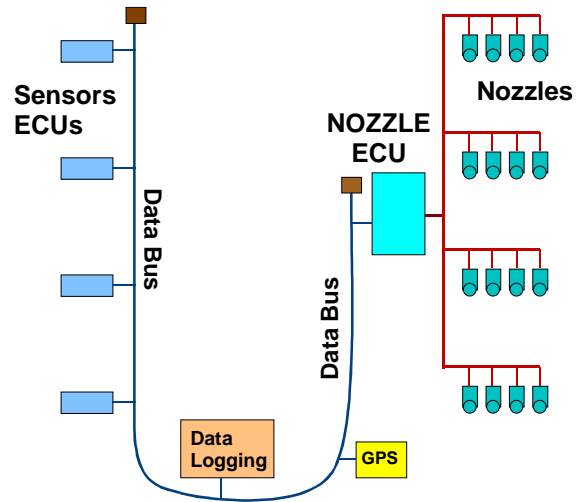
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7

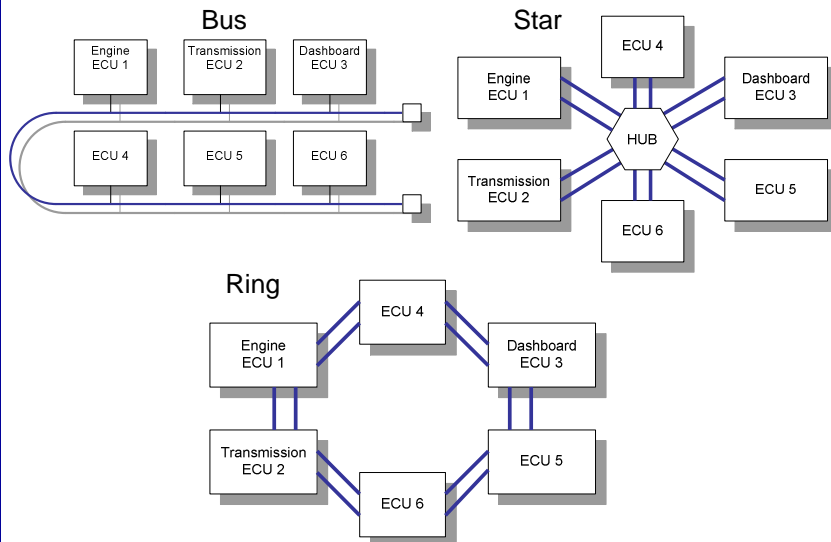
Conventional Wiring (No network?)



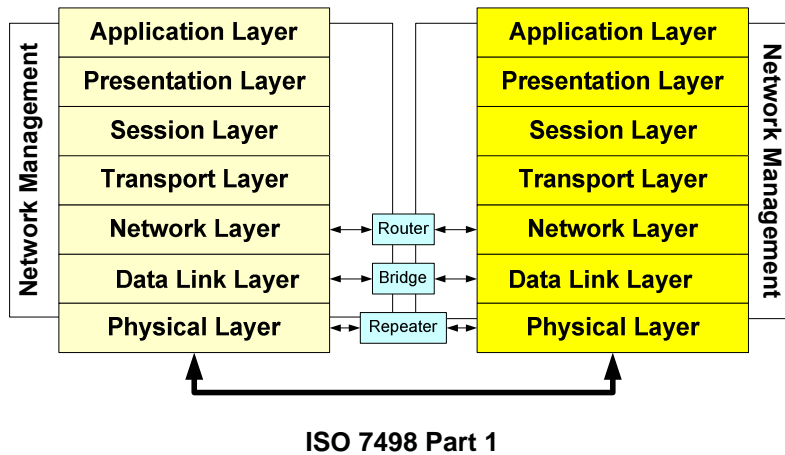
A Simple Network Application (Serial Bus Network)



Communications Network Wiring Topology



To form a complete communications system
you need multiple functions on both ends



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11

Nature of the ISO Open System Interconnection (OSI) Model

- Provides structure and definition for communication of data from one application to another over a network
- Organized as functional layers
 - Provide transparent communication services to the layer above
 - Likely implemented as “functions or subroutines” that are called from the layer above or provide an interrupt to the layer above
 - A full (or partial) set of layers is known as a “stack”
- Use protocol data units
 - Each layer may have a protocol data unit (PDU) which encapsulates the data from the layer above and adds it’s own “handling instructions” for its companion layer in the stack(s) it communicates with. eg.

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12

ISO Open System Interconnection Model (ISO 7498-1)

Specifications paraphrased from ISO/IEC 7498-1 : 1994(E)

Application Layer

- Contains all those functions which imply communication between open systems that are **not already performed by the lower layers**. These include functions performed by programs as well as functions performed by human beings.
- Presentation Layer
 - Provides for **common representation of the data transferred** between application-entities. This relieves application-entities of any concern with the problem of "common" representation of information, i.e., it provides them with syntax independence.
- Session Layer
 - Provides the means necessary for co-operating presentation-entities to organize and to synchronize their dialogue and to manage their data exchange. To do this, the Session Layer provides services **to establish a session-connection between two presentation-entities, to support orderly data exchange interactions, and to release the connection in an orderly manner**.

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13

ISO Open System Interconnection Model (ISO 7498-1)

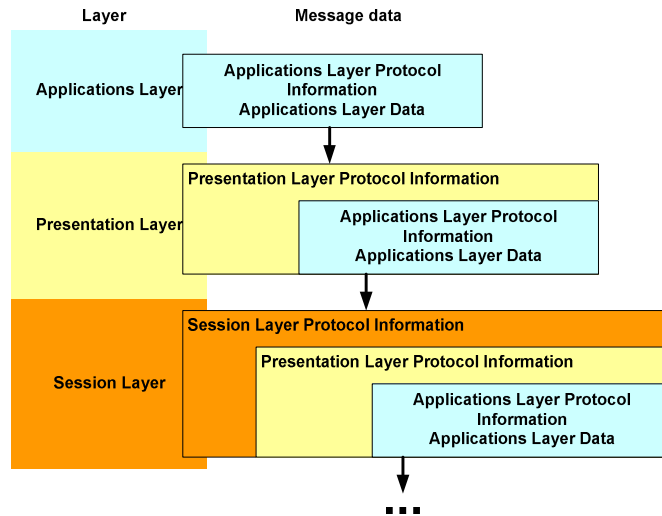
- Transport Layer
 - transport-service provides transparent transfer of data between session-entities and relieves them from any concern with the detailed way in which **reliable and cost effective transfer** of data is achieved.
- Network Layer
 - Provides to the transport-entities independence of **routing and relay considerations**.
- Data Link Layer
 - Provides for **establishment, maintenance, and release of data-link-connections** among network-entities and for the **transfer of data-link-service-data-units** built upon one or several physical-connections.
- Physical Layer
 - Provides mechanical, electrical, functional and procedural means to activate, maintain, and de-activate physical-connections for bit transmission between data-link-entities.

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14

Nature of messaging hierarchy



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15

Media sharing techniques

- Some method must be provided in a network protocol to regulate the use of shared media
 - Methods include
 - Time domain multiplexing (assigned time slots)
 - Frequency domain multiplexing (assigned frequency slots)
 - Master/Slave (speak when spoken to)
 - Carrier sense multiple access with collision detection
 - Carrier sense multiple access with bitwise priority access
 - Others
 - CSMA/CD
 - Multiple devices using the same media (Multiple access) "listen" before "sending" (carrier sense) and listen while sending (collision detection).
 - If a collision is sensed, a random back-off algorithm is used to delay the next communication attempt

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16

Laboratory exercise: CSMA/CD multiplex network simulation

- **OBJECTIVE:** To develop first hand experience with the issues and functionality of protocol in a CSMA/CD multiplex network.
- **PROCEDURE:** A simulation of a CSMA/CD network will be done by "speaking" messages within a classroom. Each member of the group will be seated facing away from the rest of the group. Each member will be assigned an address (source address) and will be given a dataset, a brief sentence along with a destination address for the dataset. It is the responsibility of each member of the group to communicate their sentence to the particular member associated with the destination address.
- The procedure for communication will be to listen for a start command generated by the instructor and to transmit each word of the dataset (sentence) as a message in the sequence the words occur in the sentence. The format of a message should be as follows:
 - Source address : destination address : word : checksum
 - The source address should be the address of the speaker. The destination address should be the destination address of the message. The "word" should be a word in the sentence. The checksum should be the number of letters in the word. Sending of the complete dataset will require multiple messages. Checksums should be pre-computed before initial sending messages.
 - It is impolite and unacceptable for more than one speaker to speak at the same time. To minimize this problem, the following protocol will be used:
 - The instructor will issue the ticks of a time clock at which a speaker may listen for at least two ticks to assure no other speaker is speaking. If no other speaker is speaking, then the speaker may begin speaking a message. The speaker must listen while speaking to assure no more than his or her message is being spoken. If more than one message is being spoken, then the speakers must refrain from speaking and wait a random number of one to ten time ticks. The speaker may then attempt to transmit the message again.
 - Each member must also listen for messages destined for their address. If a message is being spoken for their address, the member must copy down the data (word) and the checksum to assure the word was heard correctly.
 - Members should turn their seat around to face the group when their message is completely sent.
- **ANALYSIS AND REPORTING:** The instructor will ask that the received messages be read by members at the destination addresses in address order and note any inaccuracies. The overall quality of communication should be assessed. Obtain the details of the Ethernet protocol and compare and contrast communications across Ethernet with communications done in this exercise. Prepare a report with the analysis of this exercise and your comparison with Ethernet.

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17