Chapter XV
In-Vehicle Network Architecture for the Next-Generation Vehicles

Syed Masud Mahmud
Wayne State University, USA

ABSTRACT

New types of communication networks will be necessary to meet various consumer and regulatory demands as well as satisfy requirements of safety and fuel efficiency. Various functionalities of vehicles will require various types of communication networks and networking protocols. For example, drive-by-wire and active safety features will require fault tolerant networks with time-triggered protocols to guarantee deterministic latencies. Multimedia systems will require high-bandwidth networks for video transfer, and body electronics need low-bandwidth networks to keep the cost down. As the size and complexity of the network grows, the ease of integration, maintenance and troubleshooting has become a major challenge. To facilitate integration and troubleshooting of various nodes and networks, it would be desirable that networks of future vehicles should be partitioned, and the partitions should be interconnected by a hierarchical or multi-layer physical network. This book chapter describes a number of ways using which the networks of future vehicles could be designed and implemented in a cost-effective manner. The book chapter also shows how simulation models can be developed to evaluate the performance of various types of in-vehicle network topologies and select the most appropriate topology for given requirements and specifications.
INTRODUCTION

Early vehicles used dedicated point-to-point connections for inter-module communications. As the number of modules and features increased in vehicles, the wiring system became bulky, complex, expensive and difficult to install and maintain. As a result, over the years, evolution of in-vehicle communications via a serial bus took place. A serial bus can replace all the dedicated point-to-point wiring between modules. Thus, it significantly reduces wiring complexity as well as weight of the vehicle making the vehicle more fuel efficient. A serial bus system is also scalable, meaning that more modules can be connected to the bus at any time without requiring any changes at other modules. Since different functions of a vehicle need different data rates, such as power-train needs higher data rate than body electronics, the use of a single serial bus for the entire vehicle may not be the best choice to design the in-vehicle communication network. As high-speed electronic components are more expensive than low-speed electronic components, it would be desirable and cost effective to partition the serial bus into two buses: a high-speed serial bus and a low-speed serial bus. The high-speed bus can be used for power-train and the low-speed bus can be used for body electronics. This is the reason why currently most vehicles have at least two serial buses: one for power-train and the other for body electronics, as shown in Figure 1. Since there are some mutually required data between the two partitions of the in-vehicle network, the partitions are interconnected by a gateway device as shown in Figure 1. The two partitions need not use the same type of bus though they can. Since the LIN (Local Interconnection Network) bus is less expensive and LIN protocol (Ulap, 2004) is less complex than the corresponding CAN (Controller Area Network) bus and CAN protocol (Motorola, 1998), nowadays many vehicles are considering using a low-speed LIN bus for body electronics and a high-speed CAN bus for power-train. The gateway device which interconnects a CAN bus and a LIN bus converts messages from one protocol to another protocol when the messages need to go from one partition to another partition.

As the government and consumer demands are increasing for many features such as safety, fuel efficiency, comfort, navigation, entertainment, telematics, multimedia and many more, future vehicles will have many more partitions. Each partition will take care of a particular type of application. All the partitions will need to be interconnected for exchanging mutually

Figure 1. An in-vehicle networking system with two partitions

- **Partition-1: Power-Train**
  - Anti-Lock Brakes Module
  - Engine Module
  - Transmission Module
  - Accident Avoidance Module

- **Partition-2: Body Electronics**
  - Instrument Module
  - Door Module
  - Climate Control Module
  - Lights Module

High-Speed CAN bus
Gateway Module
Low-Speed CAN or LIN Bus
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