Chapter 4
Vehicular Embedded System Architecture

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ABSTRACT

The dramatic advancement of IC technologies makes electronic devices be smaller and run faster, so they are able to implement more functions in a limited space. The car electronics play an increasingly important role in automobile industry, and the embedded system has already been extensively employed for improving the operation and performance of vehicles, such as safety, comfort, convenience, and energy consumption. In terms of electronic system, an automobile is a distributed embedded system, and the control messages to each electronic control unit (ECU), go through in-vehicle networks. An ECU is a computing system, integrated with a data acquisition module or an electromechanical driver. A variety of ECUs implement versatile functions, such as powertrain, antilock braking system (ABS), traction control system (TCS), adaptive cruise control (ACC), and electronic stability program (ESP), etc. Sensors provide measurements of specific vehicle parameters in a format suitable for the digital microcontroller, while actuators are electrically operated devices that drive electromechanical components. Human machine interface is the input and output of vehicle operations to users.

INTRODUCTION

Transportation of humans and objects have been playing an important role in our daily lives since civilization first formed and needed new means of reaching destinations. The invention of efficient transportation greatly reduced the time and labor once required and in addition largely extended the living environment that people can reach. The more time and labor for transportation is saved, the more leisure time people will have. Animal-power or natural resources have been the driving force of transportation for a long time. After the steam engine was invented, the automobile started a new era. The mass production of the Ford model T cre-

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ated the modern automobile industry and made the automobile more affordable.

The basic structure of the automobile has not changed much, but evolving technologies has kept improving its functions and performance. The construction of traffic networks and mass production of automobiles have made the automobile the most important land based transportation carrier. The usage of automobiles is usually associated with the growth of economy and industry of a nation, so the population ratio that owns automobiles in a developed country is larger than that in a developing country. When the economy grows, vehicle as a transportation tool becomes more affordable and popular, for instance China or India. When people use automobiles in their daily lives, they demand not only mobility, but also safety, comfort and convenience. These are some design factors that manufacturers have to put into aspect when enhancing functions by introducing and developing new technologies.

For a government to provide a modern transportation system, it has to build not only a traffic network, but also an infrastructure to access more information to allow drivers and passengers to drive safer, more comfortably and with better convenience on the road. This is the vision of an intelligent transportation system. To achieve this goal, both the infrastructure and vehicles have to be facilitated with a modern electronic and information system.

The evolution of an automobile shows more signs of adopting electronic devices. To enhance the features or performance, some mechanical components are replaced by wires and electronic devices, or simple electronic devices are enhanced by complex electronic control systems. An automobile consists of several control systems: power train, chassis, safety, body and information. Each system may have several subsystems distributed in different location of a car and are linked through in-vehicle networks.

Since most modern electronic devices digitize signals and process them by software, embedded systems are employed for data processing and control in an automobile. The dramatic advancement of IC technology, which is described by Moore's law, makes chips smaller, faster, and able to implement more functions. In terms of electronic systems, an automobile is a distributed embedded system, and the control messages to each distributed device go through the in-vehicle network. X-by-wire is becoming a new technical trend.

From a top-down viewpoint, the ultimate goal of transportation is to develop an intelligent transportation system. The basic mobile unit is a vehicle, which is interconnected to other vehicles or backend service providers through vehicle-to-vehicle or vehicle-to-infrastructure communications. The scope of this chapter is limited to the distributed embedded systems in a vehicle.

A vehicle consists of a variety of electronic control units interconnected through an in-vehicle network, while each unit is an embedded system involving processor and memory along with other optional sensors, actuators, storage devices or human machine interface.

SAFETY, COMFORT AND CONVENIENCE

Vehicles were developed for transportation. When vehicles become mandatory transportation tools in daily life, safety is the first issue. Road safety is related to the loss of human life and property and can be categorized into three areas: human, environment, and vehicle. Human and environment factors are out of the scope, and we will focus only on the vehicle. However, the enhancement for vehicle safety can sometimes compensate the inappropriate operation caused by human or environmental factors. Vehicle safety can be further separated into active safety and passive safety (Robert Bosch, 2006). The active safety mechanism is to prevent the happening of potential accidents, while passive safety is to