Preface

This book is the result of several years of study and practical experience in the design and analysis of communication systems based on the Controller Area Network (CAN) standard. CAN is a multicast-based communication protocol characterized by the deterministic resolution of the contention, low cost, and simple implementation. The CAN [16] was developed in the mid 1980s by Bosch GmbH, to provide a cost-effective communications bus for automotive applications. Today it is widely used also in factory and plant controls, in robotics, medical devices, and also in some avionics systems.

Controller Area Network is a broadcast digital bus designed to operate at speeds from 20 kbit/s to 1 Mbit/s, standardized as ISO/DIS 11898 [6] for high speed applications (500 kbit/s) and ISO 11519-2 [7] for lower speed applications (up to 125 kbit/s). The transmission rate depends on the bus length and transceiver speed. CAN is an attractive solution for embedded control systems because of its low cost, light protocol management, the deterministic resolution of the contention, and the built-in features for error detection and retransmission. Controllers supporting the CAN communication standard, as well as sensors and actuators that are manufactured for communicating data over CAN, are today widely available. CAN networks are successfully replacing point-to-point connections in many application domains.

Commercial and open source implementation of CAN drivers and middleware software is today available from several sources, and support for CAN is included in automotive standards, including OSEKCom and AUTOSAR. The standard has been developed with the objective of time determinism and support for reliable communication. With respect to these properties, it has been widely studied by academia and industry, and methods and tools have been developed for predicting the time and reliability characteristics of messages.

The CAN standard has originally been proposed for application to automotive systems, but with time emerged as a quite appropriate solution for other control systems as well. This book tries a general approach to the subject, but in many places it refers to automotive standards and systems. Automotive architectures and functions are also often used as examples and benchmarks. We hope this is not a problem for the reader and hopefully, the generalization of the proposed approaches and methods to other domains should not be too hard. On the other side, automotive systems are today an extremely interesting context for whoever is interested in complex and distributed embedded systems (including of course those using the CAN bus). They offer complex architectures with multiple buses and nodes with gateways, real time and reliability constraints and all the challenges that come with a high bus utilization and the demand for increased functional complexity.

This book attempts at providing an encompassing view on the study and use of the CAN bus, with references to theory and analysis methods, and a description of the issues in the practical implementation of the communication stack for CAN and the implications of design choices at all levels, from the selection of the controller, to SW development and architecture design. We believe such an approach may be of advantage to those interested in the use of CAN, from students of embedded system courses, to researchers, architecture designers, system developers, and all practitioners that are interested in the deployment and use of a CAN network and its nodes.

As such, the book attempts at covering all aspects of the design and analysis of a CAN communication system. Chapter 1 contains a short summary of the standard, with emphasis on the bus access protocol and on the protocol features that are related to or affect the reliability of the communication. Chapter 2 describes the functionality, the design, the implementation options, and the management policies of the hardware controllers and software layers in CAN communication architectures. Chapter 3 focuses on the worst case time analysis of the message response times or latencies. Chapters 4 and 5 presents the stochastic and statistical timing analyses. Chapter 6 addresses reliability issues. Chapter 7 deals with the analysis of message traces. Chapter 8 describes commercial tools for configuring, analyzing and calibrating a CAN communication system. Chapter 9 contains a summary of the main transport level and application-level protocols that are based on CAN.

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