INTRODUCTION

Everyone knows what time is, or at least how the word "time" is used in everyday language. Time is so much a part of our everyday experience that it has become a self-evident aspect of the world in which we live. One might expect that this familiarity with time would enhance the ability to relate it to the behavior of computing systems. In particular, the timing of input-output relations should pose no special problems. But a quick glance at the state of affairs in computer science tells us that, in sharp contrast to the alleged exactness of the discipline, there is little concern for descriptions of systems or programs that are exact with respect to time. Most of the attention devoted to time is directed toward speeding up the rate of data processing or developing time-efficient algorithms.

In 1966, the International Society for the Study of Time was founded in order to promote the study of time and to stimulate discussion and interdisciplinary meetings on the concept of time (Whitrow, [42]). While, contributions have been made from several disciplines, this activity has passed the computer science community without being noticed. In searching for publications in the area of computer science on the subject of time, one finds nothing of interest - with some minor exceptions (e.g., [1, 14, 30]). While time appears to be essential in the area of real-time systems, it has been largely neglected as an object of study.

As the development of real-time systems is changing from a craft to a discipline, the need for special tools and constructs to deal with timing constraints becomes apparent. So far, low-level mechanisms and ad hoc
programming concepts have been used for this purpose, while some efforts have been made to extend existing languages and specification formalisms to include time. Of course, within real-time languages there are constructs that use time as a parameter, but an integrated approach to the expression and enforcement of timing constraints is still lacking.

For reasons mentioned above, we feel that reflection on the role of time in real-time systems is necessary. A clear understanding of the reasons why and of the manner in which time is involved in specification and implementation is a prerequisite for a sound methodology in this area. Our concern is with the informal part of development of real-time systems and with some basic assumptions underlying computer science. Suggestions will be made to bridge the gap between theoretical and practical approaches in design and specification of real-time systems.

This chapter is divided as follows: The following section introduces the concept of time as far as is relevant for our purpose. In section "Requirements for Real-Time Systems" real-time systems will be characterized by their general requirements. In connection with these requirements, the treatment of time in the field of computer science is investigated in the section on "The Primitiveness of Time Concept in Computer Science"; we will demonstrate that the role of time is neglected and even suppressed. In the next section ("A Different Approach: The Pragmatic Value of Common Sense Concepts of Time"), a different approach will be taken in order to develop a concept of time that is adequate for the specification and design of real-time systems. The implications for specification of real-time systems are outlined in the ensuing section, and in section "Time Slot Based Synchronization" a method is presented that demonstrates how time can be used for synchronization purposes. A summary of the main argument is given in the final section.

THE CONCEPT OF TIME

This section is intended as a general introduction to the concept of time. The word "concept", as used here, refers to a logical entity that is open to analysis. A concept has meaning by virtue of its relation with other concepts and by the way it is used in speech. Many concepts can readily be defined within some scientific framework, but the concept of time eludes easy definition; this seemingly innocent, self-evident concept is notoriously difficult to capture in a description.