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Hermann Kopetz

# Data, Information, and Time

## The DIT Model

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# Foreword

In this interesting and challenging work, Herman Kopetz introduces his Data-Information-and-Time (DIT) model, which is a comprehensive and intriguingly elegant model of truth, communication, and meaning, parameterized by time instants of an absolute and ubiquitous real time. The author, Hermann Kopetz, is somebody who definitely knows his topic as an internationally highly respected top Computer Scientist and expert on real-time systems and as the main founder of TTTech, a world-leading provider of real-time solutions to the automotive and aviation industries.

The DIT model explains the difference between data and information according to the *signifier-signified* paradigm of Semiotics and gives a modern explication and formalization of the notion of the "signified" through the introduction of the notion of *information item*, abbreviated by *itom*. An itom is essentially a simple phrase with a clear meaning at any given point in time. The meaning of an itom is determined by its inner context, roughly, the activated brain patterns and its outer context, which are, roughly, the external circumstances, laws, social norms, and states of affair. The DIT model is put in relation with theories of brain science and with important fields of Computer Science, such as the Semantic Web and Real-Time Systems. The work is clear cut and illuminating. It will serve as a reference to many authors investigating related topics.

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Georg Gottlob

# Preface

The idea of gaining an understanding of the relationships between the fundamental terms *data and information* to *time* has been part of my thinking for many years. In 1979 I attended the *Newcastle Seminar on Teaching of Computer Science* [1], organized by *Brian Randell*, and listened to an inspiring lecture by *William Kent* on the *Future Requirements of Data Modelling*. This excellent lecture, and the subsequent study of Kent's interesting book on *Data and Reality* [2], raised more questions than answers about the *meaning of a data item* and the *sense,* i.e.*, the idea* that is communicated by a natural language sentence or by the result of a database query.

In most of my career I worked with *real-time computer systems*. In a real-time control system an observation of the physical environment can only be used for the control of a real-world physical process within a limited interval of physical time. There is thus the need for a model that explains the relationships among data, information, and the flow of physical time. I soon realized that the conception of such a model requires a much wider view than that provided within the silo of computer science. Only after I have moved to the state of an emeritus I found the time to pore over the domains of linguistics, cognition, philosophy, and the biological structure of our brain that are important if one wants to understand the relations among data, information, and time in depth.

This work aims to present a model—I call it the *data-information-and-time* (*DIT) model*—that clarifies the semantics behind the terms *data, information,* and their relations to the *passage of real time.* According to the DIT model *a data item* is a symbol the signifier of which appears as a *pattern* (e.g., visual, sound, gesture, or any bit pattern) in physical space. The *signifier* of the symbol is generated by a human or a machine in the *current contextual situation* and is linked to a concept in the human mind or a set of operations of a machine as its *signified*. *An information item* delivers the *sense* or the *idea* that a human mind extracts out of a given natural language proposition that is composed of meaningful *data items*. Since the given tangible, intangible, and temporal context are part of the *explanation* of a data item, a change of context can have an effect on the meaning of data and the sense of a proposition. The DIT model provides a framework to show how the *flow of time* can change the truth-value of a proposition. I compare the notions of *data*, *information*,

and *time* in differing contexts: in human communication, in the operation of a computer system, and in a biological system. In the final Section I present a few simple examples to demonstrate how the lessons learned from the DIT model can help to improve the design of a computer system.

Many discussions within the IFIP WG 10.4, in particular with John Rushby and Brian Randell, have created an important impetus to go ahead with this work. Special thanks go to Thomas Eiter, Frank Furrer, Georg Gottlob, Radu Grosu, Wilfried Steiner, and Neeraj Suri, who have provided very helpful comments to an earlier version of this work. My special thanks go to Paul Drougas, Senior Editor of Springer Nature, who supported this project in a most constructive way.

Vienna, Austria Hermann Kopetz
January 2022

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