Abstract  Enterprise models play a crucial role in the analysis of enterprises and constitute a basis for improvement or re-engineering. A great variety of description techniques exists, among them IDEF0 for function modelling and IDEF1X for information modelling. Both methods are FIPS standards. The methods are independent of each other but, as they may be used for a description of the same system, the need for merging of IDEF0 and IDEF1X models into one integrated model is obvious. A verification of correctness of integrated models is of paramount importance. This may be done by use of the formal description technique Estelle (ISO standard), commonly applied for specifications of computer network protocols.

Keywords  IDEF0 method · IDEF1X method · Estelle language · Models’ integration · Models’ correctness · Models’ conformity

Introduction

Enterprise models are of prime importance as a prerequisite for successful documentation, improvement or re-engineering of enterprises. A plethora of description techniques exists, among them a family of FIPS methods called IDEF are in use, particularly in projects sponsored by the U.S. federal government. Especially IDEF0—function modelling method and IDEF1X—information modelling method have gained great popularity, outside of the USA also. Both methods are graphical ones. Both are independent. Many separate software tools exist for them. But, as they may be used for a description of the same system, it is reasonable and required to merge both models into one in a clear, concise manner. Some already existing tools offer such a facility and the resulting model is called IDEF0/IDEF1X integrated model. However, the tools do not offer any mechanism to control if an integrated model has been constructed correctly. A formal description technique Estelle, stable ISO standard, may be applied for the verification of integrated models. The main, new idea is to convert both IDEF0 and IDEF0/IDEF1X models into specifications in Estelle and then to verify specific properties using the specifications. Verification criteria proposed for this may be divided into two groups: criteria of correctness and criteria of conformity. The former relates to the issue if the models are constructed in logical and non contradictory way. The latter concerns the problem if the models sufficiently precisely describe the systems modelled.

The paper is organised in the following way: IDEF methods of interest are concisely described in Section “IDEF Methods”; a brief description of Estelle is given in Section “Estelle language”; verification of IDEF0 models is discussed in Section “Verification of IDEF0 models”; verification of integrated models is presented in Section “Verification of IDEF0/IDEF1X integrated models”; a case study is described in Section “Case study”; the conclusion is given in Section “Conclusion”. 
IDEF Methods

IDEF0 method

IDEF0 (FIPS, 1993) is a function modelling method, and so called ICOM box is its basic concept. The box is composed of a rectangle representing some fragment of the enterprise activity—function—and of four types of arrows representing connections with surroundings; ICOM stands for Input, Control, Output and Mechanism, the names of connecting arrows. Function transforms inputs into outputs under the influence of a control, using the mechanisms provided. Inputs and outputs are information or physical objects. Controls activate or regulate or synchronise the function. Mechanisms are resources necessary to perform function. ICOM boxes are connected by arrows; outputs of one box can be inputs or controls of other boxes. An example of IDEF0 model is presented in Fig. 1. In this text IDEF0 models will be shortly denoted by M0.

For M0 models which consist of one box only, e.g. like the model in Fig. 1, all arrows are called border arrows. Boxes may be structured into other boxes with a higher level of precision. A0 box from Fig. 1 may be decomposed into two boxes—A1 and A2 (Fig. 2). Arrows among boxes are called internal arrows (in brief: arrows).

In the paper only M0 with at least one border input arrow and at least one border output arrow are considered.

IDEF1X method

IDEF1X (X for eXtended, because an extended version of the method is now in use) (FIPS, 1993a) is used to produce a graphical information model which represents the structure and semantics of information within a system. IDEF1X models are entity-relationship models composed of the following components:

- entities representing “the things of interest” about which data is kept, real or abstract, having the form of rectangles on diagrams;
- attributes representing characteristics of entities, shown on diagrams by listing their names into an entity rectangle;
- relationships representing relations between entities, shown in the diagram by lines connecting rectangles.

An example of IDEF1X model is shown in Fig. 3. In this text IDEF1X models will be shortly denoted by M1X.

Estelle language

Estelle, an ISO 9074 standard (ISO, 1997), is the commonly applied formal description technique for computer networks protocols. Estelle stands for Extended State Transition Model. Main notions in Estelle are: module, specification and channel. Module defines non-deterministic sequential transition system (automaton) with a finite number of control states. Specification is a distinguished, main module, which describes a hierarchically structured set of module instances. Module instances communicate among themselves by exchanging interactions through interaction points and two-directional links. Channel defines the kinds of interactions, that may be sent through the link in each