REVIEW OF STRUCTURED ANALYSIS AND SYSTEM SPECIFICATION METHODS

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Abstract: *After a presentation of a review of the design methods, we present some methods of structured analysis (SA, SADT and SA-RT) and the part of these methods on the system specification. Our contribution in this work consists in proposing a methodology that allows us to identify the tools of representations exploited by the methods of structured analysis and the differences that appear giving the advantage to one or the other of these methods. An application of the structured analysis on a line of high voltage is presented.*

Key words: *Structured analysis, System specification, Design Process, Line of high voltage.*

1. Introduction

Early in the system design process, a choice of a design method is usually dictated by what methods the designer has previously used, not by an open selection process.

Particular interest in the use of graphical modelling methods and techniques to aid changes in system operations and the interactions of staff to effectively build and use modelling for analysis, design and communication of systems in the manufacturing industry.

If a system is to be built, then the system must ultimately be described as a collection of state machines. However, these state machines are often not created by the systems engineers. The systems engineers use some method to create a high-level abstraction of the desired system. Then they turn this abstraction over to the specialty engineers who actually reduce it to a collection of state machines.

In this paper we provide descriptions of some available design methods particularly the methods used in structured analysis and examples of their use.

This paper can be loosely divided into five parts. First, we present a review of the design methods. Second, we present some methods of structured analysis. In order to deal with the issues involved in the system design process, we propose in the first hand a methodology of analysis of some models using the OOPP (Objective Oriented Project Planning) method and in the other hand an example of structured analysis of a line high voltage. The article ends with presenting likely innovating contributions in system design.

2. Review of the design methods

We present some studies of the design methods that have been presented in various researches:

Researcher, Andrew P. [1], discusses methodological design and evaluation frameworks that appear to have general applicability. The design methodology has specific relevance for the design of systemic process aids to the planning and the decision making and, potentially, to other system designs efforts as well. A five-phase iterative methodology is suggested. The author discusses objectives for systemic process aids, requirements to be accomplished in each of the five phases of the design methodology, and leadership requirement considerations as they affect the design of systemic process aids realized by use of the methodological design framework. A framework for evaluation of systemic aids is also presented. The resulting evaluation methodology may be incorporated into the design methodology or used independently to evaluate existing or proposed aids for planning, forecasting and decision support.

Researchers, Sénéchal O. & al. [2], have proposed a methodology consisting in a double modelling of the firm and an adapted tool intended to build and to exploit the models. The object is to support technical decisions about products, equipment, or about the organization of the firm. The application of the approach in a French industrial site is finally presented. In fact, cost management methods currently have to contribute to the decision support

for designers, production managers and manufacturers. This fact leads to the introduction of activity-based costing (ABC), but the exploitation of the concept of activity by non-specialists of accounting requires adapted models and tools.

Researchers, Xudong H. & al. [3], have presented several extensions to Petri nets based on their own research work and provide analysis techniques for these extended Petri net models. They have also discussed the intended applications of these extended Petri nets and their potential benefits. In fact, Petri nets are an excellent formal model for studying concurrent and distributed systems and have been widely applied in many different areas of computer science and other disciplines.

Researchers, Salminen V. & al. [4], have described experiences in designing intelligent machines and manufacturing systems. The multidisciplinary character of a mechatronic system creates special difficulties during design process. A model for carrying out design process of automatic production system is represented. Some guidelines in solving multidisciplinary problems in mechatronics are suggested.

Researchers, K. Dickers, & al. [5], have conceived a hierarchically structured model for simulating the capabilities and requirements of a power system in restorative periods for a good part, the model have been implemented. Major points in this task were the development of a new simplified long-term model for thermal plant and a predictor/selector algorithm applied for decoupling the multiple control loop of the comprehensive model.

Researchers, Makeechev V.A. & al. [6], have presented foundations of the optimization method intended for solution of power systems operation problems and based on the principles of functional modelling (FM). They have also presented several types of hierarchical FM algorithms for economic dispatch in these systems derived from this method. According to the FM method a power system is represented by hierarchical model consisting of systems of equations of lower (subsystem) levels and higher level system of connection equations, in which only boundary variables of subsystems are present. The key elements in the general structure of the FM method are functional characteristics of subsystems, which represent them on the higher level of the model as "black boxes".

Researchers, Hong-Tzer Y. & al. [7], have proposed a new fuzzy Petri Net (FPN) modelling technique to achieve the on-line service-restoration plan of the distribution system. Service restoration is a complicated combinatorial optimization problem that often has a great number of candidate solutions to be selected by the dispatchers. According to practical guidelines and experiences of the dispatchers on the service restoration of distribution systems, an FPN model is built to represent the related knowledge and inference scheme about the task of restoration. The proposed FPN model has been practically tested on a typical distribution system of Taiwan Power Company (TPC). Flexibility and effectiveness of the FPN model have been validated as a decision support for restoration scheduling of distribution systems.

Researchers, Santarek K. & al. [8], have described an approach to manufacturing systems design that allows automatic generation of controller logic from a high level system design specification. The high level system design specification was developed using SADT method and Design: IDEF software package. The interface is based on a number of transformation rules from an IDEF0 specification into a Petri net. A standard qualitative analysis and simulation of the Petri net is used to determine if the manufacturing system will operate in the desired manner.

Researchers, Ryan J. & al. [9], have proposed that a process modelling tool be developed specifically to support simulation requirements gathering. Then, a simulation process modelling tool called simulation activity diagrams is presented. In fact, many developments have taken place around supporting the model coding task of simulation, there are few tools available to assist in the requirements gathering phase of simulation. The authors have provided a selective review of some of the most important in relation to simulation. A conclusion from this review is that none of the tools available adequately supports the requirements gathering phase of simulation.

3. Methods of structured analysis

Specification of systems supposes two essential characteristics: temporal evolution of components of the system and interaction system - environment. Indeed, the complexity of relations between a system and its environment is especially verified in the domain of process conduct [10],[11].

Among the techniques of system specification, we mention the methods of analysis that permit to systematize and to canalize the various perceptions;

the languages of specification possessing syntax and a very definite semantics and languages of simulation.

In order to situate a system in its environment, we often have recourse to a general description of a process using a block diagram illustrating its various components and its ties representing the exchange of flux (Fig.1).
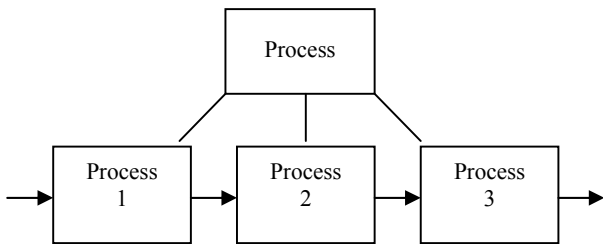

Fig. 1. Diagram block of a process.

A block diagram that permits to situate the system in its environment is insufficient to surround its various functions and their parameters.

In the functional strategy a system is seen like a whole of units in interaction, having a clearly definite function [12],[13]. Functions arrange a local state, but the system has a shared state, that is centralized and accessible by the whole of functions. Contrary to the most of the functional methods, the oriented object methods are methods of analysis and conception.

In the methods of structured analysis the highest level is called Diagram of Context. The box of Data Flows Diagram (DFD) represents a process and must be decomposed. Every process (or treatment) not decomposed is described by a "mini-specification"; a dictionary specifies the definition of data, processes and zones of storage.

3.1 SADT method

The SADT (Structured Analysis Design Techniques) method [14] represent attempts to apply the concept of focus groups specifically to information systems planning, eliciting data from groups of stakeholders or organizational teams. SADT is characterized by the use of predetermined roles for group/team members and the use of graphically structured diagrams (Fig.2). It enables capturing of proposed system's functions and data flows among the functions.
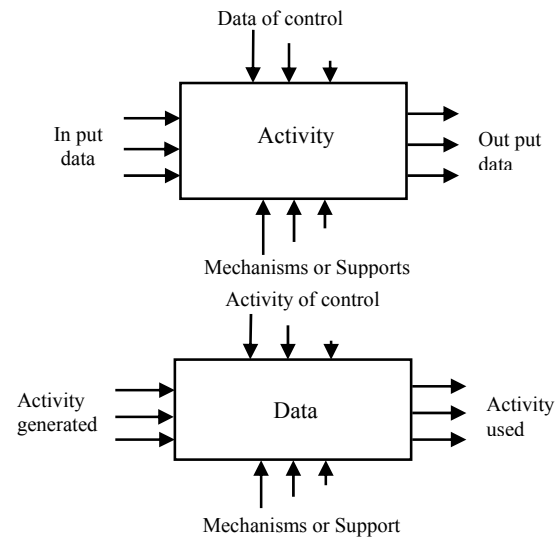

Fig. 2. Organization of the SADT model.

SADT, which was designed by Ross in the 1970s, was originally destined for software engineering but rapidly other areas of application were found, such as aeronautic, production management, etc.

SADT is a standard tool used in designing computer integrated manufacturing systems, including flexible manufacturing systems [15]. Although SADT does not need any specific supporting tools, several computer programs implementing SADT methodology have been developed. One of them is Design: IDEF, which implements IDEF0 method. SADT: IDEF0 represents activity oriented modelling approach (Fig.3).
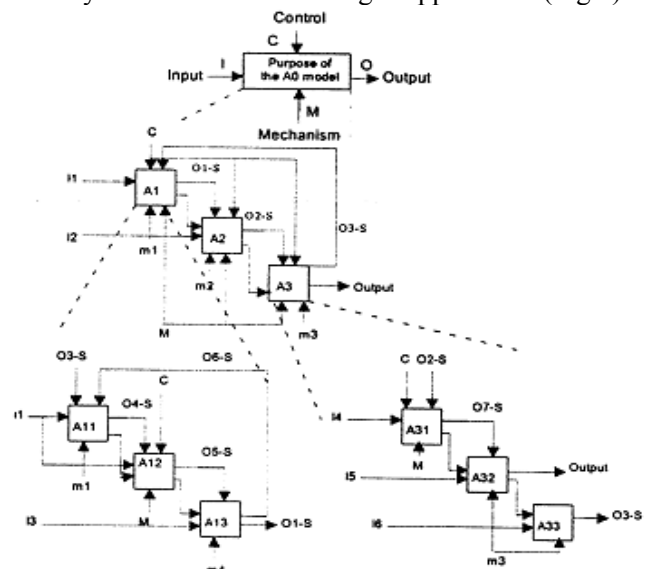

Fig. 3. Top-down, modular and hierarchical decomposition of SADT method.

IDEF0 representation of a manufacturing system consists of an ordered set of boxes representing activities performed by the system. The activity may be a decision-making, information conversion, or material conversion activity. The inputs are those items which are transformed by the activity; the output is the result of the activity. The conditions and rules describing the manner in which the activity is performed are represented by control arrows. The mechanism represents resources (machines, computers, operators, etc.) used when performing the activity.

The boxes called ICOM's input-control-output-mechanisms are hierarchically decomposed. At the top of the hierarchy, the overall purpose of the system is shown, which is then decomposed into components-subactivities. The decomposition process continues until there is sufficient detail to serve the purpose of the model builder. SADT: IDEF0 models ensure consistency of the overall modelled system at each level of the decomposition. Unfortunately, they are static, i.e. they exclusively represent system activities and their interrelationships, but they do not show directly logical and time dependencies between them. SADT defines an activation as the way a function operates when it is 'triggered' by the arrival of some of its controls and inputs to generate some of its outputs. Thus, for any particular activation, not all possible controls and inputs are used and not all possible outputs are produced. Activation rules are made up of a box number, a unique activation identifier, preconditions and postconditions.

For SADT diagrams or function boxes, we will consider two events to be representing the activation states of the activities. The first event represents the instant when the activity is triggered off, and the second event represents the ending instant [16].

SADT method has got several advantages:

- Large field of applications such as automation, software developments, management systems and so on.
- Facility and universality of the basic concepts.
- Existence of a set of procedures, advises and guidelines

3.2 SA method

SA (Structured Analysis) is a method enabling to create a logical model describing what must make a system without worrying of the how to make. The analysis structured of Tom DeMarco is based on

three main tools: Data Flows Diagram, Dictionary of data and mini-specifications [17].

The DFD of Tom DeMarco enables a static different function analysis that should assume the system. Some supplementary functionalities must there be add in order to satisfy the interpretation of the dynamic aspects of the system (Fig.3).
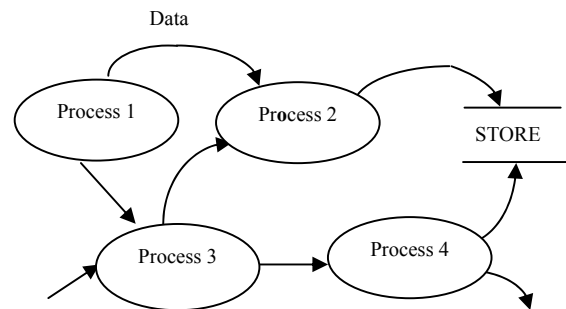

Fig. 4. Data flows diagram.

On a DFD are represented all the functions of a system: processes (symbolized by circles), data transformed by these processes (symbolized by arrows), units of data storage (represented by two parallel lines) and external elements to the system (symbolized by rectangles).

3.3 SA-RT method

SA-RT (Structured Analysis Real Time) [17] is a short name for Structured Analysis Methods with extensions for Real Time. The model is represented as a hierarchical set of diagrams that includes data and control transformations (processes). Control transformations are specified using State Transition diagrams, and events are represented using Control Flows. Thus, SA-RT [18],[19] is a complex method for system analysis and design. This is one of the most frequently used design method in technical and real-time oriented applications adopted by various Case-Tools. It is a graphical, hierarchical and implementation independent method for top-down development (Fig.5).

SA-RT method enables us to identify an entrance and an exit of data in an algorithm or a computer program. It is divided in three modules: Diagram of Context, Data Flows Diagram and Control Flows Diagram. Every module includes in its graphic interpretation different symbols.

Indeed, the Diagram of Context in the SA-RT method is going to enables us to identify a process in a program in relation to the entered and exits of data. This process can have different units. This process

will be able to be identified per seconds, in term of constant or variable but as this process will be able to be material type (Process interfacing).
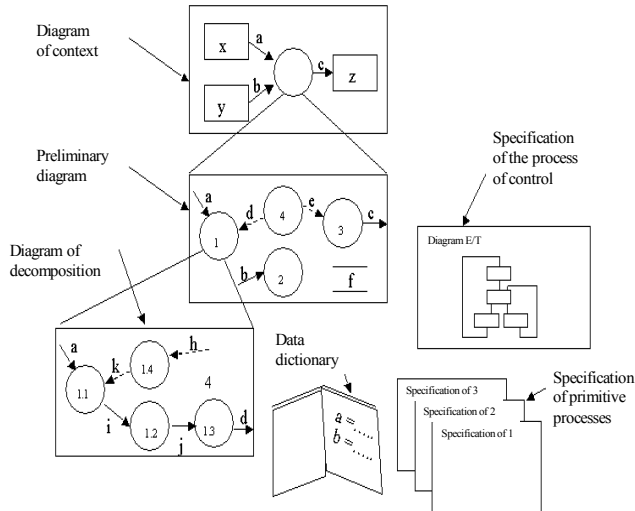

Fig. 5. Organization of an SA-RT model

The different symbols used in a Context Diagram of the SA-RT method are [20],[21]:

- The terminator is the element in end, final element that encloses the action.
- The flow of data is the final element that opens up on a last action.
- The flow of control is generally a tie back of the process toward the terminator. It can be a main element of the process.

The termination is generally a direct tie between a terminator and the process.

The DFD is an under-process of the Diagram of Context. One can analyze every element of the Diagram of Context and more especially terminators and flows of data. It is going to concern entrances and exits of process exclusively.

The Control Flows Diagram is the last stage of the SART analysis. The Control Flows Diagram represents in fact a summarized of the Diagram of Context and the DFD while integrating the new exits and entrances.

The Process of control is going to either define a function, a procedure or a place with its internal or external parameters. It can happen that a process of control corresponds to a structure. It can be carrier of parameters in the setting of function or procedure but it is especially a tie between the process of control and an under-process.

4. Approach of analysis of the SADT model

In this part, we present the different stages of a modelling using a method of structured analysis. In fact, we elaborated a methodology of analysis based on the use of the matrix of activities of the OOPP analysis.

In fact, the OOPP method which is also referred to as Logical Framework Approach (LFA) is a structured meeting process. This approach is based on four essential steps: problem analysis, objectives analysis, alternatives analysis and activities planning. It seeks to identify the major current problems using cause-effect analysis and search for the best strategy to alleviate those identified problems [22],[23].

The methodology of analysis proposed consists in exploiting the formalism of the OOPP method particularly the matrix of activities (Tab.1).

Tab. 1. Matrix of activities of the OOPP analysis.

N°	Code	Designation
1	GO	Global Objective
2	SO	Specific Objective
3	R	Result
4	A	Activity
5	T	Task

Table 2 presents the results of the analysis of the SADT model using the matrix of activities of the OOPP method.

This analysis enables us to identify three steps in order to create an SADT model:

- Creation of the diagrams of activities.
- Creation of the diagrams of data.
- Test of the quality of the diagrams of activities and the diagrams of data.

5. Case study: analysis of a line of high voltage

Electric power transmission is the bulk transfer of electrical energy, a process in the delivery of electricity to consumers. A power transmission network typically connects power plants to multiple substations near a populated area.

In fact, electricity is transmitted at high voltages (110 kV or above) to reduce the energy lost in transmission. Power is usually transmitted as alternating current through overhead power lines.

In this part, we present an application of a structured analysis method (SADT) on a process of

electric power transmission in order to determine the material of a line of high voltage.

Based on the approach of analysis presented (See Tab.2), a corresponding SADT model of actigrams of the process of electric power transmission type has been built. An important point must be noticed: the point of view of the analysis is that of a person without concrete experience on the power transmission, i.e. only through a bookish knowledge,

whose objective is the use of the final model for determining the material of line of high voltage.

So, this SADT model is composed exclusively of actigrams (Fig. 6-7). It starts with the main function 'To determine the material of a line of high voltage' (Fig.6). Then, this function is broken into sub-functions and this process is developed until the last decomposition level has been reached (levels A1, A2, A3 and A4).

Tab. 2. Analysis of the SADT model using a matrix of activities.

| N°	Code	Designation
1	GO	Essential model of the SADT method created
2	SO1	Diagrams of activities of the SADT method created
3	R1.1	Diagram A0 sketched
4	A1.1.1	To draw the interfacings arrows
5	A1.1.2	To create structure box / arrows
6	A1.1.3	To trace the A0 diagram
7	A1.1.4	To improve the A0 diagram
8	A1.1.5	To control the A-0 diagram in relation to the A0 diagram
9	R1.2	Select the box to decompose
10	A1.2.1	To prepare creation of the selected box
11	A1.2.2	To create the corresponding diagram to the selected box
12	A1.2.3	To sketch the diagram corresponding to the selected box
13	A1.2.4	To draw the interfacings arrows
14	A1.2.5	To create structure box / arrows
15	A1.2.6	To trace the diagram of activities of the selected box
16	A1.2.7	To improve the drawn diagram
17	A1.2.8	To control the drawn diagram in relation to box's mother
18	A1.2.9	To establish list of the activities
19	A1.2.10	To regroup the activities of the list by family
20	A1.2.11	To establish the list of all data transported on arrows
21	A1.2.12	To identify the activities of the list using a matrix
22	A1.2.13	To regroup the activities using a matrix
23	SO2	Diagrams of data of the SADT method created
24	R2.1	Diagram D0 sketched
25	R2.2	Creation of the selected box prepared
26	SO3	Test of the quality of the diagrams of the SADT method
27	R3.1	Verification of the factor of amplification done
28	R3.2	Verification of the respect of the point of view done
29	R3.3	Verification of the goal done
30	R3.4	Verification of the balance of levels detail done
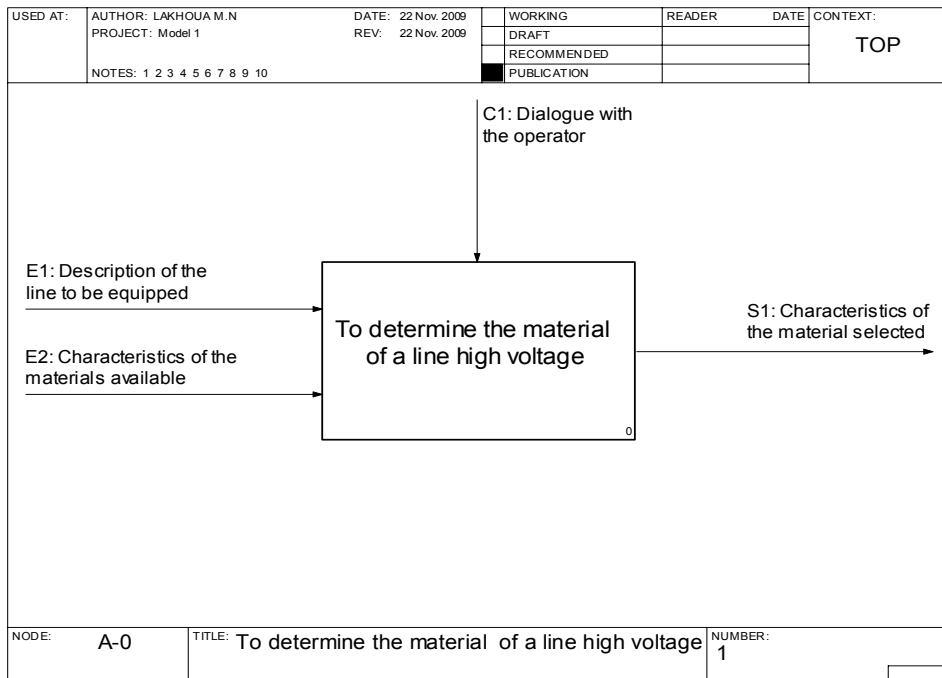
Fig. 6. Node A-0 of the SADT model.
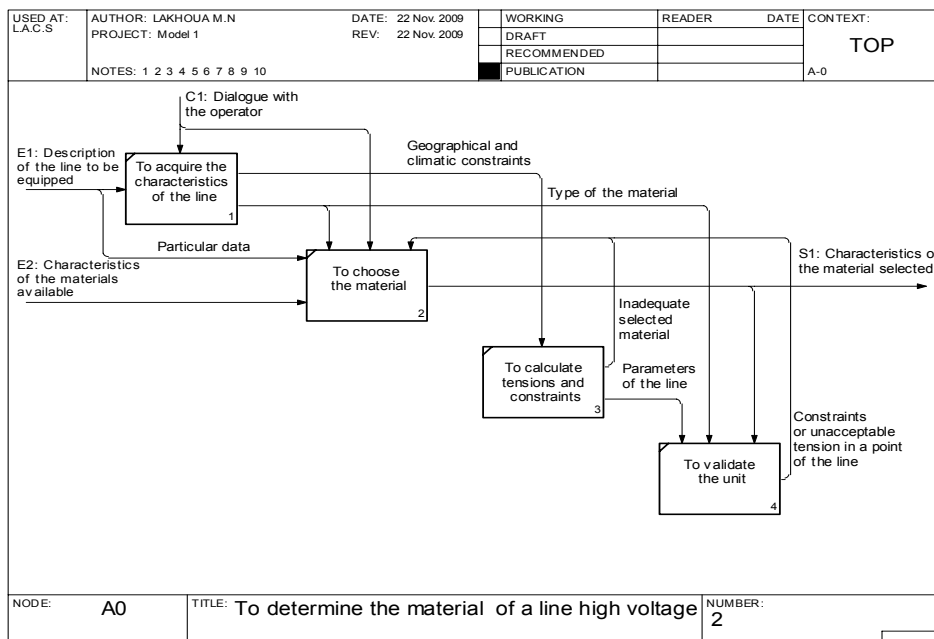
Fig. 7. Node A0 of the SADT model.

Recall that the techniques such as SADT are semi-formal. By consequence, for the same subject, different correct models can be built without having to know with certitude which model is the good or, at least, the best. In fact, this kind of model allows lets users sufficient freedom in its construction and so the subjective factor introduces a supplementary dimension for its validation. That is why the validation step on the whole necessitates the confrontation of different points of views.

As to the SADT technique, users can follow rules or recommendations to the level of the coherency of the model, such as distinction between the different types of interfaces, numeration of boxes and diagrams, minimal and maximal numbers of boxes by diagram, etc. One intends, by coherency application of the heritage rule i.e. when data are placed at a N decomposition level, it is explicitly or implicitly present at the inferior levels. However, a complementary mean to check coherency of actigrams is a confrontation between actigrams and datagrams, which is not possible in our case.

For the SADT box, there is the function (verb to infinitive) and around this box, the associated data are specified of which the nature (input, output, control or mechanism) appears directly.

6. Conclusion

In this paper, we presented different methods of structured analysis. The approach proposed consists in identifying the tools of representation used by these methods and the differences that appear giving the advantage to one or the other of representations.

In order to lead to high-quality products at low costs with shorter cycle times, a number of production systems are forced to consider various new product design and management strategies. In fact, enterprise modelling is currently in use either as a technique to represent and understand the structure and behavior of the enterprise, or as a technique to analyze business processes, and in many cases as support technique for business process reengineering.

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