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Methodology for the Upgrading and the Automation of Industrial Systems: Case Study

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The aim of this paper is to present firstly the issues involved in designing automated systems, and secondly to present a methodology for the upgrading and the automation of industrial systems. Two interesting methods of analysis have been applied, SADT (Structured Analysis and Design Technique) and OOPP (Objective Oriented Project Planning) on a process, an example a grain silo. These methods allow a systemic analysis of industrial processes. The paper briefly discusses the design of industrial systems and some advantage of the application of systemic analysis for the upgrading and the automation of industrial systems. Then the basic principles of the two methods applied on the grain silo are presented. Finally, the different results obtained from the two methods are discussed.

Keywords: Systemic methods, Automated systems, Information System.

1. INTRODUCTION

The design of industrial systems and the development of the information system become closely linked to the industrial system environment and to the automation task. This is especially true in the case of the methodologies used in the upgrading and the automation of industrial systems. The transition into an automated system is often an awkward process. Part of this problem consists in the lack of standard tools for the translation of industrial systems into automated systems.

The present work describes a methodology of upgrading and automation supporting the design of an industrial system. This methodology is based on the use of participative methods. The high level system design specification was developed with the use of the methods SADT (Structured Analysis and Design Technique) and OOPP (Objectives Oriented Project Planning).

This paper can be loosely divided into five parts. First, we present the methodology of designing automated systems. Second, we present the issues involved in upgrading industrial systems. Third, we present the methods used to enhance participation in Information System planning and requirements analysis. In order to deal with the issues involved in the upgrading process, we present a case study of a grain silo that we propose to apply on the SADT and OOPP methods which aims both to characterize and model the operational architecture, and to validate the proposed methodology supporting the design of the automated system. The article ends with presenting likely innovating contributions in designing automated systems.

2. DESIGNING AUTOMATED SYSTEMS

Automated system design involves constructing three distinct classes of architecture [1]:

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The functional architecture of the automated system is built according to the functional specifications and represents the links and interactions between the system's diverse functions. The model of this architecture is composed of the elementary functions that are found when the main functions are decomposed.

The equipment architecture reflects the choices made concerning the components, macro systems or communication devices that are incorporated into the system. These choices can be improved in order to satisfy the dependability criteria. The operational architecture is established by projecting the functional architecture into the equipment architecture.

The operational architecture must be validated in terms of the objectives stated in the functional specifications, such as dependability, performance, and cost objectives. If the objectives are not accomplished, the feed-back loop existing between activities 6 and 1 (Figure 1) provides information that can be used to improve system performances, by modifying for example the model's functions or by facilitating decisions about making certain components redundant or integrating other more reliable components. Hence, if the architecture includes equipment with integrated functions, a partial specification has already been done by the equipment designers.

The figure 1 presents a methodology for designing automated systems. In fact, the boxes 1 and 2 are related to the functional architecture; the boxes 3 and 5 are related to the equipment architecture and the boxes 4 and 6 are related to the operational architecture.

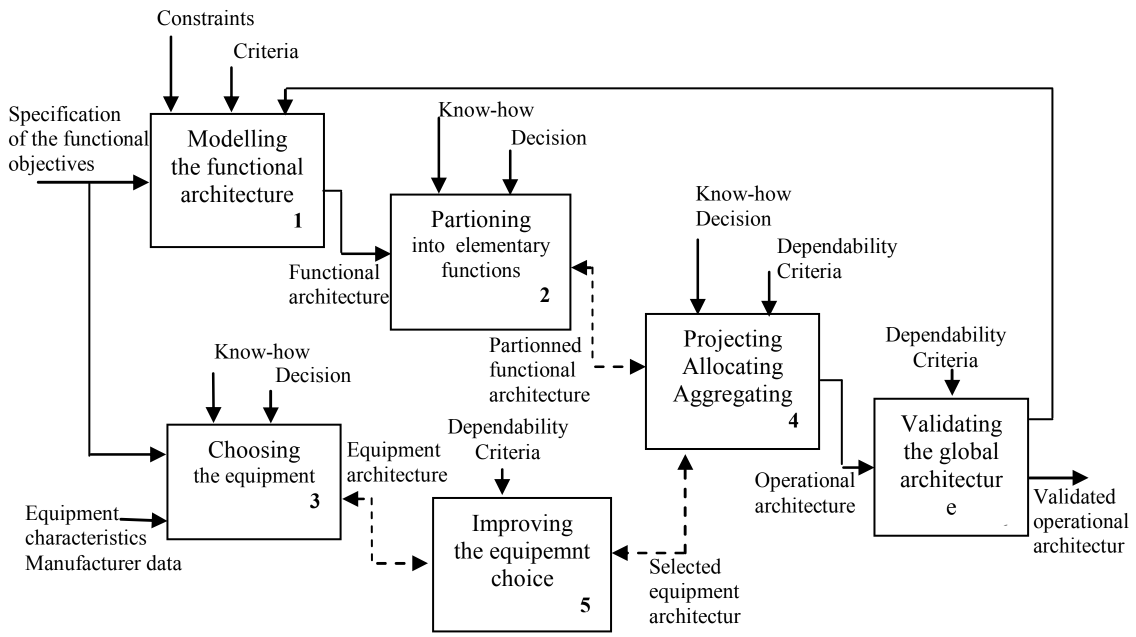

Figure.1. Methodology for designing automated systems.

All the system's equipment is heterogeneous, and cannot be supplied completely by a single source. Because the equipment serves as a host for part of the distributed application, it must be configured, downloaded, and organized as a whole entity, using compatible and interoperable functions.

The design of an automated systems must not only take into account the parts of a system (software and equipment), but must also consider the system as a whole, which means deciding how the software will be allocated into the equipment, including allocating tasks and controlling data processing, data access, and distributed time references.

3. METHODOLOGY FOR UPGRADING AND AUTOMATION

According to the methodology for designing automated systems outlined above, our goal is to adopt a TQM methodology of upgrading industrial systems and to validate it through a practical case study of a grain silo. The different steps of the adopted methodology of upgrading and automation of industrial systems and their chronological events are:

- **Step 1:** Initialisation of the process of upgrading of the industrial system according to the OOPP formalism.
- **Step 2:** Preliminary definition of different functions of the industrial system and constitution of the different commissions according to the defined functions. The participants at a commission must be chosen by speciality. The results of the works of each commission must be presented in a dedicated Workshop and a preliminary validation must be done.
- **Step 3:** Coherence of the different works of the dedicated Workshops by a Total Quality Cell.
- **Step 4:** Presentation of the dedicated functions and global validation of the activities of each function of the industrial system.
- **Step 5:** Determination of the operational parameters of the analysis, particularly the delimitation of the responsibilities of the diverse activities of the industrial system.
- **Step 6:** Using SADT method to delimit the domain of the industrial system and to identify the four parameters (Input-Control-Output-Mechanisms).
- **Step 7:** Elaborating a global architecture of the automated system, a working algorithm, an order diagram and a GRAFCET.
- **Step 8:** Simulation that can be achieved either while using equipment that enables us to illustrate a given function or a set of functions while developing a dedicated computer simulator.
- **Step 9:** Determining the dimensionality and the choice of the technology and the necessary programmable automaton features as well as the operator's desks of the global supervision system. These choices take into account the technological evolution, the availability on the market, the industrial references and the quality as well as the cost.
- **Step 10:** development of the loads notebook in order to submit it to the decision-maker for approval.

4. PRESENTATION OF THE METHODS

In this part, we present the participative methods literature and particularly the two methods SADT and OOPP used in this research.

4.1. Participative methods literature

There are many methods that have been used to enhance participation in IS planning and requirements analysis. We review some methods here because we think they are fairly representative of the general kinds of methods in use. The methods include Delphi, focus groups, multiple criteria decision-making (MCDM), total quality management (TQM), SADT and OOPP.

The objective of the Delphi method [2] is to acquire and aggregate knowledge from multiple experts so that participants can find a consensus solution to a problem. A second distinct method is focus groups (or focused group interviews) [3]. This method relies on team or group dynamics to generate as many ideas as possible. Focus groups have been used for decades by marketing researchers to understand customer product preferences.

MCDM [4] views requirements gathering and analysis as a problem requiring individual interviews. Analysts using MCDM focus primarily on analysis of the collected data to reveal users' requirements, rather than on resolving or negotiating ambiguities. The objective is to find an optimal solution for the problem of conflicting values and objectives, where the problem is modelled as a set of quantitative values requiring optimization.

TQM is a way to include the customer in development process, to improve product quality. In a TQM project, data gathering for customers needs, requirements elicitation may be done with QFD [5].

The SADT and OOPP methods 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. It enables capturing of proposed system's functions and data flows among the functions [6],[7]. The OOPP method is used to enhance participation in IS planning and requirements analysis. It has become the standard for the International Development Project Design [8],[9].

4.2. SADT method

SADT is a standard tool used in designing computer integrated manufacturing systems, including flexible manufacturing systems [10]. 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. 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. Preconditions and postconditions describe what is required for and what results from the activation. Both preconditions and postconditions are logical expressions of ICOM codes, where each ICOM code identifies a single control, input, output, or mechanism arrow for that particular box. When an ICOM arrow does not participate in activation, it is simply omitted from the precondition. Similarly, when some of the outputs of a box are produced during activation, the ICOM codes for those outputs not generated are omitted from the postcondition. A precondition expresses the required presence (or absence) of any of the objects associated with the inputs, controls, outputs, or mechanisms involved in the activity. A post condition indicates presence (or absence) after the activity has occurred.

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.

We present, in an in exhaustive manner, some studies of the SADT method with an industrial character that have been presented in various researches:

Researchers, Santarek K. & al. [11], 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, Benard V. & al. [12] have developed and proposed the Safe-SADT method. This method allows the explicit formalization of functional interactions, the identification of the characteristic values affecting the dependability of complex systems, the quantification of the reliability, availability, maintainability, and safety (RAMS) parameters of the system's operational architecture, and validation of that operational architecture in terms of the dependability objectives, and constraints set down in the functional requirement specifications (FRS).

Researchers, Lauras, M. & al. [13] have proposed an approach based on enterprise modelling tools (GRAI, SADT/IDEFO) that allows integrating the best practices defined by these methods. Besides the indicators following through the results and determinants, three types of indicators are introduced to analyse the performance: the facility viewpoint measures, the appropriateness of the resources available with the determinants of the activity. The ambition viewpoint evaluates with the determinants the feasibility of the aims assigned to the activity. The reality viewpoint measures the impact of determinants on the results of the activity.

4.3. OOPP method

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 [8].

The first step of "Problem Analysis" seeks to get consensus on the detailed aspects of the problem. The first procedure in problem analysis is brainstorming. All participants are invited to write their problem ideas on small cards. The participants may write as many cards as they wish. The participants group the cards or look for cause-effect relationship between the themes on the cards by arranging the cards to form a problem tree (Figure.2).

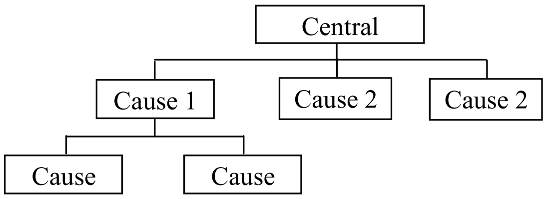

Figure.2. Problem tree of the OOPP method.

In the step of "Objectives Analysis" the problem statements are converted into objective statements and if possible into an objective tree (Figure.3). Just as the problem tree shows cause-effect relationships, the objective tree shows means-end relationships. The means-end relationships show the means by which the project can achieve the desired ends or future desirable conditions.

The objective tree usually shows the large number of possible strategies or means-end links that could contribute to a solution to the problem. Since there will be a limit to the resources that can be applied to the project, it is necessary for the participants to examine these alternatives and select the most promising strategy. This step is called "Alternatives Analysis". After selection of the decision criteria, these are applied in order to select one or more means-end chains to become the set of objectives that will form the project strategy.

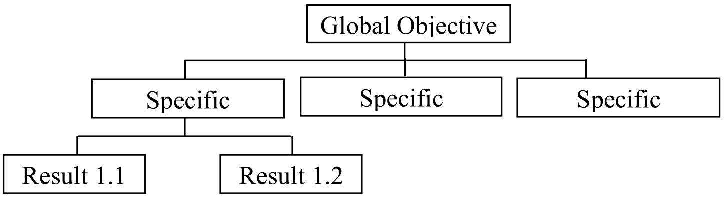

Figure.3. Objective tree of the OOPP method.

After defining the objectives and specifying how they will be measured (Objectively Verifiable Indicators: OVIs) and where and how that information will be found (Means of Verification: MOVs) we get to the detailed planning phase: "Activities Planning". We determine what activities are required to achieve each objective. It is tempting to say; always start at the situation analysis stage, and from there determine who are the stakeholders.

We present some studies of the OOPP method in Information System planning that have been presented in various researches:

Researchers, P. Gu & al. [14] have presented an object-oriented approach to the development of a generative process planning system. The system consists of three functional modules: object-oriented product model module, object-oriented manufacturing facility model module, and object-oriented process planner.

Researcher, Peter S. Hill [15] has question the appropriateness of highly structured strategic planning approaches in situations of complexity and change, using the Cambodian-German Health Project as a case study. He has demonstrated the limitations of these planning processes in complex situations of high uncertainty, with little reliable information and a rapidly changing environment. He has recommended changes that shift the focus away from planning towards informed strategic management, which monitors the changing environment and is given freedom to respond to emerging risks and opportunities.

Researchers, Peffers K. & al. [16], have used information theory to justify the use of a method to help managers better understand what new IT applications and features will be most valued by users and why and apply this method in a case study involving the development of financial service applications for mobile devices.

5. PRESENTATION OF THE PRACTICAL CASE OF A GRAIN SILO

In Tunisia, the cereals production (Durum wheat, Soft wheat, Barley, etc.) is widely tributary of climatic conditions. The needs are known (3 millions of tonnes per year) and increase regularly at the rhythm of consumption evolution. The quantities produced are very variable (0.4 millions of tonnes for dryness years and 2.5 millions of tonnes for good years). The deficit is satisfied by the importation [17].

In order to regulate the product alimentary market destined for the consumption, it's necessary to adapt the conditions of production, consumption, storage and transformation of cereals. In fact, a storage system of cereals constitutes a cereal transit process coming from a local or an exterior destination in order to be conveyed to a transform, storage or a consumption place.

The different constraints are economic (offer and demand), social and climatic ones. Hence, a storage system of cereals must be reliable in order to improve the quality of its services and to optimize its costs. Its organisation and management system must be reliable. Thus, a global approach of upgrading and automation is necessary.

According to the methodology of Upgrading and automation proposed, we present in this part the results of the analysis and the modeling of the grain silo activities using SADT and OOPP methods, on the first hand and the automation of the equipment of the grain silo, on the other hand.

Because of the evolution of the socio-economic context of the country after the process of globalisation and partnership particularly with the European Union, the managers have inscribed in their priorities the upgrading of the different grain silos [18].

In most situations, a grain silo already existing, conditioned by its history, its culture and its context is in difficulty facing the necessity to restructure itself in an organizational and technological environment in perpetual evolution. This is how all operations of upgrading and automation first of all require a diagnosis based on a various function analysis. This global analysis exploits the various available documents (legal texts, balances, reports, etc.) on the one hand and takes in consideration various testimonies through investigations, the interviews or the collective workshops on the other hand. It also takes observations through visits as a basis and even of the specific operations. The exploitation of this diagnosis enables to elaborate the project of restructuring thereafter.

In order to establish the upgrading model of a grain silo situated in Bir El Kassâa (near to Tunis), we proceeded at first to the instruction of the situation close to the managers according to a Brainstorming approach; secondly, we exploited an existing analysis done by the Supporting Comities constituted in the enterprise [19]. This analysis was achieved according to a participate approach associating the diverse structures of the enterprise directly concerned by the activities of the grain silo and adopting an environment of Quality Circle.

After proposing to adapt a systemic approach exploiting notably the OOPP method to analysis the activities of the grain silo [20],[21], we organized a series of production Workshops which are implicating all the bodies concerned. Thus, various workshops have been organized to make the diagnosis and to identify the various functions of a grain silo. In fact, in addition to the classic functions (exploitation, maintenance, management of stock, quality produces, common services), the function "Insurance Quality and Information System" has been instituted.

The first Workshop enables us to identify the basic functions, the defined participants of the dedicated Workshops for each function and to establish a first planning. Then, during these Workshops diverse validations and adjustments are done. The dedicated Workshops enable us to exploit the Resource Persons expertise in order to describe logically and hierarchically the diverse functions activities.

6. APPLICATION OF THE SADT METHOD

Based on the description of the grain silo, a corresponding SADT model has been built. So, this SADT model composed exclusively of actigrams (Figures 4–5). It starts with the main function 'To stock cereals' (Figure 4). Then, this function is broken into sub-functions and this process is developed until the last decomposition level has been reached (levels A1, A2and A3).

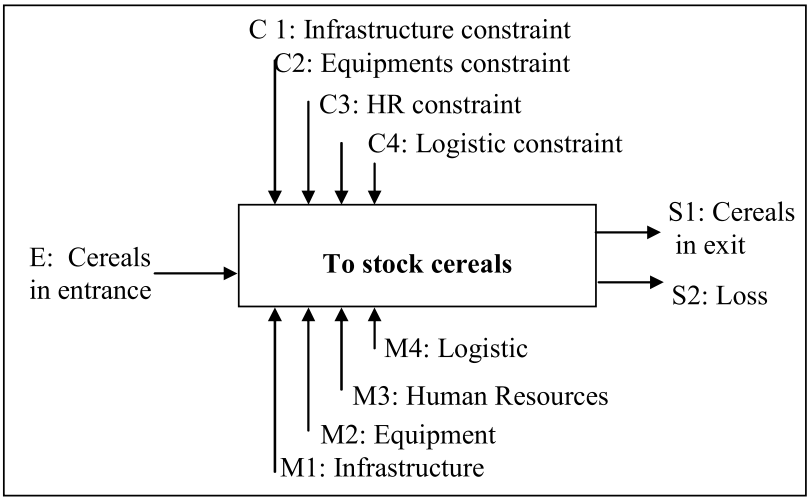

Figure.4. Node A-0 of SADT model.

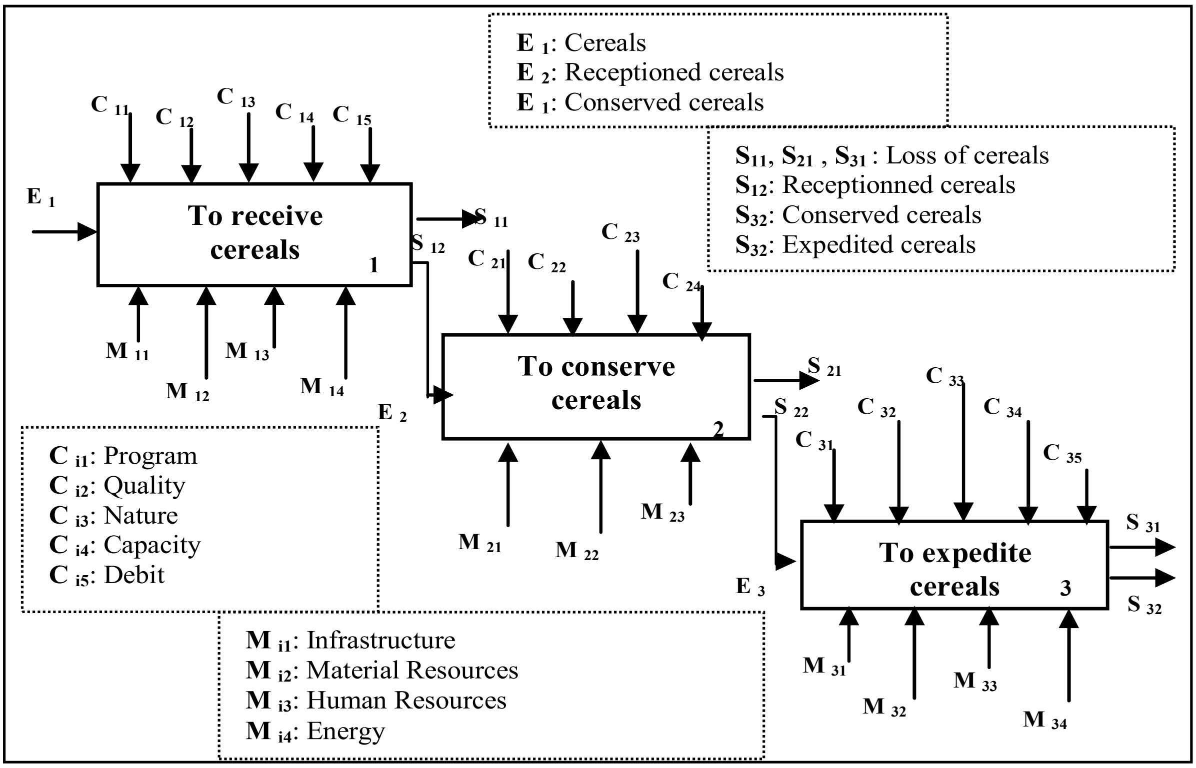

Figure.5. Node A0 of SADT model.

Recall that the methods 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. Indeed, few rules often remain; only some recommendations can be applied:

- As to the SADT method, 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.
- 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. However, despite the differences between these two techniques, the models built supply roughly the same quantity of information: most of the functions are both developed and only a function, such as the function linked to the membrane vessel, appears only through the FAST model.

The possible uses for the SADT model are the design of a monitoring display and a diagnosis display. For the design of a monitoring display, the A0 level of this model supplies a global view of the system. Indeed, information relative to each function represented through this level should appear in a monitoring display.

For the design of hierarchical diagnosis displays, each actigram of the SADT model constitutes a vision at a given abstraction level. So, each of these actigrams gives a less or more detailed vision. In function of the objectives defined by the designer for each display, a particular actigram can supply the required information.

7. APPLICATION OF THE OOPP METHOD

After an SADT analysis of the grain silo, we applied a different method of systemic analysis: the OOPP method. In fact this method enables us to identify six Specific Objectives corresponding to the basic functions of the grain silo (exploitation, maintenance, quality product management, management of the common services, TQM and Information system). The analysis of these Specific Objectives enables us to identify 14 Results and more then 1700 activities. The table 1 presents the different Specific Objectives (SO) and the Results (R).

In order to design the responsible of each activity, we adopted the structured analysis elaborated using the two methods SADT and OOPP after its validation and we proceed to identify the responsible of the activities and their collaborators for the functions in the grain silo.

The global analysis using the OOPP method allows us to answer clearly to the questions « what ? » and « who? », and allowed the establishment of the post record and the elaboration of the grain silo chart notably by the specification of the responsible of the activities and their collaborators. The answer to the question « how? » enables us to elaborate the procedures and the answer to the question « when? » enables us to establish the planning of the actions and finally by answering to the question « where? » we determine the frontiers of a post.

The "TQM and Information system" function gives extent to the informational process that is the base of the success of a management mode and of its efficiency degree. Thus, this process of upgrading allows us to give more of transparency to the different activities of the grain silo.

Table.1. Analysis of the different functions of a grain silo using OOPP method.

N°	Code	Designation
1	GO	Functions of the grain silo defined
2	SO1	Exploitation of the grain silo assured
3	R1.1	Planning of the exploitation of the grain silo assured
4	R1.2	Realisation of the operations assured
5	SO2	Maintenance of the grain silo assured
6	R2.1	Planning of the maintenance of the grain silo assured
7	R2.2	Intervention assured
8	R2.3	Management of the material resources assured
9	SO3	Management of the stock assured
10	R3.1	Programme of the movement of the cereals established
11	R3.2	Movement of the cereals recorded
12	R3.3	Reporting elaborated
13	SO4	Function of cereals quality management assured
14	R4.1	Evaluation of cereal quality assured
15	R4.2	Preservation of cereal quality assured
16	R4.3	Amelioration of cereal quality assured
17	SO5	Function of Common services management assured
18	R5.1	Administrative management of the personnel assured
19	R5.2	Formation management assured
20	R5.3	Financial and Book-Keeping management assured
21	SO6	Function of assurance quality and information system defined
22	R6.1	Function of assurance quality defined
23	R6.2	Information system efficient

According to the methodology of analysis using the OOPP method outlined above, we identified four Specific Objectives in order to reach the Global Objective (automation of the equipments of the grain silo). These Specific Objectives are: Survey of the project of the automation; Definition of the equipment; Elaboration of the loads Notebook; Realization of the automation solution (Table 2).

Following the OOPP analysis and the identification of the different information allows us to fix the characteristics of the automatons to install thus, and to elaborate the architecture of the automation solution adopted.

8. AUTOMATION OF THE GRAIN SILO EQUIPMENTS

After identifying the stations of production and consumption of information which enable the dimensioning and installing a LAN Network covering the totality of the space of a grain silo, a particular importance has been granted to the automatic control of various equipment of the handling and the storage of a grain silo. Hence, we focused on the automation of the Tabular Room of the grain silo while considering it like an Information system characterized by the information in entry (coming from the sensors or through the network), of information in exit (destinies to the auctioneers or to the administrators) and of the information circulating inside (signalling, synchronization).

Table.2. Analysis of the automation of the equipment of a grain silo using OOPP method.

N°	Code	Designation
1	GO	Automation of the equipment of the grain silo assured
2	OS1	Survey of the project of the automation achieved
3	R1.1	Diagnosis of the existing assured
4	Ri1.1.1	Observation of the work stations done
5	Ri1.1.2	Documentation collected
6	Ri1.1.3	Analysis of the existing done
7	R1.2	Scripts of working identified
8	Ri1.2.1	Different scripts of loading identified
9	Ri1.2.2	Different scripts of discharge identified
10	Ri1.2.3	Different scripts of transit identified
11	R1.3	Final report elaborated
12	OS2	Definition of the equipment assured
13	OS3	Loads Notebook elaborated
14	OS4	Realization of the automation solution assured

Following the system analysis and the identification of the different information enabled to fix features of the automatons to install, and to elaborate the architecture of the automation solution adopted.

We could determine a possible routing circuit of a cereal product automatically. The operator must take into account the equipment availability between a selected source and a destination storage cell of cereals. Once the validated circuit is chosen, different procedures of control and command of the equipment are done. This strategy of automation gives the possibility of throwing several routing circuits at the same time. It can be applied to all groups and according to all possible scripts with the possibility of managing several circuits at the same time.

The GRAFCET of conduct (Figure.6) assures the management of the fashion of working identified from the GEMMA, the operator can hire either a manual march (step105: manual order validation), either a march AUTO (step101) that activates the GRAFCET of preparation or the one of coordination of the tasks. If a defect is detected, it will be signalled to the operator, in the contrary case, after the end of cycle, an order of active draining the GRAFCET.

In order to benefit from a high level of reliability, a good mastery of the process, a help to the regulating and of the maintenance as well as a dynamic management, we finalized several scripts of architecture that answer these requirements. We chose a solution of automation that seems to us better then the adapted one to the elaborate functional decomposition (Figure.7).

An automaton is charged to manage the whole handling process (carriers, elevators, etc.), a second automaton is reserved to manage the measures (temperature, humidity, level, etc.) and the control system. The distant modules Input/Output are connected to these automatons via the BusX. They are foreseen in order to minimize the wiring. We foresaw a redundant configuration in order to assure a system tolerating the breakdowns a very big availability.

A normal/help configuration offers a regulation without to stroke in case of breakdown of an element or interruption of the source of food. One of the automatons of the configuration present the primary automaton role; while the other is considered in reserve, ready to take possession of the link of the Input/Output in a completely transparent way. This configuration guarantees a maximal working time.

The automatons are connected to Ethernet offering an open communication "transparent factory" enters automatons, and benefiting from the network available LAN on site. We also foresee an Input/Output block distributed situated on the same network of automatons and marked by its IP address offering flexibility. Thus, in that case one wants to incorporate new elements to control the process of handling.

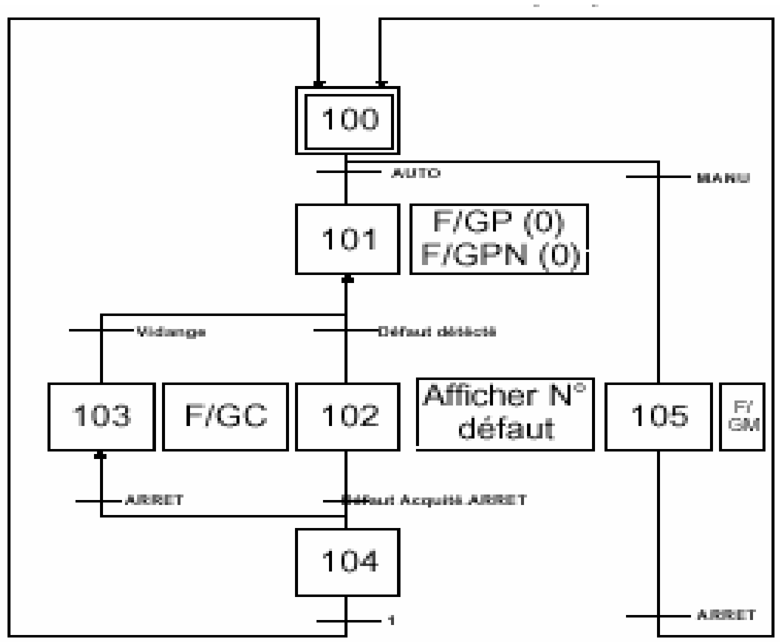

Figure.6. GRAFCET of conduct of the automation solution.

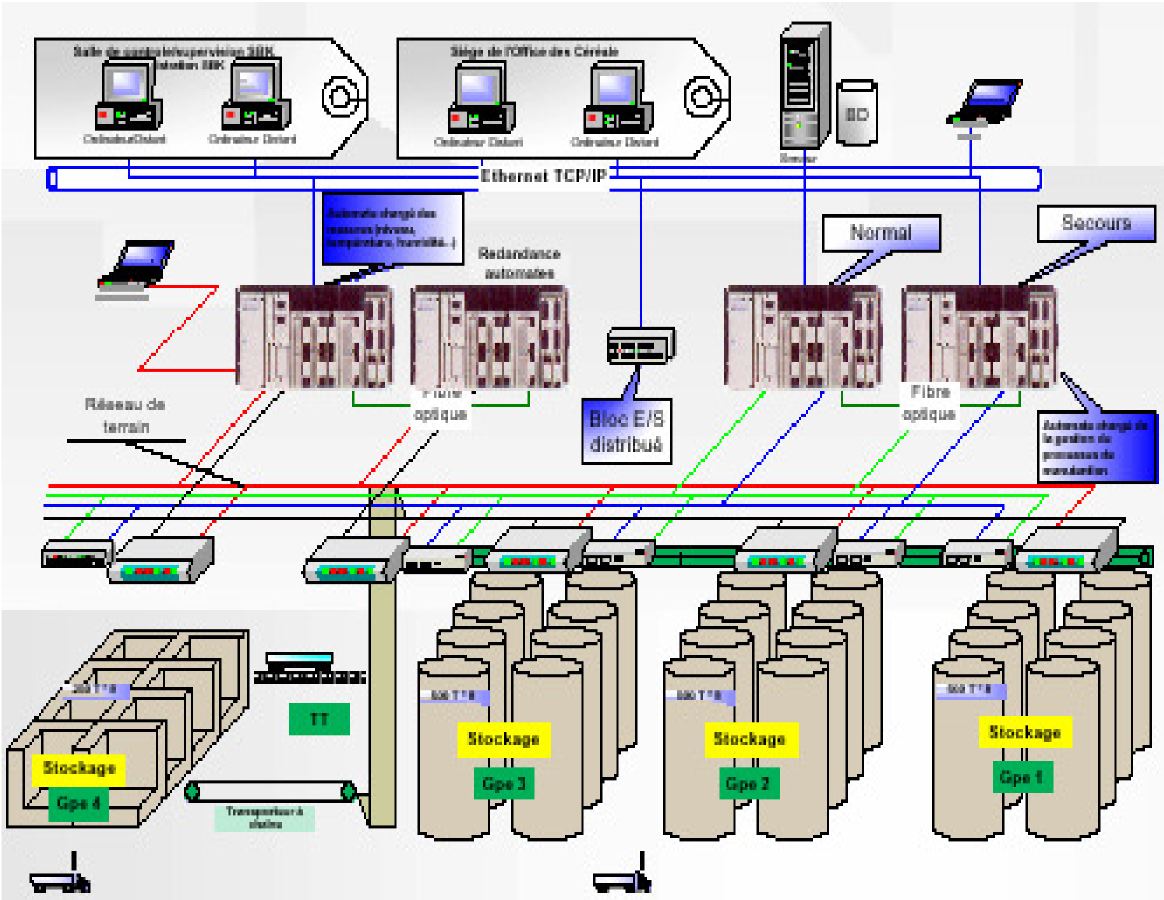

Figure.7. Architecture of the automation solution.

The set of the process is managed by a supervision system. The main screen of automation solution allows the operator to choose one fashion of cereal handling (Reception, Expedition or Transfer) and to reach the list of the shortcomings in case of a signalling by an alarm. The information on the state of the cells can be visualized at all times by simple click on the cell needed from the screen of exploitation. Thus, a selection of the function Receipt gives access to the screen, the operator can select the cell (unit of storage) of destination specific to a group as well as the source of the receipt of the cereals. After validation of the choice, the computer application determines the circuits of possible receipt while taking into account the occupation of the equipment. The operation of research of the valid circuit makes itself in a completely transparent manner for the operator.

Once the circuit is selected and validated, several actions are possible: Positioning (the mobile elements get in place before the starting up) ; Start (the motorized elements start in cascade, of the point of destination to the starting point) ; Stop (stop all equipment of the grain silo) ; Empty (one stops the circuit of the point of origin to the point of destination while letting the time to the equipment to drain itself) ; Delete (for a circuit that doesn't take place anymore to be protected in the picture).

9. CONCLUSION

In this paper, a methodology for designing automated systems is presented. Two participative methods SADT and OOPP are used and a practical case of a grain silo management is presented. It has been found that the functional architecture of the automated system proposed will affect the return of a production system, and the effect depends on the efficient designing of the industrial system. The analysis and the modelling of the grain silo allow us to implant a process of the tractability of flux movements with the knowledge of the handling circuits and the actions of the maintenance of the different equipment in a grain silo.

The adopted automation solution is presented in architecture and in supervision solution with the particularity of use of an automaton for the management of the whole handling process and an automaton for the measures and the control system. Thus, the new environment of the grain silo management allows the establishing of an information and communication system.

Future study in this field may focus not only on the cooperation between the different models developed in designing industrial systems but also on the development of the information system.

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