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A CONTROL MODEL FOR THE ASSEMBLING PROCESS OF PRODUCTION ASSETS USING PROCESS MODELING

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ABSTRACT

Organizations increasingly need new ways of doing things that allow them to become different and thus gain a competitive advantage over their competitors. Process models are widely used in automated systems where data from certain equipment, such as flow and temperature, for example, are recovered and treated automatically. Thus, a model that allows the development of a process modeling environment to simulate and control the operational process of an organization is proposed. The model was divided into three layers. In the first layer, are the process models and in the third layer, the operational processes of an organization. The second layer is responsible for the integration of the first and third layers through communication and information technologies. For the validation of the model, the following were developed: a computational environment for process modeling for layer one; an assembly process model with automation components such as Programmable Logic Controller (PLC) and sensors for the third layer; and an event-aware data retrieval program, such as input and output of a production item on a resource, using the SCADA Elipse developer software for the second layer.

Keywords: Process Modeling; Automation; Simulation and Control.

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1. INTRODUCTION

In today's global environment, organizations need to be agile, flexible, and competitive. In the face of technological advances, there is a need for rapid adaptation to changes in the business environment and the use of new technologies. Because of these new, often expensive and complex technologies, organizations need to be innovative, seeking a different way of acting at a lower cost. Prajogo *et al.* (2007) argue that companies need to adopt innovation strategies, ensuring that the organizational culture is properly adapted, with the aim of improving the quality, versatility, flexibility and competitiveness of organizations.

Recker et Rosemann (2009) argue that companies and academies have begun to recognize that the level of education needs to improve in the future, and for this a large number of universities are investing in the design of a process-related curriculum as part of Information Technology - IT and Information Systems. In this article, they propose a curriculum for a university-level course called Business Process Modeling.

Typically, for a business process, specific information systems are developed to support organizational decision making or to support its operational processes. According to Laudon et Laudon (2011), a strategic information system transforms the organization and brings a competitive advantage over its competitors. They cite, for example, the bank ATM system developed by CityGroup. It can thus be said that a production system will be as efficient in relation to its information management or operation of its systems as it is able to retrieve data from the operational process automatically, as in a transaction of an information system.

Valliris et Glikas (1999) and Becker et Laue. (2012) state that there are two main categories of methodologies for Business Process Management (BPM): value management and the one that supports the development of information systems. For Valliris and Glikas (1999), in the first category, the analyst strives to reorganize business processes and uses IT to support their execution efficiently. In this methodology, the focus is on the minimization of cycle time and costs. In methodologies for developing information systems, analysts need to understand and possibly reorganize processes and thus introduce IT to store and retrieve data for decision making. In the same sense, Becker et Laue (2012) affirm that the most recent use of process modeling goes beyond the implementation of transactional processing; it is used to identify cost performance and process quality.

This work, therefore, proposes the control of the assembly processes using the process modeling. The process model must be able to automatically retrieve data and identify the performance of its assembly processes. In addition, it can be used in the representation and simulation of its processes. For this, the designed model was divided in three layers in order to give an individual view and at the same time integrated of its modules. In the first layer is the process model. The process of assembling the product or production system is part of the third layer. Communication and information technologies comprise the second layer, with the objective of integrating the two other layers.

For the validation of the proposed model, a computational environment for the modeling of the processes was developed in the first layer. In the third layer, a product assembly process model was developed to represent a production system based on the components of an automation system. In the second layer, an integration module of layers one and three was developed and the SCADA software Elipse Developer was used. In this layer, a supervisory system was developed to automatically retrieve events from the assembly process model and make them available to layer one.

This work was organized as follows: in the theoretical reference, section 2, the work on business processes is presented; section 3 shows the proposed model; in section 4, the developed structure and the application for the proposed model are presented and; analyzes and conclusions are presented in section 5.

Business processes

Business processes can undergo small continuous improvements or radical improvements, the latter called Business Process Reengineering (BPR). Hammer et Champy (1994) and Davenport (1994) have made a significant contribution to these areas in order to support organizations to continually and radically improve their way of doing business. Hammer et Champy (1994) structured a set of guiding principles for BPR, while Davenport (1994) proposed the use of IT for organizational improvement. The approaches of BPR defend that the businesses of the companies are described from the techniques of process modeling.

Models are simplified representations of the real world that support analysis and problem solving. According to Boothrovd (Appud, Pidd 1998), models are artificial worlds that have been created to help in understanding the possible consequences of particular actions. For Beuren (1998), business process models provide the way organizations do business. In the BPR approach, Fowller (1998), Greasley (1998) and Soliman (1998), identify that processes need to be simulated. For continuous improvement, Valiris et Gli-

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kas (1999) state that processes are used to observe if they add value. Work on business processes is typically related to BPM, business process modeling, and business process modeling techniques.

Business Process Management - BPM

There are several BPM definitions and most of them designate a sequence of activities to perform some work, with certain resources, in order to obtain organizational improvements. Lee et Dale (1998) define BPM as a series of tools and techniques for continuous improvement of business process performance. BPM, for Baldam et al. (2007), involves the discovery, design and delivery of business processes. For Röglinger et al. (2012), BPM processes have a development lifecycle that can be defined, managed, measured, and controlled over time. Calazans et al. (2016) state that BPM makes it possible to identify the information needed to support the operationalization or automation of the business process and that many organizations have used BPM as a facilitator for understanding the processes of the business area and for the construction of software. For success in process-oriented companies, Weil et al. (2008) suggest that companies create a stable base - digitize their core processes and embed a foundation for execution. This foundation is defined through the IT infrastructure.

An important aspect in any area of study is to identify the level of maturity of an organization. McCormack et al. (2009) argue that a high degree of maturity in business processes results in improvements in goal forecasting, costs and performance. In this article, the author proposes a score to measure maturity through a set of factors such as documentation and structure of processes, support for information systems and focus on "CORE". In this same line, Röglinger et al. (2012) state that maturity models are used to evaluate the current situation and that there are two types of maturity levels, process maturity models and maturity models in BPM. The author then presents a BPM project maturity analysis structure divided into three groups: 1- Basic project principles; 2- Project principles for describing a proposed use; and 3- Project principles for prescription of a proposed use.

BPM is used in the value analysis of its processes to then propose improvements. Kohlbacher (2010), Houy et al. (2010) and Zellner (2011) carried out bibliographical surveys with the aim of quantifying the work on BPM in different perspectives. Kohlbacher (2010), for example, identified the lack of research on quantitative analysis of performance work in process-oriented companies. In this work, he conducted a survey of 26 case studies and quantified the effects on costs, company value, and customer satisfaction due to BPM applications.

Houy et al. (2010), on the other hand, collected 136 articles on BPM published in journals and used a structure to perform the quantitative analysis. The structure has three perspectives: 1- Goal perspective, in which it raises the number of contributions per year, by journal, by country and by researcher; 2- Perspectives of contents, in which it raises the numbers related to organizational, intraorganizational and technological aspects; and 3- Methodological perspectives, in which it quantifies work information on case study, survey and experiments.

Zellner (2011) also states that no one has investigated quantitatively how procedures in business processes can be supported or implemented methodologically to reduce uncertainties in terms of how to move from the current situation, as-is, to the future situation, to-be. Zellner (2011) has raised a number of academic papers on how to improve processes with a focus on Business Process Improvement (BPI). In this article, the author proposes a quantitative analysis of the use of elements called MEM - Mandatory Elements of a Method that are: 1- Procedures or sequence of activities; 2- Techniques used; 3- Results or artifacts generated; 4- Function, which performs the activity; and 5- Models of information on the elements described above.

On BPM applications, Gonçalo (2017) proposes an automation model for integrated urban mobility centers using process modeling. For this, the author uses the concepts of Internet of Things, intelligent cities, Big Data and Data mining. The model uses RFID and sensors for data collection and urban mobility control. Gonçalo (2017) states that process automation allows monitoring the variables according to data acquisition and monitoring. Back (2016) proposes a work on BPMN in order to facilitate his learning through case studies. This work is intended to generate documentation to facilitate understanding and communication between employees.

In Back (2016), work was therefore not concerned with supporting methodologies for the development of information systems and value management, while in Gonçalo (2017), the proposed model was used for the development of information systems, identifying the ITs to perform his functions. Thus, the model does not emit performance data of its processes as in the methodology of value management.

Business process modeling

Becker et Laue (2012) define business process model as a means to analyze existing business processes, create a process in a structured way and use it as communication support in projects and employee training. The author also states that a large variety of models is developed

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by different people and one problem is to manage large process repositories due to their similarities. Therefore, they propose a method of comparison of two models of processes using the same modeling techniques.

The use of different techniques for modeling the same business is another problem. There are different techniques that model the same business process for the same vision, such as the Activities Network (AN) (Torres, 2002) and the Petri Network. There are other different techniques that show different views for the same process model, such as AN and IDEF0.

Thus, several authors, such as Recker et al. (2009), Torres (2002), Presley et Liles (2001), Yu et David (1997), and Luo et Tung (1999), for example, corroborate that, in process modeling, business must be seen from several perspectives, by means of various techniques. Thus, a business process project must be fully and comprehensively represented. In modeling, each perspective presents some of the business information. Thus, by using a set of perspectives, designers can implement improvements in a process, either by developing an information system or by incorporating information technology to improve process performance or cost. An important aspect is that different techniques tend to emphasize different capabilities of representation of real-world processes and exemplify that the Petri Net has a different view of a Data Flow Diagram (DFD) or a Business Process Modeling Notation (BPMN) for the same domain (Recker et al., 2009).

Presley et Liles (2001) present, for example, a process modeling method for business project analysis. For this, they used the techniques of process modeling that allowed the development of an integrated vision through the following perspectives:

a) Activity: Defines the functions performed by the business;

b) Process: Identifies the set of time-sequenced steps to achieve business process objectives;

c) Organization: Details how the business is carried out through plans, methods and objectives;

d) Rules: Defines the entities, how these are managed and dealt with by the business;

e) Resource: Models the resources managed by the business.

Luo et Tung (1999) suggest a framework for selecting business process modeling techniques by defining the business vision from its diverse perspectives. Business process modeling techniques not only have different characteristics but also provide different perspectives of business insight (Luo et Tung, 1999).

In the same line, Torres et al. (2014) propose a model for the development of project of modeling of business processes due to their objectives. The work begins with the survey of a set of techniques, perspectives and desirable characteristics of the process model. It then proposes a set of structured steps to select the most appropriate process modeling techniques for the development of process design.

Still on the modeling of processes and the techniques of modeling, Pavlovski et Zou (2008) propose the incorporation of two artifacts for the BPMN process modeling technique, operating condition and control for the non-functional requirements of the processes. Thus, while methodologies focused on the development of information systems are more concerned with the elicitation of functional requirements, the methodologies focused on process value analysis and aggregation are more concerned with non-functional control requirements such as cost, quality and performance.

Business modeling techniques

There are several techniques for modeling processes such as IDEF0, AN, BPMN and Petri Net, for example. For this work, the IDEF0 modeling techniques were chosen to represent the static characteristics and the Activities Network (AN) to represent the dynamic characteristics. To give an autonomous characteristic to the process models, the software components that can be defined as interface objects have been used. For this selection, the model proposed by Torres et al. (2014) was used. The AN elements are shown in figure 1.

AN was developed with the purpose of describing and controlling the processes, artifacts and development teams of a software project. The AN was inspired by three basic models: Petri net, object-oriented models, and the rule model at the ECA (Event-Condition-Action). It allows modeling the multiple activities that are (in)dependent and under which conditions new activities are initiated.

The basic concept of the graphical modeling technique in IDEF0 can be easily understood. The model consists of diagrams, texts and a glossary. Diagrams are two-dimensional models. Each of these diagrams is simple and can be viewed on a single page. The text is a description of the functional elements shown in the diagram. The glossary acts as a definition for the words used or texts within the specific context of the model. The functions in the boxes

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are restricted to operate the incoming inputs, using controls through the indicated mechanisms. The output of the "box" is restricted to go to another function or finish.

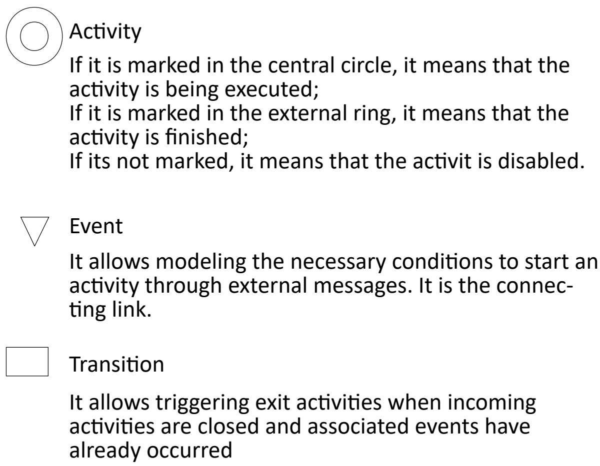

Figure 1. NA Elements
Source: Torres (2002)

IDEF0 is important in modeling the static aspects of organizations. IDEF0 provides a view of all the features being used in the business. From this technique, one identifies the input material that is processed, the rules or controls that make the functions work and the resources used. Joining the AN and IDEF0 techniques for the same domain can give insight into more of a business process perspective.

Due to the aspects raised above, it is fundamental that the models, besides representing, coordinating and simulating the processes, are able to control the systems automatically.

The proposed model

In this work, emphasis will be placed on control, although the simulation can be implemented through interaction with the projected process modeling. Thus, the proposed model aims to support the development of control projects for an organization production system, based on process modeling. Control is performed by automatically retrieving production data. It is of fundamental importance that the recovery of production data is performed at the same instant as the process of assembling a product. Given this, the performance of the assembly process can be identified on-line.

The proposed model is organized in layers. In layer one there is the process model that will be responsible for the recovery and storage of the data of the production system. Layer two is formed by information and communication technologies, so that the process model can interact with the production system model. The model of the production or assembly system is part of the third layer, responsible for assembling the production items. The structure of the model defined in layers and an application for the control of an assembly process are detailed in the following sections.

The computer environment

The computational environment aims to model the processes responsible for the recovery of data from the assembly process of a production system. For this, several elements of the process model, from a production order to the production system, were developed as software components. In the environment, therefore, the operating resources, queues, customers, orders and items, among others, are software components. From these components, new structured components are developed and made available in the environment, such as the Sewing Machine component, which inherits the properties of the primitive component Operational Resource.

In order to relate these several elements, the concepts of the Modeling, Entity and Relationship (MER) technique were used as in a Database project. Thus, for an Operational Feature there is a related queue, while for a Queue there are several items. An Item is an Order, while for an Order, there are several Items. And also, an Order comes from a Customer, while for a Customer, there are several Orders. The cardinalities of these relationships are always 1: N. The model is based on a queue structure, such as on an assembly line where production items are queued to be assembled on the operational resources or workbenches.

The components of the computational environment with their properties and methods were developed in Delphi. The Operational Feature component has the Resource Number and Description properties and numbers of the input and output queues, while the Item component has the Number properties and the Item Description as well as the Order Number and Queue Number. It resembles a database project, for the component is an entity and the properties are the attributes.

In addition to the properties mentioned above, the components have methods. The main methods belong to the Operational Resource component. The methods were implemented in order to update the production data table when the start and end events of a processing of a production item occur. In the data table of the production, are the data of the movement of the items that will be in production process. Table 1 shows the attributes of the production data table and their descriptions.

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Process modeling is based on two events: the first when the item takes one resource to be transformed and the second when the same resource ends the processing of an item. Figures 2 and 3 show the modeling developed in NA for these two events respectively. This modeling is intended to give a dynamic perspective view of the production assembly systems and to show the events that trigger the methods *SeRecursoPegouItem* (If Resource Picked Item) and *SeRecursoTerminouProcessamento* (If Resource Terminated Processing).

Figure 2 shows the transition from the initial situation to the situation after occurring event 1, *SePegaRecurso* (If-Catch Resource) (1). In the initial situation, there are only items in the initial queue in the Wait Activity (1). In the activity-wait, several items are queued in order to be processed. When the *SePegarRecurso1* (If-Catch Resource1) event occurs, Activity-End (1) is started. In practice, this event happens by identifying the passage of an item by a presence sensor.

Figure 3 shows the transition from a situation after event 2, *SeFimProcessamento* (If-End Processing), to a new situation or state. This event identifies that the end-activity has been terminated and the item passes to Standby-Activity (2) in a new queue. In addition, there is a transition from a Standby-Activity (2) to End-Activity (2) item because there is no markup in End-Activity (2) and the Event *SePegouRecurso* (If-Caught Resource) (2) happens automatically. In practice, these events happen due to the identification of item passages by presence sensors at the output and input of resources respectively. It is observed, therefore, that now there are two items being processed simultaneously. This dynamic happens all the time, as events unfold.

The modeling in IDEF0, figure 4, shows the items being processed, inputs, resources that are used to carry out an activity and the rules that are the events of AN.

It is important to note that AN activities are performed by a Resource that can be a machine or a person assembling part of a product. When the *SePegarRecurso* (If-Catch Resource) event occurs, the transition of an activity-wait item to activity-end occurs and to record this event and update the production data table, the *SeItemPegouRecurso* (If-Item-Caught Resource) method was developed. The text below shows your algorithm in a structured (Algorithm 1).

This method updates the production data table when an item takes an operational resource, End-Activity. This method first identifies the record in the production data table that must be updated, that is, the record referring to this item. To do this, the method searches the registry with the Status value equal to zero and with the value of the queue number equal to the value of the RopFilaE component property. This is a property of the *RecursoOperacional* (OperationalResource) component that identifies the input queue associated with the operational resource. After identification, the record of the production data table is updated with the processing start date and time, with the operational resource number and status value equal to one.

The *SeRecursoTerminouProcessamento* (If-Resource-Ended Processing) method updates the production data when an operational resource finishes processing an item, but also creates a new record for that item in a new queue of a new operational resource.

Table 1. Attributes of the production data table

Attributes	Description
1. Processing date	Identifies the date of the occurrence of the event in the assembly process of the production system.
2. Queue number	Identifies the queue number of an in-process item in an operational resource.
3. Queue sequence	Identifies the position or sequence of the item in the queue.
4. Order number	Identifies a customer's order number.
5. Order item	Identifies the order item that is in a row in the queue.
6. Customer number	Identifies the customer number for the order.
7. Operational asset in transaction	Identifies the resource where the item will be processed or is being processed or has been processed.
8. Process start time	Identifies the time when the process started.
9. Process end time	Identifies the time the process ended.
10. Time of item arrival	Identifies the time of arrival of the item in the queue.
11. Item Status	Identifies the item's status. If 0, it indicates that the item is in the queue waiting for processing. If it is 1, it indicates that the item is being processed and 2, the item has already been processed in a particular resource.
12. Time of arrival of the item in the system	Time of arrival of the item in the system.

Source: The author

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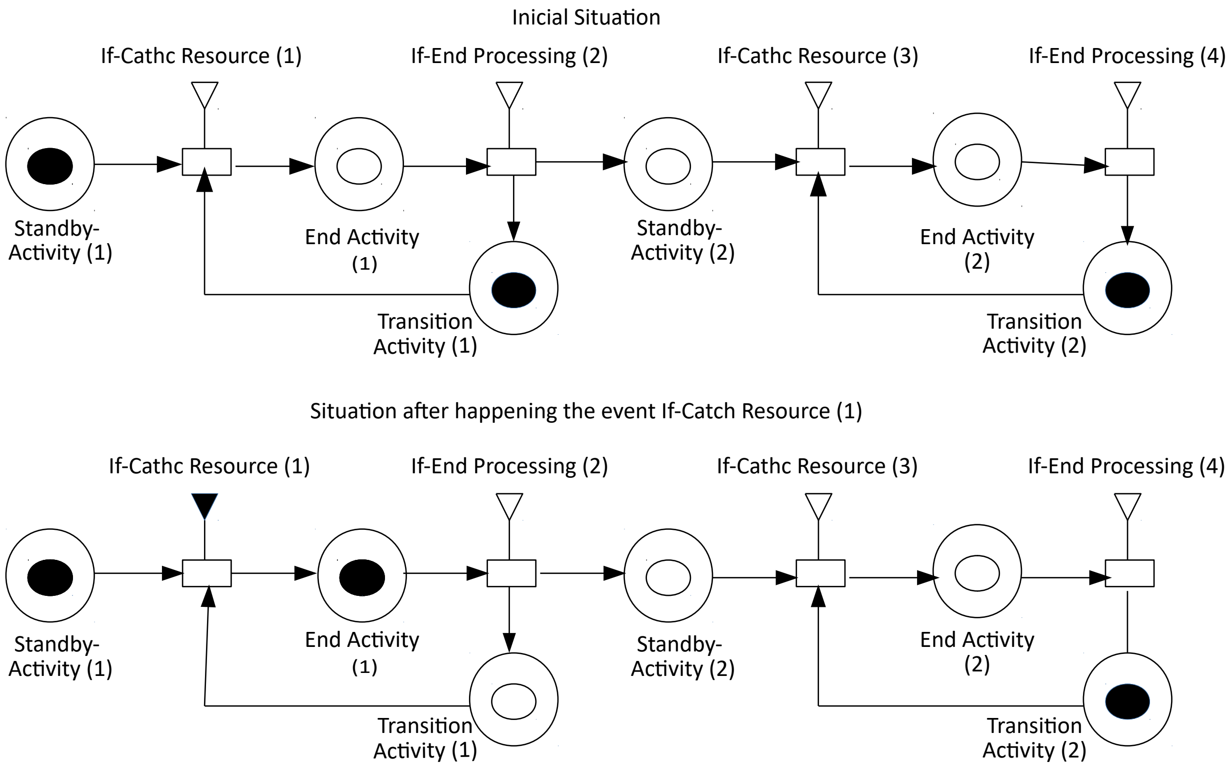

Figure 2. The AN model for initial situation

Source: The author

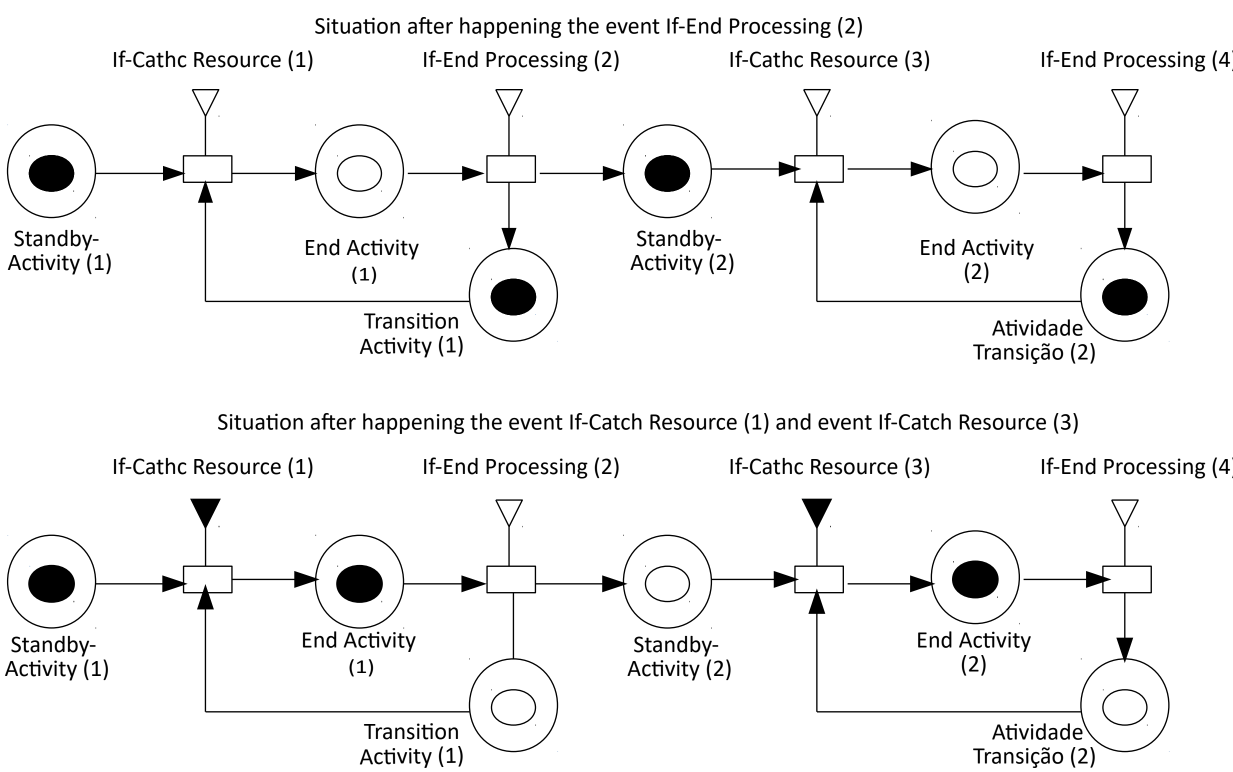

Figure 3. The AN model for situation 2

Source: The author

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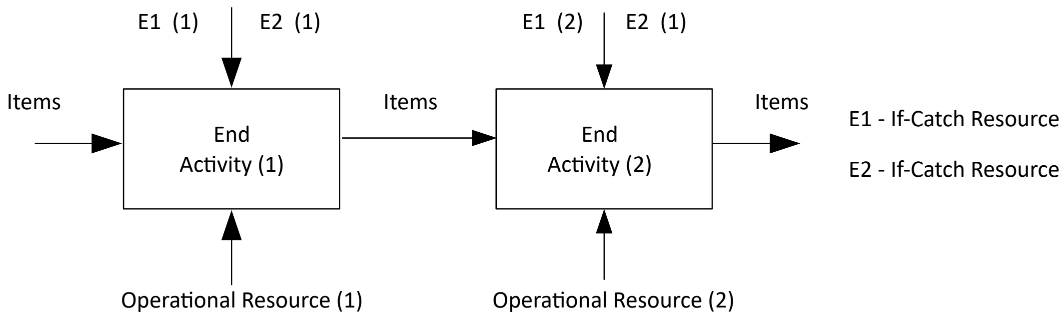

Figure 4. The IDEF0 model
Source: The author

When updating the production data table, in the same way as the previous method, the method identifies the record that must be updated, that is, the record referring to the item, where the Status value is equal to one and the value of the queue number is equal to the value of the RopFilaE property of the *RecursoOperacional* (OperationalResource) component. Then the end date and time of processing are stored with the system date and time and the status is stored with a value equal to two. The method additionally creates a new record in a new queue. In the new record, the item number, order number, and customer number are recorded with values equal to the record values of the processed item. The number of the recorded queue has the same value as the RopFilaS property of the Operational Resource component. Additionally, the status value is equal to zero and the queue sequence is recorded with the value of the last queue sequence plus one. Thus, at the end of a processing of an Item, it is placed at the end of the back queue and a new Item, first of the previous queue, takes the Operational Resource or got free. The text below shows the method *SeRecursoTerminouProcessamento* (If-Resource-Ended Processing) in structured (Algorithm 2).

The product assembly process model

The assembly process model aims to represent a production system for validation of the proposed model. A characteristic identified in the assembly process model was the need to receive the items in processes by the operational resources automatically and with an adequate transport speed. Another characteristic identified was the need to transport an item to the end of the next queue, after its processing, automatically.

Next, the main concepts for the development of the components of the assembly process were identified. For example, the need to use conveyor systems based on conveyor belts has been identified. The selected concept was a set of automated conveyors using as central element a Programmable Logic Controller (PLC). After selecting the concepts, the design of the assembly process was detailed and divided into three modules.

For the physical module, first, a set of 11 conveyor belts were developed, with 6 conveyors being larger to transport the items in processes and 5 smaller conveyors representing the resources. In the electric command module, second, a transformer from 220 to 12 V, motor power of 0.5 HP of 12 V, speed reducer from 1700 to 40 rpm for each conveyor and 11 cables for activation of the

Algorithm 1

```
Do unto the end
    If-item-Caught Resource
        Finde Record This Item
        Read Tabel Until Finding Record with Operation Resource and Status equal to zero
        End of Item Identification
        Update as Resource and Status are the Same
        Make Status equal to 1
        Update Data Table with Resource Number and Processing Start Time
        End of Item Identification
    End of decision ir Item Caught Process
End
```

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Algorithm **2**

- Do unto the end
  - If-Resource-Ended Processing
    - Finde Record of the Resource
    - Read Tabel Until Finding Record of this Resource
    - Make Status equal to 2
    - Update Data Table with Processing End Time
    - End of Item Identification
    - Generate Registration for New Queue
    - Identify Posterior Queue of Operational Resource in Transaction
    - Identivy Last Queue Sequence
    - Increment 1 for Queue Sequence
    - Make Processing Date, Order Number, Item Number equal to Previous Queue
    - Make arrival time equal to the System time
    - Make Operational Feature, Start and End Dates of Processing and Status equal to zero
    - Save new record
    - End of Registration Generation
  - End of Processing
- End

conveyor belts were detailed. Finally, in the automation control, third module, the presence sensors were identified, in total of 12, placed at the input and output of each resource and a PLC with 17 inputs and 12 outputs, as can be seen in figure 5.

The integration model

For the integration of the two models, a supervisory program was developed in the Elipse SCADA Software, layer two. The decision on the use of Elipse software was made because this software has the protocol that allows communication with the PLC used. The supervised program, developed in the Ladder language, is responsible for the movement of the production items by the conveyor belts and for updating the event data table. This table consists of the attributes: event number, which is identified by the position of the sensor in the conveyor system; date and time of occurrence of start and end of event processing; and event status, which changes from 0 to 1 after including the data in the production data table. Thus, event one corresponds to the sensor located in the input queue of the first conveyor resource, while event two corresponds to the sensor located in the output queue of the first conveyor-resource and thus for the other sensors.

This program basically works as follows: 1) by identifying the occurrence of the end event of an assembly process of

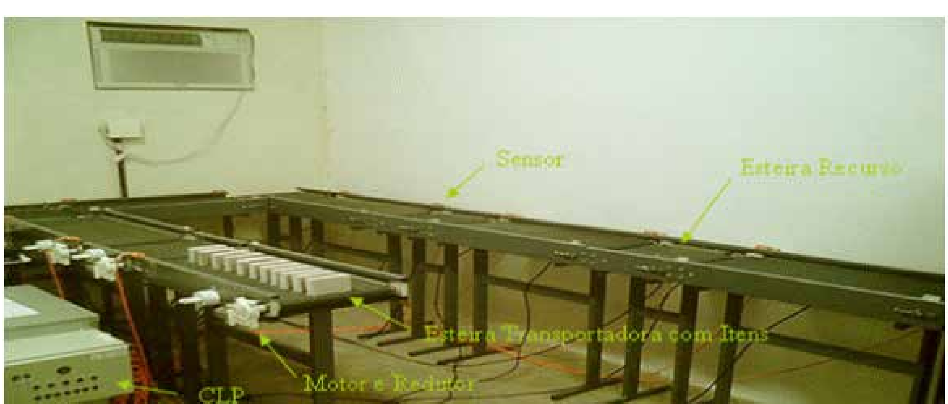

Figure 5. Assembly process model
Source: The author

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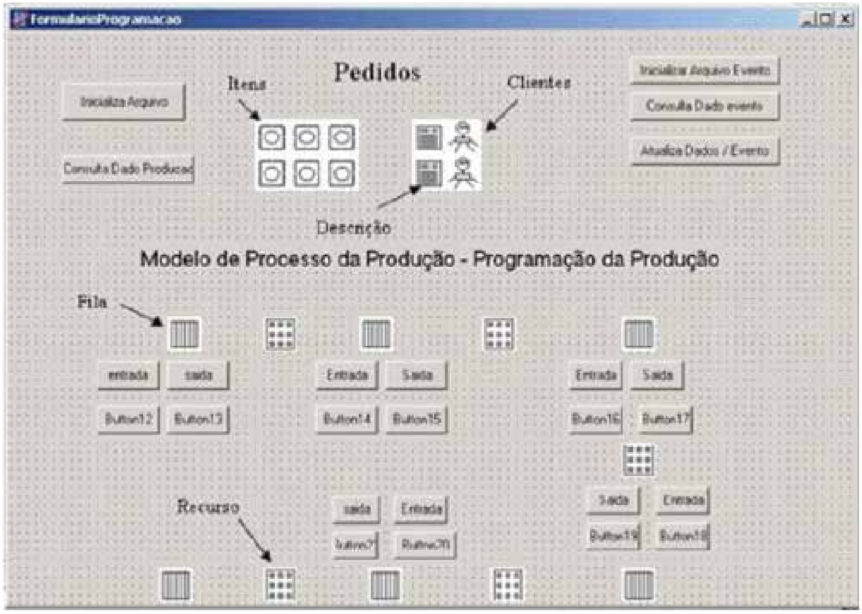

Figure 6. The computational environment

Source: The author

an item in process, a new item to be assembled is transported by conveyor to the free resource and the event data table is updated; 2) upon reaching the free resource, the conveyor belt is stopped; 3) At the same time, the production data table is updated through the *SePegouRecurso* (If-Caught Resource) and *SeTerminouProcessamento* (If--Processing Finished) methods using the event data table.

Thus, the communication system developed to integrate the two layers of the proposed model acts in two ways. In the first, by sending messages to the assembly process model by the supervisory system developed to move the conveyor belts. In the second form, it acts through the recovery and transfer of data to a temporary table of events occurrence so that it can be used by the process model of the computational environment. In the computational environment process model, a component reads the data from the event table and calls the specific operational feature method, which updates the production data table.

Control for an assembly process

In this section, the control system will be presented through an application for the proposed model. The application was developed in function of the structure presented in the previous sections and developed for a specific situation. The main purpose of the control is to automatically retrieve the data from a specific production order, by identifying the start and end of processing events in each workbench.

Thus, from a production order, the process modeling was performed through the interface of the computational environment. The modeling is done by dragging the components into the Delphi form, figure 6, which represents the assembly process model through the software components. It is observed that the production order represented by the process model of the computational environment has five features, six items to be processed and queues in the same way as the assembly process model. In addition, the process model has two customer requests, each with three items.

The computational environment also allows simulating the behavior of the assembly process model by clicking the input and output buttons of the resources that activate the *SeItemPegouRecurso* (If-Item-Caught Resource) and *SeRecursoTerminouProcessamento* (If-Resource-Terminated Processing) methods, respectively, as in the assembly process model with the desired production rate. After the process modeling, the communication system is integrated with the proposed model for moving the conveyors and updating the production data.

The data in the production data table is initially recorded with the data coming from the production order, figure 6. For the first three equal items, three registers with the same queue and Item numbers are generated, but with sequences 1, 2 and 3. This is possible because the item has a relationship with the queue, that is, a particular item is part of a queue. The next three items are generated in the same way with the same number as the previous queue, with the new item number and

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with sequences 4, 5 and 6. For each item there is a related request and for each requested component there is a related customer. This means that the order number and the customer number are saved for each item. In addition, for each record, the processing date and the Item status with a value of zero are recorded. The detail of the functionality of the control is presented in table 2.

Table 2. Control of the process model on the assembly process model

1. The components of the process model of the computational environment such as item, order, client, queue, and resources are related through their properties. This technique is similar to Model, Entity and Relationship (MER), a tool used for database project. Thus, an item comes from an order and an order comes from a customer;
2. The model of processes of the designed computational environment represents the process model of assembly of production items;
3. The formation of the queues of the production order of the process model of the computational environment is identical to the formation of the queues of the assembly process model, that is, the items that are placed sequentially in the queues of the assembly process model are the same as the model of computational environment processes;
4. The production order is prepared by placing the items sequentially on the first conveyor of the assembly process model;
5. The assembly process model is started, beginning production and following the sequence of items placed on the conveyor belt;
6. Resource number one of the assembly process model picks up the first production item from queue one and begins its processing, at the same time it makes available the data of that event to the process model of the computational environment;
7. The Process Model of the computing environment identifies the event and sends the message to the corresponding resource component, which, in this case, is the number one resource. It receives the message and updates the production data table by placing the item number one in the processing situation;
8. After processing the item in the assembly process model, the event data is sent to the process model of the computational environment;
9. Again the event is treated in the process model of the computational environment from the corresponding resource component method and again the production data table is updated, informing the end time of processing and placing the item in the back queue and activating the conveyor belt so that a new item will take the resource that was left free;
10. This way, events occur for all the resources of the assembly process model and production data is updated online without interference of human resource or item identification via bar codes, for example.

Source: The author

When starting the assembly process, updating the production data table is performed by the *SeItemPegouRecurso* (If-Item-Caught Resource) and *SeRecursoTerminouProcessamento* (If-Resource-Ended Processing) methods that are constantly sent. The *SeItemPegouRecurso* (If-Item-Caught Resource) method updates the production data table when an item that is in the first position of the input queue takes an available operational resource, while the *SeRecursoTerminouProcessamento* (If-Resource-Ended Processing) method updates the production data table for the processed item and generates a record for this item, placing it at the end of the back queue or output. Thus, as a new free resource, the *SeItemPegouRecurso* (If-Item-Caught Resource) method takes a new item.

Reports can be issued after clicking the Update Event Data button. Clicking the Production Data Query button shows the production data table information. Thus, start and end processing data, position of an item in the queue, the order number of the item and the number of the customer who made the order are shown in the production data table. In this way, several reports can be issued.

A report that can be issued is about the order status of a customer at any time, that is, which and how many items were processed, which ones and how many are being processed, and which ones and how many are queued for processing. These reports can be displayed with the customer and item name, using the organization's corporate database, which has the item and customer names for their codes.

A set of other reports, for example, can be issued online, as for example: situation of a customer request; order items that are in the various queues to be processed; average and maximum size of the queues in the various resources; resource productivity due to processing times; overall total of items produced; and total of items produced by resources.

2. CONCLUSION

This work showed, through a proposed model, the search for innovation through the customization of the companies' way of acting. This strategy is based on Prajogo et al. (2007), when they say that companies need to adopt innovation strategies. This feature can be observed through a proposal of a layered model, which shows a way to think and conduct your business in a personalized way. This may be fundamental so that companies can take competitive advantage over competing companies.

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One of the characteristics observed in this project is a strategic information system that retrieves data automatically, as in the bank ATM system developed by CityGroup, according to Laudon et Laudon (2011). The model thus operates autonomously, without the interference of human resources in relation to the collection and storage of data from a transactional processing system using software components.

It is also observed that the proposed model acts in the two categories of methodologies of processes, according to Valliris (1999) and Becker et Laue (2012). In the development of information systems, the functions and the available ITs were identified for the structure of the layered model for its realizations. In the value management, the model provides the technologies to support the realization of its processes and to recover the performance data of the assembly process model.

As for the selection of process modeling techniques, it was based on the approaches of Luo et Tung (1999) and Torres et al. (2014). The selection was made due to the need for different perspectives for the same business vision, with a view to a better understanding of the whole rather than just some parts of the system. In this way, the business process model can be represented more comprehensively in function of the perspectives presented in the modeling with IDEF0, AN and with the development of the software components.

Regarding the results, the control, through process modeling, can be observed from the storage in the production data table automatically by the model and by means of the on-line identification of the performance of the assembly process model. A variety of information can be obtained by storing the production data through reports, such as the situation of a customer request, the average time of a waiting item in a queue, and the processing time of an order according to the number of items. A simulation can be performed by clicking the input and output buttons, depending on the desired frequency of the production system.

An important aspect of this work is the identification of the need to design projects for elements external to the information system to support the business process. Thus, the development of a structure as a set of automated conveyors requires a systematic product development process, and this happened for this project.

For future work, three proposals were formulated. The first one refers to the simulation of the process model from a frozen situation of the operational process. The simulation would then be started from a set of products being processed. The second refers to the use of wireless technologies to improve the implementation and maintenance of the assembly process due to the amount of cables used in the model. It is also proposed to use a microcontroller as the third proposal. The microcontroller would have the following functions: first, to act by moving the conveyor belts to transport the production items in processes and, secondly, to transmit the occurrence data of events directly to the production data table. This would avoid developing a communication protocol for integration of the two other layers.

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