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A SIMULATION AND PRODUCTION CONTROL ENVIRONMENT THROUGH THE PROCESS MODELLING UTILISING SOFTWARE COMPONENTS

José Belo Torres (UFC)
Departamento de Engenharia Mecânica da UFCdress
belo@ufc.br

Abstract. *Most of the times, process modelling is seen as a tool only for defining and understanding part of systems that they try to model. The advance of technology allows models to be utilized beyond these characteristics. Thus, it is important that models may be utilized more dynamically through the interaction with organizational resources to recover information of the productive systems, as well as simulate and control resources and products that are being fabricated. This work purposes an environment for the process modelling and its objective is to represent, to simulate and to control the productive processes. Like this, models may support organizations in a broader way such as controlling business processes while utilising technology such as the software components one. In this environment, the components represent and interact with various elements of the productive system like order, client, finished product and organizational resources. Interaction is realized through the implementation of algorithms that are embedded in the software components. Thus, as a productive system is modelled, it is possible, besides the simulation, to identify the situation of a certain client order automatically, for instance.*

Key words: Process modelling, simulation and software components.

1. Introduction

According to Boothroyd (Pidd, 1998), models are artificial worlds that have been created deliberately to help understanding the possible consequences of particular actions. They are part of a reflection process that takes place before the action. Models can be quantitative, but, in any case, they will be simplified abstractions of the interested system. To Pidd (1998), a model is an external and explicit representation of part of the reality that is seen by the person that wants to use that model to understand, change, manage and control part of that reality.

As it is observed, models are limited to verify and comprehend how systems work. With the advance of technology, it is possible that models may be utilised beyond these characteristics. Today models must be utilised more dynamically, recovering information automatically and supporting the execution of organizational processes.

Therefore, this work identifies the limitations of business process models, related to the simulation and control, within the organizational support. In the control, beside the usual production accompaniment, the model do the client request situation accompaniment automatically, in all the production process, with the support of the technology of software components. In addition to this, it is necessary that models may be utilised in a more flexible and dynamic way through the use of new technologies such as the software components one, for example. Having this before, this work purposes a computational ambient that simulates and controls a productive system through the process modelling utilising software components.

The rest of this work is organized in the following way. In section 2, some works about process modelling are raised and analysed, as well as some techniques. The simulation and control environment is presented in section 3 through a practical application, while in section 4 some conclusions are presented.

2. Business Process Modelling

To Yu (2000), models can be seen by different perspective and therefore may support users to identify and make clear particular aspects of a certain business. The model is understood as a tool that makes available one or more perspectives of a business. In a classic work about process modelling for software engineering, Curtis (1992) suggests that the process model presents one or more perspectives and he identifies the four more often used perspectives: the functional, the behavioural, the organizational and the informational

Presley (2001), however, presents a work that allows an integrated vision of a business through a group of perspectives. For the development of these perspectives, there were utilised the techniques of the IDEF family modelling. Besides this, Presley (2001) identifies the necessities of the models for interacting with the organizational resources, such as holons. Thus, it is observed a worry with the utilisation of business process modelling. The industrial automation (Natale, 2000, Rosário, 2005, Cícero, 2001) utilises graphical programming languages, but its programs need to be compiled and transferred to the programmable logic controller, the PLC, to execute the asked tasks.

Torres (2002) purposes a Business Process Modelling Architecture with the objective of selecting several techniques to give a business vision from different perspectives. This architecture is constituted of a set of phases such as: identifying the project objectives, identifying the necessary qualities of the model, identifying the necessary different perspectives, analysing and identifying techniques to support the project. In the same work, three techniques were selected to comply with the objectives of the project. These objectives were to support the simulation and control of the organizational processes. The selected techniques were: the RA (Torres, 1996), the IDEFO (VALLIRIS, 1999) and the representation of resources through the software components.

A Net of Activities has the objective of controlling the interdependencies between the activities, while the IDEFO identifies the functions, the resources, the rules or controls used in the functions or activities, the entries that are processed and the exits of these functions. The components are used to interact with the resources of a production system. Due to its reuse characteristic, the designers are stimulated to select a component and convert it into new personalized components, improving the quality and productivity of an organizational project.

It is observed the lack of works in which the models interact dynamically with the organizational resources. It is important that the models are used more efficiently through technology and that they are more flexible when there is the necessity to adjust to new business.

3. The Simulation and Control Environment – A Practical Application

This section has the objective of presenting the simulation and control environment, purposed through the programming of an organization production. First, it is presented the kind of system that will be used in the simulation and control. This representation includes a production order and whom each order items is destined to. Then, it is presented how the simulation and control happen. Finally, it is presented an implementation for the purposed environment.

3.1. The Production System

The adoption of the used production programming for attending the orders is based according to the demand. So, every time a set of orders is held, a programming plan of the production is done, and several resources distribute a fabrication order of the items. Besides this, the production sequence is identified through the rows and then used. Figure 1 shows the process of a production order in which each element of the model such as client, order, item, resources and rows are represented and related. For this representation, the environment purposed uses the software components. The relationship possible must the characteristics of the components of software that they allow to identify, for example, that determined order is of a costumer and an item is of an determined order. The model shows the ordered items, which are distributed to be processed in the organizational resources.

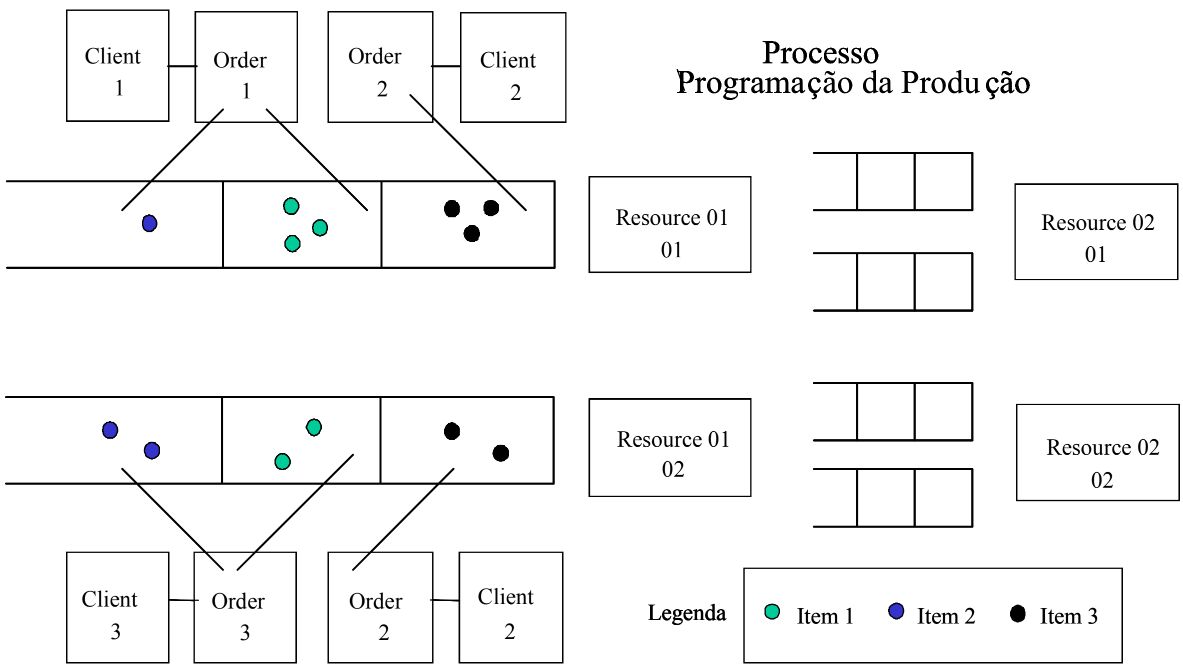


Figure 1 – Production Programming Process

When finishing the production order modelling, an automatic procedure is done, with the objective to support a simulation and the production control. For this, the items are put in rows in a sequential order according to the elaborated model, figure 2. This figure identifies the collocation on row 1 of three items 3, three items 1 and one item 2, sequentially, and yet these items were programmed to be produced in the first resource 01. For the second resource 02, there were put on row 2 two items 3, two items 1 and two items 2, sequentially. This model had its origin in the order of the modelled production. Another observation of the model is that the items that will be produced belong to specific orders, and specific clients did them.

3.2 Simulation and Control Process

For following the client's order, a data table of the production was purposed, table 1, to keep the obtained data and the occurred events in the productive system. This table has a primary key with this attributes: process date, row and sequence or position. These attributes allow the identification of the other attributes of the production data table. Thus, it is possible identify according to the row and its position the item that will be processed or is being processed, as well as the number of the order and its client, consequently. This table is unique and is used to update the corporative database.

The integration between the components of the models and the resources happens through the events that occur in the production system. Three kinds of events may occur. The first is concerned to the occurrence of a process start, while the second and third are concerned with the end and with the stops of the resources. Thus, the components that represent the resource must be capable of identifying these occurrences that may be implemented through sensors, whose are put in the productive system. When an item holds a resource, for instance, it activates a sensor that makes a marking, which is identified by the model component. A way of signing this event is pressing a button in the keyboard of a computer for the occurrence of this event. The update of the data table happens because of these events.

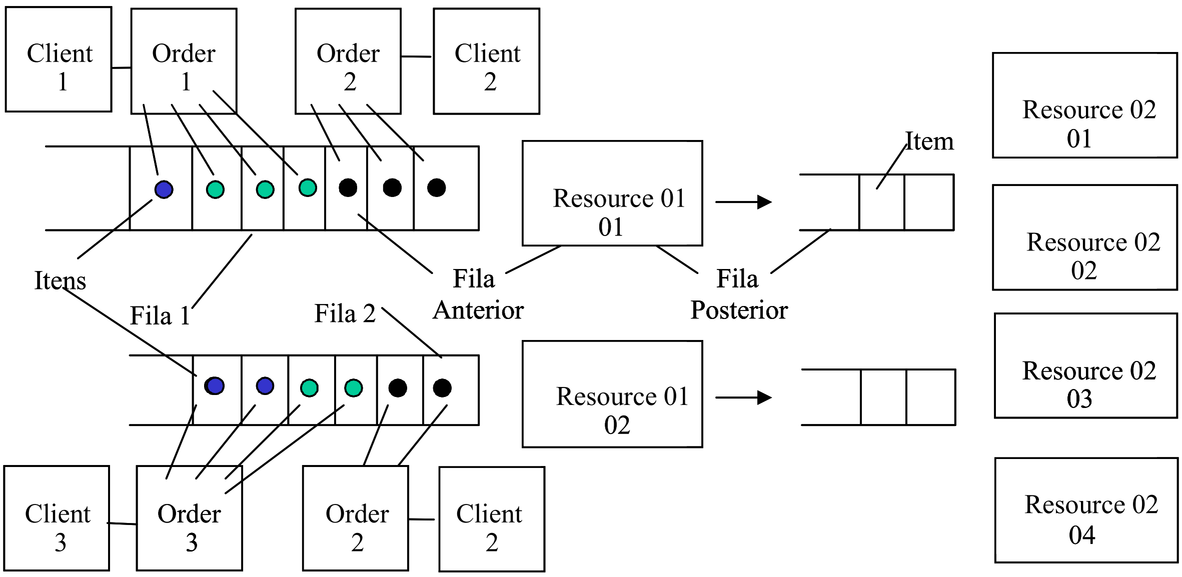


Figure 2 – Production Control Model

The production data table update is done in several times for a certain item. When an item in process is produced, for instance, it is put in the end of the next row to be processed when it is its turn and the resource is available. When an item takes a resource, the attributes of the previous row of the resource are utilised. The following attributes of the production data table are utilised: the resource took an item, the process starting time and the status is on 1. The identification of the item on the row and, consequently, its order, happens through a search for the first registry on the row in which the attributes, numbers and sequence of the resource and status are zero. After the end of the process, the component updates both previous and posterior rows.

The previous row is updated with the process ending time and has the status values on 2. The update is done through the identification of the resource that is fabricating the item and with the status on 2. Then, the item is put in the posterior row to be processed. The row number is identified through the property Posterior Row of the component, model resource, while the process date, the order Number and the Item are acquired in the previous row, which was updated. For the other attributes, the values are zero. An action diagram for this algorithm is shown on figure 3. It is observed that an alteration in the production order of an item of an order must obligatorily alter the projected model.

Table 1 – Attributes of the Production Data Table

Attributes	Description
1. Processing date	Identifies the process occurrence date.
2. Row	Identifies the row number which item is in process.
3. Sequence	Identifies the item position on the row.
4. Order number	Identifies the client's order number.
5. Order's item	Identifies the order's item that is located in a position on the row.
6. Operational resource in transaction	Identifies the kind of resource in which the item will be processed or is being processed. There are two kinds of resource. The first one processes one item only, while the second processes a lot.
7. Resource sequence	Identifies the resource in which the item is.
8. Process starting time	Identifies at what time the process started.
9. Process ending time	Identifies at what time the processes ended.
10. Item status	Identifies the item status. If 0, it indicates that the item was still not processed. If it is 1, it indicates that the item is in process and if it is 2, the item was already processed by the operational resource in transaction.

In this model, at any moment it is possible to identify in which process a certain item is and, consequently, how is the attendance of a certain order going. Thus, it is possible to simulate the projected model from the current situation of the production system. This may be done through the identification of the occurrence of events based on a statistic distribution, instead of the identification of real events. It is possible due for the structure of the control model is similar to the model of simulation based on entities, rows and resources. This way, the cycle time calculated here is not utilised only for identifying the passed time of the execution of the order, but, mainly, the time that was spent to make the delivery. Thus, the simulation is used to answer the client about the delivery date of his order. For this, the simulation must also use the production data table to anticipate the amount of time which will be spent to comply with the orders of the several clients.

3.3 The Purposed Environment Implementation

A prototype of the purposed environment was developed in the Delphi ambient (Torres, 2002). The Delphi has a structure called Visual Components Language – CVL –, which allows the reuse of its components, as well as the incorporation of new components to its environment. The new developed components were included in its interface. The presented model utilised, then, the Delphi ambient to make the simulation and control of the production.

For each element of the production order model, the software components were developed and put in the ambient *paleta* and then the model was built, figure 4. Thus, the simulation and control of the productive system was done through projected model. This interface was utilised because of the easiness for representing an event instead of putting sensors between the rows and the resources of the productive system.

Thus, when identifying the occurrence of a certain event in the productive system, the operator presses the key of the matching component, in other words, *Resource Taking* or *Resource Freeing*. When pressing Resource Taking, the procedure *If the Item Took the Resource* presented in the algorithm will go on. This procedure identifies the first item that was still not processed and starts its processing and then updates the production data table. When finishing the process of an item, the operator presses the component Resource Freeing that activates the procedure If The Resource Ended the Process. This procedure identifies the item in the production data table that was being processed and updates the data of the previous row, with a "processed" status, regarded to the posterior row to be processed. The complete algorithm can be seen in Torres (2002). Thus, the environment interacts dynamically with the organizational resources. At any moment or in the end of the attendance of a production order the update in the corporative database may occur. At any moment the accompaniment report of the situation of several orders may be done, like figure 5 shows.

- Do While
  - If Item Took Resource
    - Find Registry the Item
      - Reading Table Until Finding the Registry with Operational Resource Sequence and Status and Sequence on 0
    - End of Item Identification
    - Do the Updatate While Resource and Status Are the Same
      - Do Status igual a 1
      - Update Data Table with Resource Number, Sequence and Starting Process Time
    - End of Item Update
  - End of decision if Item Took Resource
  - If Resource Finishing Processing
    - Find Registry the Resource
      - Reading Table Until Finding Registry of this Resource
      - Make Status On 2
      - Update Data Table with Process Ending Time
    - End of Identification the Item
    - Generate Registry For New Row
      - Identify Posterior Row of the Operational Resource in Transaction
      - Identify Last Number of the Row (Row Sequence)
      - Developing 1 To Row Sequence
      - Make Process Date, Order Number, Item Number Just Like the Previous Row
      - Make Operational Resource, Sequence, Starting and Finishing Process Dates and Status On Zero
      - Record Registry
    - Registry Generation End
  - Process End
- End

Figure 3 – action diagram

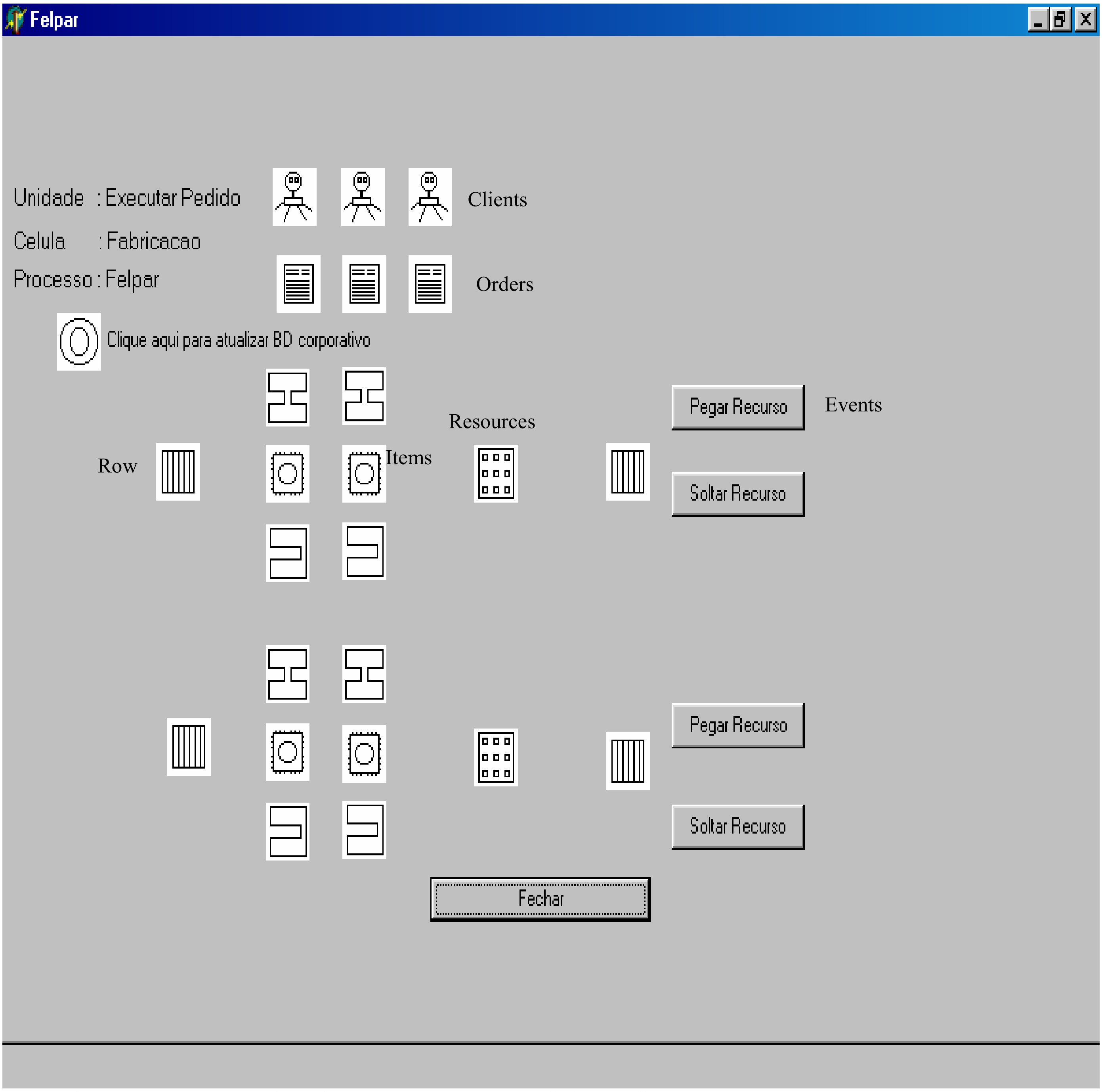


Figure 4 – Implementation of the Model Through the Software Components

4. Conclusion

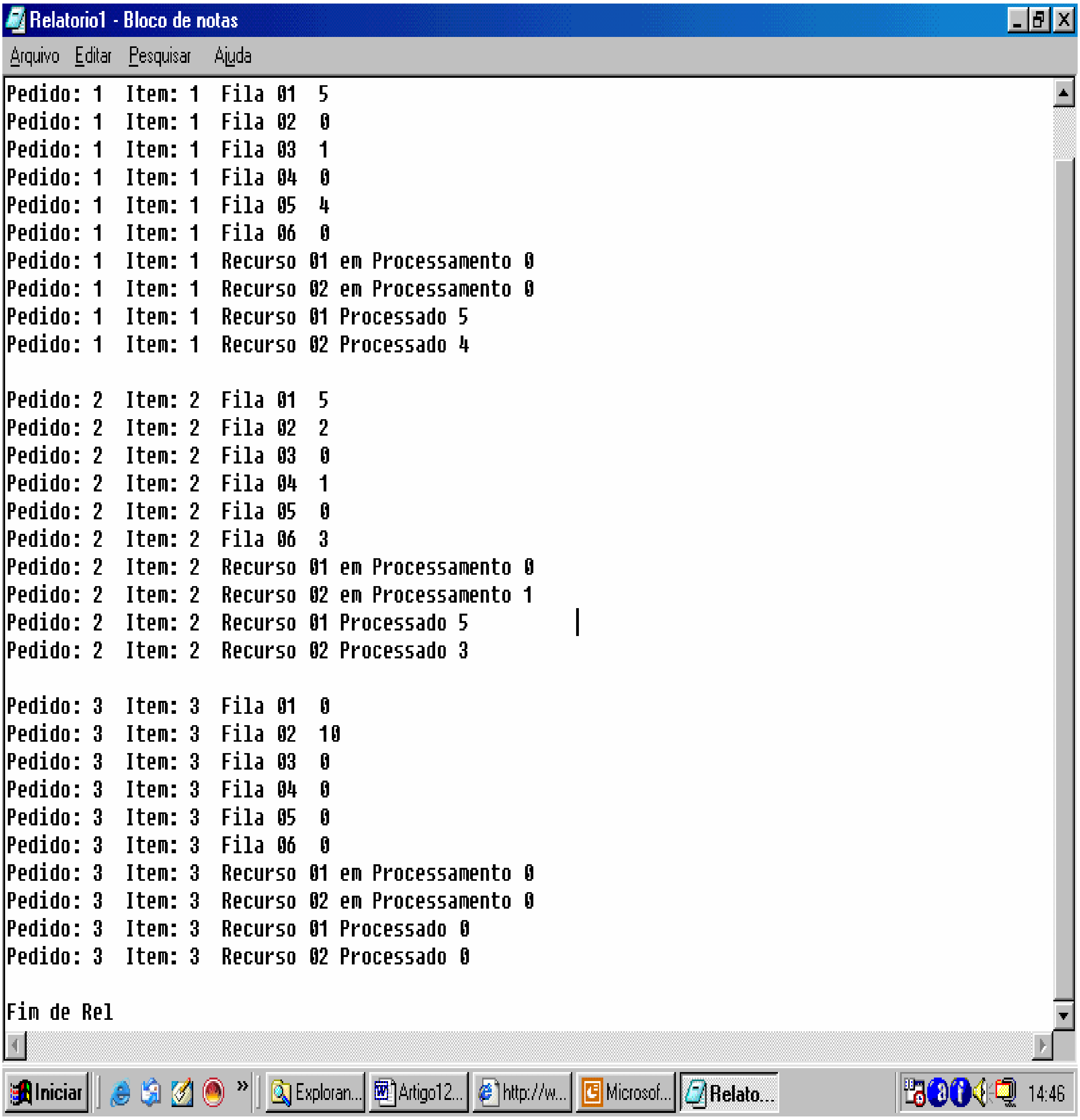
Because of the raised aspects above, this worked tried to supply the lack of business process models through technologies in supporting the simulation and control in a dynamic way. In the control, the model follies the situation of the order of the customers of automatic form, in all the production process, with the support of the technology of software components. This work was not worried with developing a product or environment of development, but it was worried with searching for a structure that could consolidate the purposed investigation. And this was done by the Delphi ambient for the project. Summarizing this, this work consolidates the contribution in relation to the following aspects:

1- Components technologies are important in the process modelling, for they may represent and interact in a dynamic way with the organizational elements,

2- Models may be utilised to support a process project, since its representation to its control;

3 – Models importance, in relation to the interaction with the operational processes, catching dynamically and answering quickly to the clients the position of their orders.

For future works, it is possible to use models based in software components for interacting not only to support information systems, but also to support the industrial automation through the integration of the ambient with the programmable logic controllers. Another purpose is that the models may be utilised as a supervisory system of an automatized production system.

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Pedido: 1  Item: 1  Fila 01  5
Pedido: 1  Item: 1  Fila 02  0
Pedido: 1  Item: 1  Fila 03  1
Pedido: 1  Item: 1  Fila 04  0
Pedido: 1  Item: 1  Fila 05  4
Pedido: 1  Item: 1  Fila 06  0
Pedido: 1  Item: 1  Recurso 01 em Processamento 0
Pedido: 1  Item: 1  Recurso 02 em Processamento 0
Pedido: 1  Item: 1  Recurso 01 Processado 5
Pedido: 1  Item: 1  Recurso 02 Processado 4

Pedido: 2  Item: 2  Fila 01  5
Pedido: 2  Item: 2  Fila 02  2
Pedido: 2  Item: 2  Fila 03  0
Pedido: 2  Item: 2  Fila 04  1
Pedido: 2  Item: 2  Fila 05  0
Pedido: 2  Item: 2  Fila 06  3
Pedido: 2  Item: 2  Recurso 01 em Processamento 0
Pedido: 2  Item: 2  Recurso 02 em Processamento 1
Pedido: 2  Item: 2  Recurso 01 Processado 5
Pedido: 2  Item: 2  Recurso 02 Processado 3

Pedido: 3  Item: 3  Fila 01  0
Pedido: 3  Item: 3  Fila 02  10
Pedido: 3  Item: 3  Fila 03  0
Pedido: 3  Item: 3  Fila 04  0
Pedido: 3  Item: 3  Fila 05  0
Pedido: 3  Item: 3  Fila 06  0
Pedido: 3  Item: 3  Recurso 01 em Processamento 0
Pedido: 3  Item: 3  Recurso 02 em Processamento 0
Pedido: 3  Item: 3  Recurso 01 Processado 0
Pedido: 3  Item: 3  Recurso 02 Processado 0

Fim de Rel
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Figure 5 –Order Accompaniment Report

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