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STOCHASTIC APPROACH - MARKOV CHAIN APPLIED TO THE ANALYSIS AND PROJECT OF THE INFORMATION SYSTEMS ORIENTED TO OBJECT

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ABSTRACT

This research sought an understanding of the implementation of a stochastic approach, as applied to analysis and development of information systems to object-oriented. In order to contribute towards advancing the scope of the area called System Analysis and Development, whose focus is on modeling the view of management, execution and process engineering. From an existing template, the Unified Process, was created the diagram of transition of states graphically that represents the Markov Chain, concerned with the probability of transition between their steps. The application of the stochastic approach will allow better control of the transition from each state in which you encounter the process of creation, validating the possibility of applying the use of Markov Chains in the development any information system, and will obtain results around capacity, time and cost of production; minimizing costs and maximizing profit.

INTRODUCTION

The models are simplified representations of reality, it fell to Systems Engineering a significant share of contribution for the process of structuring and systematizing the modeling. Since few applications used in Engineering and Computer Science, suggest the analysis and development of project information systems object-oriented, by applying a stochastic approach (Wazlawick, 2011). According to Clarke & Disney (1979) once a stochastic process involves the behavior of a system over a period of time, this process should start by specifying the set of time *T* involved, in general terms, it is a phenomenon that varies to some degree, in an unpredictable way, as time goes by. Markov chains are often used for dynamic process model, the behavior of such a system can often be characterized by a stationary analysis of distribution required to obtain analytical results. According to Meyn & Tweedie (2009) it is a particular type of stochastic process that is based on a defined sequence being stationary the probability and transition. In this study it was applied a process model of analysis and development of information systems uses the Unified Process - PU, a process of software engineering which uses the object-oriented approach in its conception (Mclaughlin et al, 2007), it was developed and documented using the Unified Modeling Language – UML notation, which is a unified modeling language, used to illustrate the processes in action. The goal is to present a model of state transition diagram that graphically represents the Markov chain, using the Unified Process - PU applied to analysis and to the development of information systems oriented towards object, thus enabling the understanding in a conscious and effective form about the implementation of the model. The justification comes from observation that there is a vast literature aimed towards the presentation of analysis and development of information system, not worrying about the probability of transition between its states. The application of stochastic approach will enable the control of the transition from each state that the process of creation is encountered, seeking contribution to advances in the scope of the area called System Analysis and development, in which the focus is on the modeling, view of the management, execution and process engineering (Tricoire, 2012). This kind of application can be used to solve many kinds-types of organization problems (Xiao et al, 2016).

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INFORMATION SYSTEMS DEVELOPMENT PROCESS ORIENTED TOWARDS OBJECTS

The process, in the context of Software Engineering, refers to the process of development of information systems, i.e. consists of the necessary states to the construction and conclusion of a software, from the beginning, through the steps of approval and then coming to the final training, in regards to the user on the new tool. Its goal is the construction of devices, software, or the improvement of an existing product, through the participation of various types of users (customers, final users, developers, managers, etc.) (Laudon & Laudon, 2010). There are various processes that proposed to be suitable for software construction. This task has already been thought of many times. Even before help of UML, we had an informal process of software construction, which was summarized to gathering requirements (needs), for the definition of an Entity Model and Relationship (MER) and finally the encoding was started (Medeiros, 2004).

A process must define WHO is doing WHAT, WHEN and HOW, for a goal to be reached (Malone, 2005). When an information system oriented towards objects is developed starting from scratch, the development is the process of creation starting from the requirements. However, after it has taken shape (that is, has passed from the initial development cycle), subsequent developments will be the process of adapting to new or changed requirements. This applies throughout the entire life cycle of the information system. From good software practices, much has been sought to develop studies that give subsidies for a good construction of an information system that it has not been designed, and it is detriment with all existing technology. For years, it has tried to project software having as a comparative the Civil Construction, the major problem is the requirements collection that undergo several changes. According to Wazlawick (2011), buying a hammer does not transform you into an architect, it might be necessary, but it is not enough.

Unified Process- UP

It fits in the general definition of a process: a set of activities executed to transform a set of customer requirements in an information system. According to Scott & Prince (2003) the UP makes extensive use of the UML, wherein in its core is the model, which in the context of a development process is a simplification of reality that helps to understand some complex aspects inherent to these systems. Three "gurus" of object orientation have also proposed the UP: Grady Booch, James Rumbaugh and Ivar Jacobson, it being the result of over thirty years of accumulated experience (Wazlawick, 2011).

It is based on three values:

- It is directed by cases of usage: development planning is done on the basis of identified-case usage, treating the most complex with priority.
- It is focused on architecture: the development process prioritizes the construction of an architectural system that will allow the carry out of the requirements. This architecture is based on the identification of a class structure, produced based of a conceptual model.
- It is interactive and incremental: on each work cycle performed, new features are added to the information system architecture, making it more complete and closer to the final version.

It holds in its disciplines the activities of the study of viability, requirements analysis, domain analysis and development. Given that these activities appear associated, with greater or lesser emphasis on the four phases, which are: creation, elaboration, construction and transition. Wazlawick (2011) defines the creation phase and also incorporates the viability study, the requirements gathering is a part of the analysis. The elaboration phase includes the details of the requirement analysis, domain modeling and development. The construction phase corresponds to the programming and testing, and the transition phase consists in the installation of the information system and data migration.

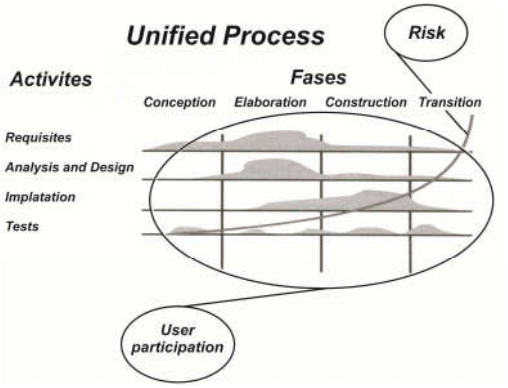

Figure 1. The different emphases of development activities throughout the four phases of the UP (Medeiros, 2004)

The UP defines a set of activities: Well defined; With responsible; With input and output devices; With dependencies and execution order; With a life cycle model; With a systematic description of how to perform them; Using the UML modeling language.

Modeling of an Information System Oriented Towards Objects

The models provide a plan of the project of an information system; it may include detailed plans, as well as more generalized plans with a panoramic view of the considered system (Shitsuka et al, 2005)0. Any information system can be described under different aspects, with the use of different models, and each model will be a specific semantic abstraction of the information system. Modeling is a central part of all the activities that lead to the establishment of a good information system. We build models to communicate the structure and the desired behavior of the system, to view and control the architecture, to better understand the system we are developing, often exposing opportunities for simplification and reuse and to manage risks. The choice of models to be created has an influence on how a particular problem is handled and how a solution is defined (Booch, 2012).

Models can be structural, emphasizing the organization of the information system, or may be behavioral, emphasizing the dynamics. Booch (2012) defines four goals of the modeling: Visualize the system as it is or as we wish it to be; Allow to specify the structure or the behavior of a system; Provide a guide to system construction; Document the decisions taken. The modeling is not restricted to large information systems, but it is true that the larger and more complex the system is, the greater the importance of modeling.

We build models of complex systems because it is not possible to understand them in their entireties. For Booch (2012) the contemporary view on the development of information systems adopts a paradigm object-oriented, the main building block of all information systems is the object or class. An object is something usually structured from the vocabulary of the problem space and the solution space, a class is a description of a set of common objects. All objects have an identity, you can assign them names or distinguish them from other objects in some way by the states or behavior. The object orientation used for the development of information systems, is a part of the main flow, because its worth has been proven for the construction of systems in all kinds of problem domains, including all degrees of size and complexity. The UML is developed to visualize, specify, construct, and document information object-oriented systems.

STOCHASTIC PROCESSES

The stochastic processes are of interest in describing the behavior of a system operating over some period (França, 2009). A stochastic process is a phenomenon that varies to some degree, unpredictably, as time goes by. The unpredictability in this case implies that an entire time sequence of the process at various different occasions under identical conditions was observed, the resulting sequences under observation would be in general different. Thus, the probability appears, but not in the sense that each output of a random experience determines only a single number (Clarke & Disney, 1979). The random experience determines the behavior of some systems for a sequence or a full-time interval, which is the result of random experience being that a sequence or series of values, a function and not being a unique number. This study considered only one type of discrete *T*, consisting of a sequence of consecutive integers.

$$T = \{0,1,2,3\ldots\} \text{ or } T = \{1,2,3,\ldots\} \quad (1)$$

And a type of continuous T, consisting of all subsequent times to some given origin.

$$T = \{t: 0 \leq t < \infty\} \quad (2)$$

Clarke & Disney (1979) defines that in each point *t* of the set of time *T*, it can be observed a measure or random variable *Xt*, so it is assumed that some random experiment is given and for each one sample point or experimental result, corresponds not only to a single number but to a whole *Xt* 0If the sample point or experimental result is indicated by s, then the function will be:

$$X_t(s) \text{ for } t = T \quad (3)$$

The random function of t is called a stochastic process or random process. Being a single sequence of observations *Xt* that corresponds to one sample point s is called a realization of the stochastic process.

Markov Chains: Probability and stationary transition

Markov chain whose transition probabilities are independent of n are said to have stationary transition probabilities or that they are homogeneous in time, and in this case;

$$P(X_{n+1} = j \mid Xn = i) = P(X_1 = j \mid X_0 = i), \forall n \geq 1 \quad (4)$$

According to Hillier & Lieberman (2006) the Markovian property says that the conditional probability of any "event" in the future, given any past "events" and the present state $Xt = i$, is independent of past events and depend only on the current event (Hillier & Lieberman, 2006). The transition probabilities in one step can be displayed as a square matrix called transition matrix probabilities, *P* from the chain, as the following:

$$P = \begin{matrix} p & p_1 & p_2 & \ldots \\ p_1 & p_{11} & p_{12} & \ldots \\ \ldots & \ldots & \ldots & \ldots \\ p & p_1 & p_2 & \ldots \\ \ldots & \ldots & \ldots & \ldots \end{matrix} \quad (5)$$

In this matrix, the lines correspond to the states of the process, that is, the values that the random variables *X0; X1*; ... Assume for each fixed *t, t = 0; t = 1./* ... therefore it follows that:

$$pij \geq 0, \forall i,j = 0,1,\ldots$$

and

$$\sum_{j=0}^{\infty} pij = 1, i = 0,1,\ldots \quad (6)$$

The state transition probabilities in one step can be represented by a diagram called state transition diagram. The transition diagram is a graphical representation of a Markov chain. In this diagram the states are shown (represented by circles), transitions (represented by arcs) and the probabilities of transitions. Generalizing, it can represent the states and transition probabilities, respectively, by *Ei* and *pij* where *i* and *j* are an index that identifies the various possible states (so *pij* is the probability of a state transition from *Ei* to the state of *Ej*). From this generalization, one can draw a diagram, as in Figure 2:

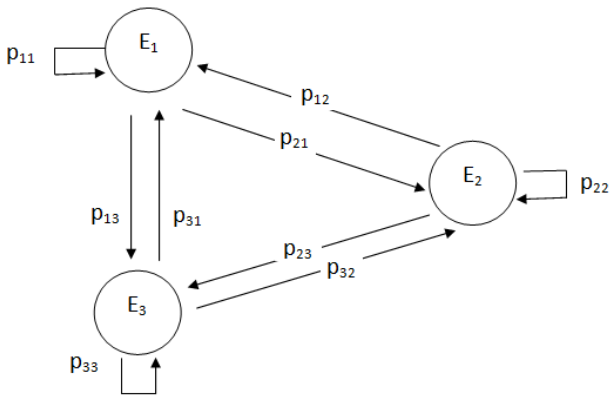

Figure 2. States Transition Diagram

APPLICATION OF THE STOCHASTIC APPROACH

The study is associated with the fact of the possibility of "forecast" of the impact of changes in the process, in respect to the four states of the UP applied to the analysis of development of information systems oriented towards objects: conception, elaboration, construction and transition, utilizing the states transition diagram in the representation of transitions.

This " forecast " is performed in a short time by analyzing the transition probabilities between the states, making it possible

to define the capacity, time and cost of production. In this way seeking to take the adequate decision to maximize profit and minimize cost, so adapting the project to its technical and budget specifications. In the stochastic modeling we will consider the UP as not deterministic, but probabilistic. This way, it is possible to combine the actual data with those interpreted to generate a number of equally likely scenarios. The state Transition Diagram will run a simulation, according to the states of transition in the development of the project.

States transition diagram - Unified Process (UP)

The UP foresees four major phases: S1 - Conception, S2 - Elaboration, S3 – Construction and S4 – Transition figure 3 shows the stochastic modeling through the transition diagram, which is a graphical representation of a Markov chain, which aims to control the transition from each state that the process of creation of an object-oriented system development project is encountered. Iterations occur within each state; a state may have one or more iterations. According to Medeiros (2004) the UP foresees five Workflows, which are: Requirements; Analysis; Project; Implantation; Tests. The term workflows has here the meaning of a set of activities with a common goal. These are the activities for which it must go through when it is in a state, each state can predict the five activities. The user has participation in all states with more intensity in the design, in the transition state it is clear the risk, being that in this state the implementation happens.

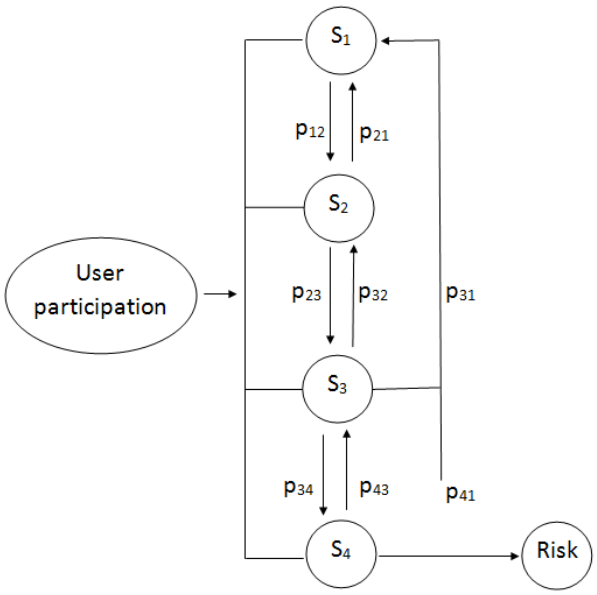

Figure 3. Model of State Transition diagram for the Unified Process – UP

Expected results

The optimization in the production processes is of great importance for companies, in the creation of development of information system oriented towards objects, it is clear the difficulty of control in the transition between the creation of states, making it difficult to minimize costs and production time. The Research shows the possibility of applying the Stochastic Approach using Markov chains through a transition diagram in any development of information systems, being that results around capacity development, time and costs will be obtained, allowing the full feasibility of the project.

Research methodology

According to Lakatos and Marconi (1996, p 15): "to Search is not just seek the truth; It is to find answers to questions proposed, by using scientific methods." By this definition we see that the research is not something simple, in this study the descriptive research was used which is a kind of conclusive research and has as a main objective the description of some phenomenon (Lakatos & Marconi, 1996). The development of the research involved two areas of knowledge, systems analysis and Stochastic Processes development, appropriate insights were made gradually. Below are the steps:

- Research on Stochastic Processes and their applications;
- Research on Systems Analysis and development and its importance today, as well as applications and study suggestions in the area;
- Research on Modeling of Information Systems and Object Orientation and its applications;
- Scenario analysis for application of strategies of stochastic approaches in the solution.

Problem modeling

In the area of analysis and information systems development we question the form of how to measure the time, effort and cost that a project will consume, thus the stochastic approach proposed enables the control of time by applying Markov chain, and for the capacity control of production and costs the state transition diagram is used. During the analysis and information system development oriented towards objects, what is the capacity of production and costs involved using the Unified Process - UP?

CONCLUDING CONSIDIRATIONS

The application of the stochastic approach on information systems development currently is little used, therefore, the goal was to present a model of state transition diagram that represents graphically the Markov chain using the Unified Process - UP applied the analysis and development of information systems object-oriented. The optimization of the production processes is of great importance for businesses, in the creation of an information system project, it is clear the difficulty of control in the transition between the creation of states, making it difficult to minimize costs and production time. Research shows the possibility of applying a Stochastic Approach using Markov chains through a transition diagram in any project, and results around the capacity development, time and costs will be obtained, allowing the full feasibility of the project.

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