Using Markov Theory to Deliver Informed Decisions in Partially Observable Business Processes Operation

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ABSTRACT

This article explores the stochastic capabilities offered by Markov theories combined with business transaction models, from the Enterprise Engineering field, to contribute to the decision-making body of knowledge. An agro-food case study shows the utility of this solution and the evaluation argues the management decisions value in situations where is not possible to fully observe the state of the reality, or to be fully aware about it. A full policy graph that forecasts the belief states from observations and enacted actions is delivered.

KEYWORDS

Business Transactions, Decision-Making, Management, Observation, POMDP, State

INTRODUCTION

Decision-making is a management competence (Shewhart, 1980; Laudon & Laudon, 2013) encompassing four main stages: (i) the intelligence to discover the organizational problem, then (ii) the design of potential solutions, afterward (iii) choose the best solution, and finally, (iv) implement the solution and check if it fulfills the desired goals. These traditional stages support many levels of organizational management, e.g., project management, operational management or middle management. Under complex organizational environments, those stages are not always completely feasible due to: (i) Inability to map the current operational observations with the current state where the organization actually is (Weber, 1987; Montiel & Bickel, 2012), e.g., when actors perform workarounds (Alter, 2014) and override the previous defined prescriptions then the manager need to collect more information to interpret what, in fact, was executed; and (ii) Incomplete observations (Cassandra, 1998), e.g., because it is too expensive to collect information, or, if the business processes are partially performed in paper by humans and partially machine-based.

In the majority of the situations, the management competence should support their decisions with partial information about the surrounding environment, also named, in the literature, as partial observable environments or asymmetric information (De Giovanni, 2017) or information imperfections (Amor et al., 2017). In line with this limitation, (Frank, 2014) states that to make enterprise models a versatile tool for supporting professional action in organisations, new research challenges are posed in order to widen the scope of modelling by adding further topics that also comprise concepts to support managerial decision making. This foreknowledge drives this research effort.
Weinberg (2001) divides systems in three distinct types: organized simplicity, for self-contained problems that could be treated with analytical tools; unorganized complexity, for complex systems, but yet sufficiently random in their behavior so that they are sufficiently regular to be studied statistically; and organized complexity where all the remaining organizational-wide problems fall. Moreover, organized complexity does not fit analytical nor statistically solutions. The author states that new formal approaches dealing with systemic perspective are needed to develop the knowledge on how to address organized complexity problems. This assertion is the essence of this research: the integration of knowledge from information systems and operations research.

Within an organization, business processes play a dual role of: (i) being the result of applying design constraints for a particular organization reality (Hoogervorst, 2009), and are valid over a given period of time, and (ii) support for implementation of systems operating actions performed by organizational actors. However, the actors have an active and independent role in the execution of business processes. Therefore, it does not guarantee that the requirements of business processes are met properly on the daily routines. For example, if a company’s recommendation is to always obtain a written record when contacts are made with clients, nothing limits the ability of an actor to contact a client directly, by phone, without leaving any trace of that communication. The same example can be applied to the contemporary financial markets, with a huge adverse impact to the organization and to its environment. Alter (2014) describes this phenomenon as workarounds found by the actors.

Accordingly, with this presented problem, the authors narrow the decision-making management field to the business processes operation optimization. This well-defined domain sets the research within the scope of unorganized complexity offering solutions for decision-making (Mezghiche et al., 2015; Quttineh et al., 2017; Öner-Közen & Minner, 2017). So forth, this paper proposes and evaluates an innovative approach combining the DEMO enterprise engineering (Dietz, 2006b) with a stochastic approach based in partial observable Markov decision process (POMDP) theory (Russell & Norvig, 2010).

The rest of the paper follows a simplified design science research (DSR) approach (Hevner et al., 2004; Winter, 2008), encompassing the iterations of (i) the posed problem statement in this section, (ii) the design of a solution for the given problem and (iii) the evaluation phase. Firstly, the Sect. Background concepts identifies the problem statement boundary and the background concepts that are available in the literature. Then, in Sect. Modelling the business transactions space, the design for an informed management solution for a partial observable business processes environment is detailed as an DSR artifact. After that, Sect. POMDP combined with Business Processes is devoted to the explanation of the case study and an argumentative evaluation of the achieved results. It corresponds to the evaluation phase of DSR. Afterwards, in Sect. Related work, the potential applications for controlling partial observable environments are explained and the innovation offered by this paper is identified. Sect. Innovation presents the managerial implications, the unique contribution to theory and the current limitations. Lastly, the Conclusions and future research directions are presented.

BACKGROUND CONCEPTS

This section identifies and details the core concepts to construct the solution for an informed management in partial observable organizational environments.

Markov Theories

In probabilities theory, a Markov process is a stochastic process that satisfies the Markov property (Russell & Norvig, 2010): if the transition probabilities from any given state depend only on the actual state and not on previous history. By other words, the predictions for the future are solely based on its present state. Its future and past are independent. Table 1 classifies the different Markov theories for systems that are controlled or uncontrolled vs. observable or partial observable. Where a system is completely observable if every state variable of the system affects some of the outputs. And, a
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