Towards a More Cognitively Effective Business Process Notation for Requirements Engineering

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Abstract. We are developing a semi-formal business process modeling notation based on the modification of theatrical blocking notation that is more cognitively effective for application in requirements engineering communication than extant notations. The Socio-Technical System Notation (STSN) incorporates ontological, semantic, and visual design improvements over extant languages that were pinpointed by prior research as areas for improvement to existing notations, such as the UML and BPMN, for the purpose of reducing the likelihood of errors and misinterpretation during the encoding and decoding processes. The research-in-progress paper follows a design science research approach to motivate the development of the STSN, to present a prototype of the notation, and to set the stage for the empirical evaluation of the language based on its design objectives. The research presents a process notation that enables the encoding of more detailed requirements information into a visual representation than extant notations.

Keywords: conceptual modeling, requirements engineering, cognitive effectiveness, business process modeling, notation design.

1 Introduction

The standard rationale for conceptual modeling during the requirements engineering (RE) process is that visual representations of the system and processes mitigate risks associated with incorrect and incomplete requirements specifications by acting as a means for eliciting, analyzing, agreeing, and communicating domain knowledge [1, 2]. Further, these models assist with framing the problem scope, establishing system boundaries, and overcoming the perception gaps between the goal and process oriented problem domain and the machine oriented solution domain [1, 3]. Ideally, conceptual models help to establish a common-ground understanding and shared mental model of the system among project stakeholders, and thereby increase the efficiency and effectiveness of problem solving and developing an apposite solution during the RE process [4]. However, the persistently significant level of requirements-related IT project failures [5, 6] indicates that there remains room for improvement in the RE communication process despite the advances in available modeling notations.

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A potential source for the disparity between the intention and realization of the goals for RE conceptual modeling is that the development of the de facto standard languages used, the Unified Modeling Language (UML) and Business Process Model and Notation (BPMN), has not been focused on expressly facilitating the cognitive effectiveness and ease of use of these languages as communication tools [7-9]. Further, analyses of these languages indicate inherent ontological, semantic, and visual design factors that may limit their utility in RE communications because of the potential for ambiguity, cognitive overload, and practitioner error during encoding and decoding [10-12]. This suggests that attention to the standards applied to the analyses of these notational languages may potentially improve RE communications and reduce the incidence of requirements-related project failures. However, a comprehensive revision of these languages would be exceedingly broad in scope and fundamentally incompatible with their purposes.

We propose the Socio-Technical System Notation (STSN) as a prototype language designed as a comprehensive solution to this problem and initially apply its scope to business process diagramming. The informal iconical form of theatrical blocking notation (TBN) serves as the basis for STSN. We chose it because of its utility in cross-functional communication in the theatrical industry. We intendedly designed the notation for ontological and semantic clarity and completeness, based upon the ontological work of Bunge [13, 14] and Wand, and Weber (BWW) [15, 16] and Moody's Semantic Clarity Model (MSCM) [11]. The visual design was informed by Moody's Physics of Notations Theory (PoNT) [11]. The comparative empirical evaluation of the STSN will require test subjects to encode and de-code business processes in STSN and UML Activity Diagrams (AD). In addition, the decoding process evaluation includes recognition, recall, and transfer tests to measure user retention and understanding as indicators of the cognitive effectiveness of the languages [17].

This research contributes to information systems (IS) with a theoretical solution for mitigating risks associated with communication problems in RE in the form of a visual notation artifact. The artifact is designed as an efficient means for creating cognitively effective visualizations of business processes. The resulting artifact may also have utility for business process management and (re)engineering, supply chain management, and other disciplines where activities and data flow inform decisions.

2 Identification of the Problem

The need to bridge the socio-cognitive differences that shape the way business stakeholders and developers frame problems and engage in sense making is an intrinsic challenge for information systems RE [3]. Recent research supports the importance of overcoming this perception gap to mitigate project performance risks [18]. Failure to bridge this gap may reduce innovation, value creation, and efficiency during the software development process [19-21].

RE is an inherently complex and human-centered discipline. The success of the RE process is challenged by many factors, including the heterogeneous needs of the business stakeholders [22, 23] and the complexity and dynamism of contemporary business and IS [24]. Because of the many risk factors associated with ambiguous and uncertain requirements and change management, the degree of success in executing the RE process has a critical influence on project outcome [25-28].

To overcome these obstacles, RE practitioners strive to communicate the complexity and interconnectivity of IS requirements in a way that is mutually understandable to business stakeholders and developers [24]. Natural languages alone do not provide an unambiguous communication tool for conveying the complexity of business processes and IS [29]. The cognitive theory of multimedia learning (CTML) [17], based upon dual coding theory [30], supports the potential for enhanced cognitive effectiveness, and thereby communication efficacy, through supplementing textual or verbal information with diagrams during RE communication. Consequently, supplementing natural language communication with visual notation languages during RE should facilitate improved domain understanding, system and process analysis, decision making, cognition, and communication between the business stakeholders and developers [1, 4]. However, RE practitioners must be proficient in selecting and using the modeling language(s) that enable accurate and complete visual representation of the problem domain with the desired perspective(s) for analysis [23]. Otherwise, RE practitioners risk diminishing the efficacy of the communication and design process by providing inaccurate, incomplete, unnecessary, redundant, or ambiguous information in diagrammatic form.

The de facto standard notations used for RE system and process diagrams, BPMN, for business process modeling, and UML, for systems modeling, are not explicitly designed to facilitate the intuitive creation and interpretation of diagrams by novice language users or to bridge the perception gaps among stakeholders by managing complexity at higher levels of detail, agility, and diagramming [7-9]. As these notations evolved from the tradition of workflow diagrams, they relied primarily on abstract geometric shapes rather than "semantically immediate" icons [11, p. 765] and placed little emphasis on visual designs to improve usability and cognition through the application of relevant theories such as Bertin's eight visual variables [31] or Mayer's CTML [17]. They also do not provided visual constructs for mapping goals to actions [7, 9] that give purpose to the activity [23] and are required by the definition of an activity in a social system [14]. Further, the results of analyses of the ontological and semantic mapping of these notations indicate that there are extant concerns with the clarity and completeness of these languages and the impact of these restrictions on the cognitive effectiveness and expressiveness of diagrams created in these languages [12, 32-35]. The complexity and interconnectivity of problem domains that fall outside of the intentions and philosophy of these notations may exacerbate these limitations. The implication of these analyses is that a language specifically designed to adhere to the principles of these recommended notational design theories would serve as an instrument to facilitate improved RE communications.

3 Objectives of the Solution

For the STSN to provide a design research contribution by improving RE communications, the notation system should satisfy the following objectives: it must (1) be ontologically and semantically clear and complete as defined by the BWW ontology and MSCM; (2) be easy to learn and to use; and (3) facilitate greater recognition, recall, and transfer, when compared with the UML AD. We compare STSN's performance to that of the

UML AD because of high adoption rates and long implementation history. The overall set of objectives was derived from analyses of the factors that limit the utility, expressiveness, and cognitive effectiveness of the UML AD as a communication tool.

4 Design and Development

The language constructs necessary for the satisfaction of the objectives of the solution were designed into the STSN notation during the conversion process of TBN into a socio-technical system business process notation. Objective (1) required the creation of language constructs in full support of (a) the BWW ontology, the de facto standard for evaluating ontological completeness and clarity as a measure of the semantic construction of software engineering conceptual modeling notations, and (b) the MSCM. Objectives (2) and (3) required the practical application of the design principles from the PoNT and the evaluation of the utility of the notation through empirical testing.

The TBN language was selected because it serves as a common-ground tool for decision-making, training, analysis, and design and as a means to create an historical record of the production within the domain of theatre [36]. By tradition, this relatively intuitive, actor-oriented language enables the rapid, live recording and easy modification of the detailed complexity of actors interacting with other actors and objects within their environment and being acted upon by external factors. It therefore serves within the theatrical domain similar purposes as required of diagramming within the RE domain. In its iconical forms, TBN inherently facilitates semantic immediacy and provides the combination of text and graphics recommended by the CTML. These attributes combined with over a century of successful use in theatre recommended the adaptation of the TBN to achieve the goals of this research.

The primary weakness of the TBN is a lack of standardization. Although common sets of notational symbols are included in theatrical curricula and reference books, stage managers primarily develop their modeling style through apprenticeship and experience [36]. Beyond a few basic symbols and common variants, TBN is primarily an ad hoc notation, similar to the Rich Pictures used in Soft Systems Methodology [37]. Therefore, although TBN could theoretically mitigate many of the aforementioned RE communication challenges, the informal nature of TBN prevents a standardized application of the notation directly to the more formal and complex RE problem space. Fig. 1 is a simple example of a business process recorded directly in TBN.

TBN is concerned with physical movement and the relative and absolute positioning of things within the environment and is temporally linked to the script. In contrast, business processes are concerned with workflows and must have internal methods of depicting temporal changes. Therefore, the STSN required the addition of both the semantic constructs and syntax for depicting these concerns. For this initial phase of the design, we selected Hofstede et al.'s workflow patterns [38] because of their level of completeness and standardization. As these models have been applied to analyses of the UML AD and BPMN their use also enables a comparative evaluation of the relative completeness of the STSN. An example of the STSN is depicted in Fig. 2.

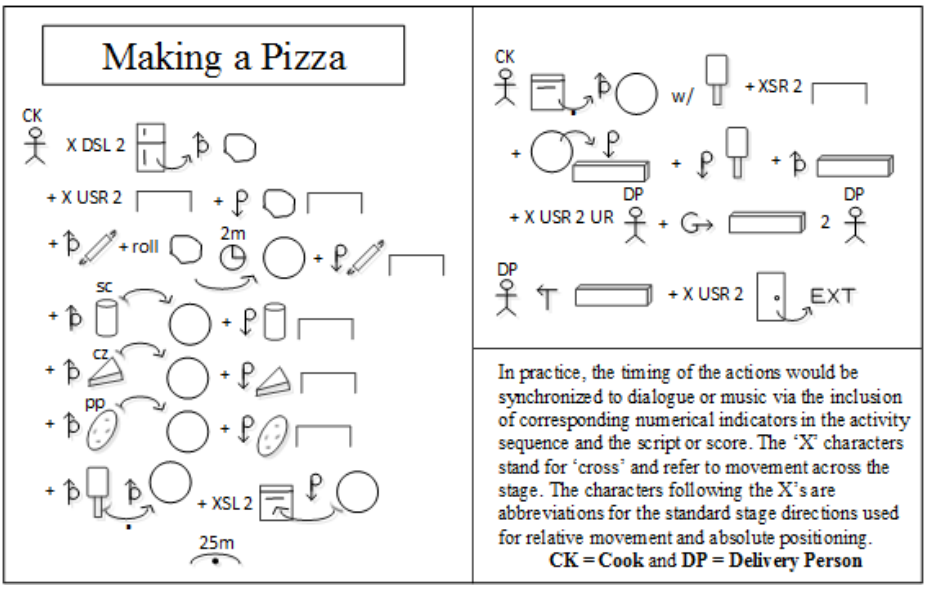

Fig. 1. An example of a heavily iconical form of TBN

The STSN is intended to supplement existing diagrams in the UML by providing the means for encoding more detailed requirements information into a more cognitively effective representation of business processes. The socio-technical viewpoint of the notation enables an enhanced depiction of the interaction of humans and technology from the standpoint of the actors (both human and artificial) within the system. The reliance upon icons enhanced with text is recommended by the CTML for communication efficacy and cognitive effectiveness. The summary goal of the STSN is to assist with overcoming the perception gap during the RE process by providing a comparatively humanistic and intuitive method for decoding information and to enable the effective encoding of complex system information.

5 Evaluation

The artifact will be evaluated in an experimental setting with the treatment group interacting with the STSN and the control group interacting with the UML AD, both, for the purpose of interpreting the notation and for encoding requirements. The evaluation will follow guidelines for the empirical evaluation of conceptual models from Burton-Jones et al. [39] and Gemino and Wand [4]. Diagram interpretation will include tests for recognition, recall, and transfer. Encoding will require the creation of a simple business process diagram. Perceived ease of use will be assessed based upon the guidelines provided by Moore and Benbasat [40].

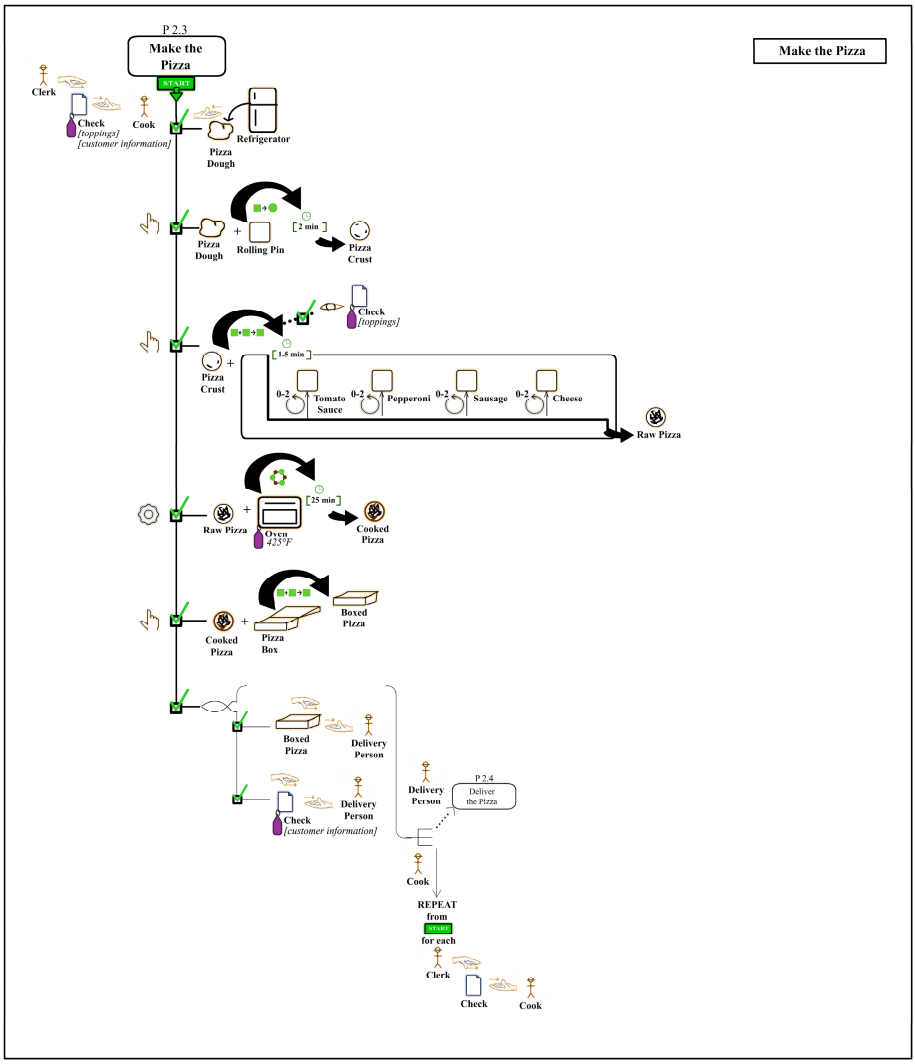

Fig. 2. STSN diagram demonstrating the use of custom and generic objects

6 Conclusion

This research contributes to the IS body of knowledge by proposing a theoretical solution for mitigating risks associated with communication problems in RE. The solution takes the form of a visual notation artifact designed as an efficient means for creating cognitively effective visualizations of complex business processes. It also contributes to the study of notational design through a demonstration and evaluation of the application of relevant theories intended to enhance the communications efficacy of notations.

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