Business Simulation by Using Events from Pre-Conceptual Schemas

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ABSTRACT

Business simulation is an interactive learning experience for simplifying and summarizing real systems. Events occur in such systems for changing states of processes and controlling system behavior. Some computational models are used in business simulation for recognizing events and processes from a domain and developing software systems. However, such models lack components for simulating business by using events. We propose business simulation by using events from pre-conceptual schemas (PSs). Such schemas are conceptual models for representing a business domain, which include simulation components based on mathematical notation. Thus, we represent a PS as simulation model for recognizing events in a seafood service monitoring system. Simulating events by using PSs allows for identifying the future system behavior and functionality.

INTRODUCTION

Business simulation is an interactive experience for learning and understanding processes of real systems by constructing models in business environments (e.g., organization) and engineering (e.g., industry and production). Such models allow for operating a business by using internal and external variables used in some context in order to promote critical decision making. Such variables represent information of the system used in the requirements, processes, and services of the system (Gromov et al., 2017).

Events are important elements of a system, which are used for beginning and ending processes by changing states (Noreña & Zapata, 2018a; Noreña & Zapata, 2018b). Such changes are produced by internal constraints and specifications from events (Noreña et al., 2017). Events are responsible of system behavior by controlling system execution in a time sequence (Noreña & Zapata, 2018c), e.g., a monitoring service GPS (global positioning system) for tracking truck routes of medical products to wards destination, a system based on sensors for determining temperatures in plants of an agricultural company, etc.

Approaches to business simulation require a simulation model, which should be defined at the beginning of the simulation. Simulation users run computational models for verifying the outcomes from events and processes in a domain before implementing them. Some computational models used are business process model notation (BPMN; Gromov et al., 2017; Kalibatiene et al., 2015; Bosilj et al., 2018; Stankevicius & Vasilecas, 2016; Vasilecas et al., 2016), Petri nets (Fauzan et al., 2017), and unified modeling language (UML) class diagram (Cartelli et al., 2014; Pascual-Miguel et al., 2014) and component diagram (Byrne et al., 2017). However, such computational models lack elements based on mathematical notation, which can be used for event representation (Noreña, 2018) in business simulation.

Consequently, we propose the usage of elements of the pre-conceptual schemas (PS) in business simulation for representing events. PSs are intuitive conceptual models, which are used in learning processes and software development for representing and recognizing the complete view of a domain (Zapata, 2012; Zapata-Jaramillo & Zapata-Tamayo, 2018). PS elements are based on mathematical notation related to simulation elements (Noreña & Zapata, 2018b; Durango et al., 2018). In addition, we model and simulate a monitoring system for seafood by using PSs. Such a system allows for generating risk alerts of high temperatures and expected costs in freezing process of the seafood (locust) by using events. Simulation users can learn from this PS-based business simulation in order to understand the processes and events required in the system and system behavior and functionality.

This paper is structured as follows: in Section 2 we define the conceptual framework; in Section 3 we state the problem; in Section 4 we propose a solution; in Section 5 we present results. Finally, we discuss conclusions and future work in Section 6.

CONCEPTUAL FRAMEWORK

Business Simulation. Interactive process for solving, learning, and understanding processes, which are developed in real business environments and engineering by applying tasks like: (i) requirements analysis; and (ii) critical decision making. Some simulated elements are expressed by $M=\text{AURUTUEUF}$, where $A$ is a role; $R$ is a constraint by enterprise regulations and standards; $T$ is a type of activity, production stages, processes, and job descriptions; $E$ is an event used for influencing on decision making; and $F$ is a report or paper documents (Gromov et al., 2017). Business simulation is based on mathematical models, which are used for generating output data by using input variables.

Events. Occurrences that happen in simulation and real systems by changing states of processes (Noreña & Zapata, 2018a; Noreña & Zapata, 2018b). Such changes occur by accomplishing internal constrains and specifications from events, which are natural conditions or conditions established by using initial variables (Noreña et al., 2017; Noreña & Zapata, 2018b). Events are related to time for identifying the beginning and end of processes (Noreña et al., 2018). Such a relationship is used in order to control
execution of events and processes in time sequence (Luckham, 2012; Noreña & Zapata, 2018c). An event happens in daily life, which causes reactions, e.g., the phone or doorbell rings, email arrives, book falls on the floor, etc. Also, events can be situations, e.g., winning the lottery, the robbery in a coffee shop, etc. Thus, events can be alarms, messages, positive or negative situations in business simulation (Etzion et al., 2011).

Pre-conceptual Schema (PS). Conceptual model used for teaching and understanding elements of a domain. PSs integrate pedagogical aspects for constructing intuitive interpretations of the world. Such intuitive nature allows users and stakeholders for previously understanding concepts and relationships (Zapata-Tamayo and Zapata-Jaramillo, 2018) and representing domain knowledge (Zapata, 2012). PSs include elements based on mathematical notation, which are related to business simulation elements (Noreña & Zapata, 2018b; Noreña, 2018). PS elements are (see Exhibit 1): structural relationship (relationship among classes and leaf concepts); dynamic relationship (relationship among processes); eventual relationship (relationship among dynamic relationships and events); concept (classes and leaf concepts); specification (values and operations without conditions); constraint (operations with conditions and derived values); frame (reports and sets of same type elements); implication (connection for dynamic relationships and event flow); connection (connection for concepts and relationships); concept-note connection (connection for specification, constraint, and value-note; Zapata, 2012); operation connection (connection for operator, concept, variable, vector, and parameter); value-note connection (value of a variable, parameter, and leaf concept); class-leaf concept (node for summarizing structural relationship among classes and leaf concepts); operator (node for representing mathematical equations, e.g., + sum, sin, sq sin, sq square root, etc.); timer (event for controlling system execution; Noreña & Zapata, 2018c); event (occurrence for triggering dynamic relationships and other events, which should be have a specification or a constraint); parameter (constant); and initial conditions (initial variables and parameter; Noreña, 2018; Noreña & Zapata, 2018b).

EXHIBIT 1
ELEMENTS OF THE PS (NOREÑA & ZAPATA, 2018B)

PROBLEM STATEMENT


Commonly, authors use a simulation model at the beginning of a business simulation. Computational models—e.g., BPMN, UML diagrams, and Petri nets—can be used by including elements of simulation as events, activities, roles, resources, etc. Events and activities involve equations for generating reports and results. However, such models lack elements based on mathematical notation for representing events and activities in business simulation. Thus, a simulation model in business simulation is required for generating desired outcome in events and processes.

SOLUTION

Our proposal is based on PSs as models for business simulation, since such schemas are models used in software development for learning and recognizing elements of a domain (Zapata, 2012; Zapata-Jaramillo & Zapata-Tamayo, 2018). Also, PSs include elements based on mathematical notation related to simulation elements (Noreña & Zapata, 2018b; Durango et al., 2018). We apply PSs on business simulation by using events and other PS simulation elements on a monitoring system of seafood (locust) for generating risk alerts by using events, which are caused by changing temperatures (see Gromov et al., 2017); also, we
simulate and estimate costs (seafood cost, sale prices, and direct cost) from the freezing process (see Exhibit 2).

Simulation Elements of PSs for business simulation. We identify some elements of business simulation in PSs like: roles (concepts, e.g., simulation user); activities or processes (dynamic relationships, e.g., simulation user inserts seafood); events (also called events in PSs, which are main elements in business simulation because they are used for influencing decision making, e.g., benefit seafood decreases); reports (frames, e.g., result data), input variables (initial conditions, e.g., variable sensor state = "off", and parameter warehouse capacity = 199 Tons), output variables (independent variables when they are used during process and reports, but they are not saved in data tables, e.g., refrigerator time = 480 minutes; dependent variables when they are saved in data tables and they are leaf concept of a class, e.g., seafood sale price; see Exhibit 2).

EXHIBIT 2
PS ABOUT BUSINESS SIMULATION. THE AUTHORS.
(i) Requirements analysis. Simulation user should understand simulation elements; thus, requirements in the PS of the Exhibit 2 are initial conditions (i.e., simulation time = 3480 minutes, which can be selected by simulation user, time = 0 minutes, timestamp = “next”, random value = 0.0, threshold = 0.7, occurrence = “inactive”, seafood = “rejected”, refrigerator room state = “off”, refrigerator room temperature = 98.6 °F, refrigerator time = 480 minutes, sensor state = “off”, risk alert = “inactive”, maximum temperature = 32.9 °F); leaf concept (total amount, sale price, benefit of seafood class); time (is represented by the time passes timer, which is an event for controlling the simulation time from 0 minutes to 3480 minutes (according to initial conditions), time passes has a timestamp (“stop,” “next”) for controlling the time; conditions and constraints (are defined by using the events, which have internal conditions, e.g., time <= refrigerator time); and dynamic relationships (processes can be autonomous by using events, i.e., seafood arrives, measurement starts, seafood direct cost increases, seafood benefit decreases, and made by a role, i.e., simulation user inserts seafood (id, date, amount, cost, direct cost, and benefit, sale price and total amount are derived attributes, which are mathematical equations by emerging from others values seafood sale price = cost + direct cost + benefit, total amount = max total amount + amount, it is the maximum value or end value of total amount plus new amount) and simulation user updates seafood direct cost).

(ii) Critical decision making. Simulation user can learn system behavior and functionality from this PS-based business simulation by critical decision making based on simulation rules, i.e., simulation user should select seafood state (“accepted” or “rejected”) when seafood arrives, such a decision can change the system behavior in cost and temperature. If simulation user accepts a seafood amount > warehouse capacity, also it can bring consequences to direct cost (energy cost by temperature, production cost, etc.) and seafood benefit from sale price, because if direct cost increases then seafood benefit decreases; thus, business simulation by using events from PSs is influenced by critical decision making.

(iii) Business Simulation by using events from PSs. Dynamic features are used in the PS (see Exhibit 2) for representing autonomous processes by using events. Initial conditions (independent variables and parameters) are used for starting functionality of the system. Time passes event includes a constraint with a cycle from 0 minutes to simulation time, if timestamp = “next” and time <= simulation time. Seafood arrives event has the condition for generating a random value, If random value >= threshold (threshold = 0.7 according to the initial conditions). When occurrence is “active,” timestamp = “stop” for first decision making can be accepted or rejected such a seafood. If seafood state = “accepted” then simulation user inserts seafood data. Freezing happens event is active by using the condition seafood state = “accepted” and time <= simulation time, capture automatically the actual time plus refrigerator time programmed in initial conditions for starting freezing process in a refrigerator room where seafood is saved. Measurement starts is an event from a temperature sensor, which measures temperature of the refrigerator room, if measurement temperature > maximum temperature (39.2 °F according to initial conditions) then risk alert is “active.” Temperature can increase because other seafood arrived or other causes. If total amount > warehouse capacity or risk alert = “active,” then such a condition can generate bacteria in seafood because temperature is higher than maximum temperature. Simulation user should make two decisions: he should increase time or decrease temperature in freezing process. Such a decision increases direct cost as energy cost and decreases benefit. Simulation continue to simulation time for generating a result, which is a report with output data seafood id, total amount, sale price, benefit.

### EXHIBIT 3
##### TABLES OF DATABASE. THE AUTHORS.

| SIMULATION USER | | | |
|-----------------|-----------------|------------------|
| ID | NAME | AREA |
| 92683 | Luis Fernando Guarín | Business administration |

<table>
<thead>
<tr>
<th>SEAFOOD</th>
<th></th>
<th></th>
<th></th>
<th></th>
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<tr>
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<td>270000</td>
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<p>| MEASUREMENT | | | |</p>
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</tr>
<tr>
<td>3 minutes</td>
<td>39.02 °F</td>
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<td>38 °F</td>
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<tr>
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RESULTS

We simulate a monitoring system of seafood in the pre-conceptual schema of the Exhibit 2 as a lab study. Classes and leaf concepts are structural features, which are saved in a database (see Exhibit 3) by using the events and the processes of the PS proposed. Costs and sales prices are measured in US dollars. The report is generated by each seafood accepted, the benefit can be 10% of the sale price and direct cost can be 5% of the sale price. Commonly, the sale price is invariable, but the direct cost and benefit can be variables. When total amount is ‘210’ is greater than warehouse capacity, simulation user should increase temperature then increase direct cost.

CONCLUSIONS AND FUTURE WORK

Our proposed solution was based on the elements of PSs (initial conditions, events, dynamic relationships, reports, variables, and mathematical notation) and task (requirements analysis and critical decision making) for business simulation by using events. PSs allowed us for modeling and simulating a monitoring system for seafood by using events. Such a model was used for generating risk alerts of high temperatures and predicting costs in freezing process of the seafood. PS elements were used and validated in the lab study by using structural features and data tables. Business Simulation by using events from PSs is a new approach for modeling domains in business simulation, because PSs are models used for teaching and understanding elements of a domain. Thus, simulation user can understand behavior system and functionality by using PS elements and learn about events and processes from this PS-based business simulation.

We suggest as future work automated pre-conceptual schemas for business simulation, which allows for automatically generating results and reports.

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