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.

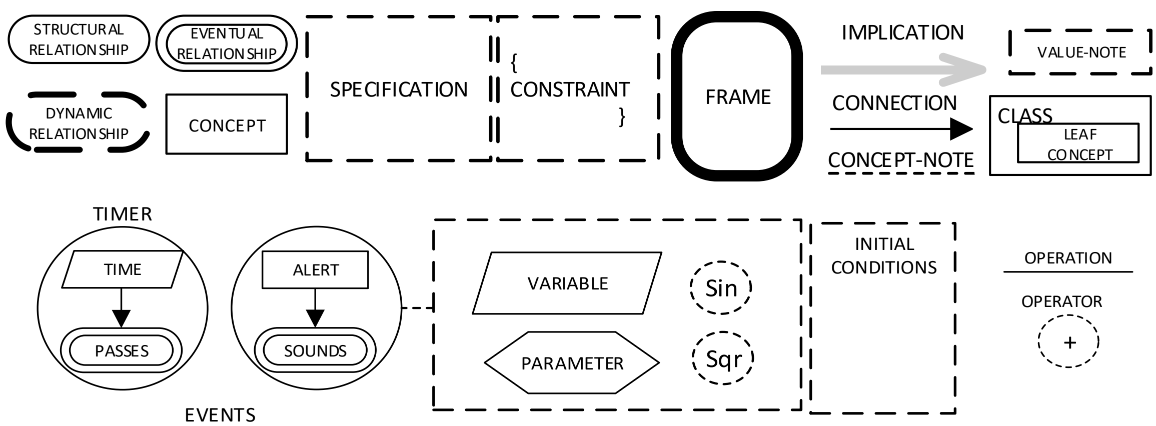
CONCEPTUAL FRAMEWORK

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 $M=A\cup R\cup T\cup E\cup F$, 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* sine, *sqr* 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

Gromov Rus *et al.* (2017) and Kalibatiene *et al*. (2015) represent work products, activities, roles, and events in business simulation by using BPMN. Also, Bosilj *et al.* (2018) use BPMN for representing business simulation about academic processes. Vasilecas *et al.* (2016) use BPMN for specifying events, resources, and data in a business simulation based on goals. Stankevicius and Vasilecas (2016) propose a model based on BPMN for running business simulation and avoiding redundant operation activation by using events. Fauzan *et al.* (2017) simulate scalability measures of processes by using Petri nets. Cartelli *et al.* (2014) represent the resource model and data model for business simulation by using UML class diagrams. Pascual-Miguel *et al.* (2014) propose a design and development of a business simulation game application for service-based and digital economy. Byrne *et al.* (2017) represent a simulator in UML component diagram for understanding the resources, including event generators.

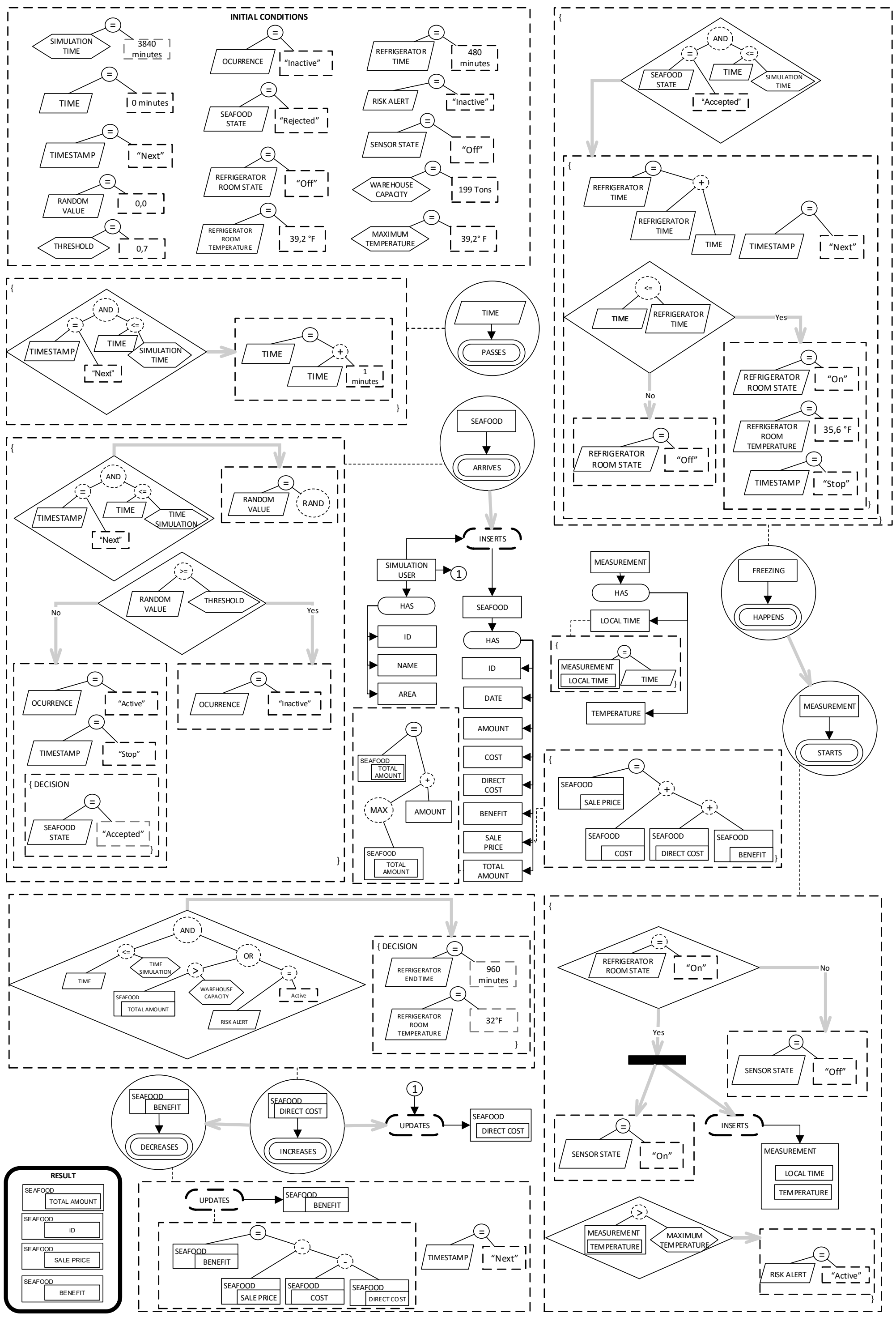
Commonly, authors use a simulation model at the beginning of a business simulation. Computational models—*e.g.,* BPMN, UML diagrams, and Petri nets—can be used by including elements of simulation as events, activities, roles, resources, etc. Events and activities involve equations for generating reports 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.



Task in business simulation.

(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 = o 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 *340 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

SEAFOOD							
ID	**DATE**	**AMOUNT**	**COST**	**DIRECT COST**	**BENEFIT**	**SALE PRICE**	**TOTAL AMOUNT**
101	10/11/2018	100 Tons	2550000	150000	300000	3000000	100 Tons
102	11/11/2018	20 Tons	510000	30000	60000	600000	120 Tons
103	12/11/2018	90 Tons	2295000	135000	270000	2700000	210 Tons

MEASUREMENT	
LOCAL TIME	**TEMPERATURE**
1 minutes	39,2 °F
2 minutes	39,2 °F
3 minutes	39,02 °F
4 minutes	38 °F
…230 minutes	39,38°F
…480 minutes	38°F

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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