Proceedings of the 2012 Winter Simulation Conference
C. Laroque, J. Himmelspach, R. Pasupathy, O. Rose, and A.M. Uhrmacher, eds

INTEGRATING DISCRETE EVENT SIMULATION (DES) AND SYSTEM DYNAMICS (SD) ON SINGLE PLATFORM FOR SIMULATING CONSTRUCTION OPERATIONS

Hani Alzraiee
Osama Moselhi
Tarek Zayed

Concordia University
1455 De Maisonneuve West,
Montreal, Qu, H3G 1M8, CANADA

ABSTRACT

Decisions in construction operation are taken at two levels, strategic and operational (Peña-Mora et al. 2008). Currently, in construction operations simulation area, there is a little understanding of how decisions at strategic level interact with operational level and how results of interactions could influence the outcomes of operations. The common practice in construction simulation is simulating operations in isolation to strategic/context level. Two methods of simulation have gained prominence in construction operations simulation are discrete event simulation (DES) and system dynamics (SD) (Alvanchi 2011). DES has been widely used in modeling construction operations; however, it lacks the ability to model the global/context aspects of operations being modeled and ignores the complex cause-effect relationships among variables. DES and SD provide a valuable decision support tool but none is individually capable of capturing the holistic picture of the operations being modeled, in addition, DES seems to overcome the SD limitations and vise versa. In this context, SD is utilized to circumvent those limitations associated with DES and to benefit from its holistic modeling capabilities. To address those issues, a hybrid simulation system capable of integrating DES and SD on a single platform is presented. The propose system applicable to modeling and simulating construction operations, and encompasses five stages: 1) identifying objectives and criteria; 2) building DES and SD models; 3) interfacing formalism; 4) time synchronization; and 5) DES_SD executer. In stage (1), objectives of operations requiring hybrid simulation are identified, and then project's operations are decomposed based on criteria developed from the unique characteristics of DES and SD. The decomposition results in units, when modeled using DES or SD, are called modules. Stage (2) focuses on building the simulation modules. The norms of building DES and SD models are used. Hybrid model structure is defined in this stage based on problem's requirements. Three possible structures are identified. First, if context variable effects on operation being modeled need to be accounted for, then those variables are modeled using SD and their effects are fed into interface variables in DES model. Second, when impacts of the strategic level on operational level need to be account for, then operational level represented in DES model components are allowed to interact only within framework set by strategic level. Third, where global SD model is built and failed to account for operational aspects, then DES is mobilized to compute operational variables, and then feed them into SD model through interfaces. Interface variables that act as contact points between modules' variables to receive or export data are selected in this stage. For stage (3), in order to facilitate integrating and interfacing of variables in the hybrid environment, formalism is used to describe the variables to the DES_SD executer. A novel synchronization method that utilizes Time Bucket concept is developed in stage (4) (Alzraiee et. al 2012). It provides an algorithm to deal with DES and SD simulation clocks. The final stage (5) involved developing the executer, which assembles the elements of the proposed hybrid simulation system on single plat-

978-1-4673-4781-5/12/$31.00 ©2012 IEEE

form. The proposed methodology was initially tested successfully through utilizing DES and SD simulation engines using circular hybrid simulation technique. Consequently, a pseudo code that results in a computer simulation application (hybrid system) is developed. Final testing and validation process is conducted to assure the reliability and validity of the application. This research is expected to be of value in hybrid modeling and simulating construction operations and understanding the impact of various factors on time and cost of the operations being simulated. This allows for improvements in planning and execution of construction work with cost and timesaving.

REFERENCES

Alvanchi, A., Lee, S. H., & AbouRizk, S. 2011. Modeling framework and architecture of hybrid system dynamics and discrete event simulation for construction. *Computer Aided Civil and Infrastructure Engineering*, 26(2), 77-91.

Alzraiee, H., Moselhi, O. and Zayed, T. (2012) "Methodology for synchronizing DES and SD models". *Proceedings of the 2012 Winter Simulation Conference C. Laroque, J. Himmelspach, R. Pasupathy, O. Rose, and A.M. Uhrmacher, eds*. Berlin, Germany.

Peña-Mora, F., Han, S., Lee, S. H., & Park, M. 2008. Strategic-operational construction management: Hybrid system dynamics and discrete event approach. *Journal of Construction Engineering and Management*, 134(9), 701-710.