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chapter fifteen

Modeling and simulation framework for systems engineering

Saikou Diallo, Andreas Tolk, Ross Gore, and Jose Padilla

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Introduction

In many application domains (military, homeland security, health care, and business), modeling and simulation (M&S) has become a standard approach for systematically developing, testing, and acquiring systems. The use of M&S usually involves three major steps: (1) identifying user requirements to capture stakeholders' needs, (2) conceptual modeling to capture system's parts and relationships, and (3) verification and validation (V&V) to evaluate the accuracy, correctness, and credibility of the simulation (Balci 1994; Balci 1998). Although these activities are supported successfully in systems engineering (SE) through standard processes, a formal (in the mathematical sense) process that ties in all SE activities has not been formulated. Further, SE projects that involve both humans and computer systems are very difficult to formulate, track, and validate because computers can only support simplified aspects of a real system

the different steps of a simulation study, as they are identified in our chapter as well. She is using metamodeling and model mappings. These metamodels are languages as identified in this chapter, and the mappings are the required filters. Her work is therefore closely related to the insight and practical applications described above. Similarly, Huang (2013) approached the problem from the challenge to better model increasingly larger and more complex systems. Using a comparable method, her dissertation shows how to define domain-specific model components and use them as building blocks for model generation of complex systems applying graph theoretic concepts ensuring the proper alignment of all building blocks. Again, the graph theory maps the formal representation that must guide the building process. Huang applied her work practically to light-rail transportation in the Netherlands on a significant scale. These are just two examples showing the general direction of the utilization of model theoretic concepts, although they are not always immediately recognizable from the direct application.

There is a long road to comprehensively evaluate the validity of systems across domains. It requires both an empirical and an axiomatic evaluation that is particularly challenging for representations of problem situations. For instances, the generation of an axiomatic structure poses many questions: what do we keep in the model, what do we leave out, do we have theories/data, and are they the appropriate theories/data? Explicitly, modeling problem situations using the MS-SDF will facilitate an objective evaluation, and the use of formal approaches should facilitate traceability, reuse, and interoperability over time.

References

Balci, O. (1994). Validation, verification, and testing techniques throughout the life cycle of a simulation study. *Annals of Operations Research*, 53(1), 121–173.

Balci, O. (1998). Verification, Validation, and Testing. In *The Handbook of Simulation*, J. Banks (Ed.). pp. 335–393. New York: Wiley.

Bonabeau, E. (2002). Agent-based modeling: Methods and techniques for simulating human systems. In *Proceedings of the National Academy of Sciences of the United States of America*, 99(Suppl 3), 7280–7287.

Bill 819 (2012). House Bill 819, General Assembly of North Carolina.

Borshchev, A. and Filippov, A. (2004). Anylogic—Multi-paradigm simulation for business, engineering and research. In *The 6th IIE Annual Simulation Solutions Conference*, Vol. 150, Orlando, FL.

Brooks, F. P. (1995). *The Mythical Man-Month: Essays on Software Engineering*, Anniversary Edition. New York: Pearson Education.

Cetinkaya, D. (2013). Model Driven Development of Simulation Models: Defining and Tranforming Conceptual Models into Simulation Models by Using Metamodels and Model Transformations. PhD Dissertation, Delft University of Technology, the Netherlands.

Clarke, E. M. and Wing, J. M. (1996). Formal methods: State of the art and future directions, *ACM Computing Surveys*, 28(4), 626–643.

DHS. (2009). National Infrastructure Protection Plan: Executive Summary. Retrieved from http://www.dhs.gov/xlibrary/assets/nipp_executive_summary_2009.pdf; accessed on July 28, 2013.

Dill, D. L. (1998). What's between simulation and formal verification? In *Proceedings of Design Automation Conference*, pp. 328–329. Piscataway, NJ: IEEE.

D'Souza, D. and Wills, A. C. (1998). *Catalysis: Objects, Components, and Frameworks with UML.* Vol. 223. Object Technology Series. United Kingdom: Addison-Wesley.

Ebbinghaus, H. and Flum, J. (2005). *Finite Model Theory*. New York: Springer-Verlag.

Fensel, D. (2001). *Ontologies*, pp. 11–18. Berlin, Heidelberg, Germany: Springer.

Hodges, W. (1993). *Model Theory*, Vol. 42. Cambridge, MA: Cambridge University Press.

Huang, Y. (2013). Automated Simulation Model Generation. PhD Dissertation, Delft University of Technology, the Netherlands.

Jackson, D. (2002). Alloy: A lightweight object modelling notation. *ACM Transactions on Software Engineering and Methodology* (TOSEM), 11(2), 256–290.

Karnopp, D., Rosenberg, R., and Perelson, A. S. (1976). System dynamics: A unified approach. *IEEE Transactions on Systems, Man and Cybernetics* 6(10), 724–724.

Kelton, W. D., Sadowski, R. P., and Sadowski, D. A. (2002). *Simulation with ARENA,* Vol. 3. New York: McGraw-Hill.

King, R. D. and Turnitsa, C. D. (2008). The landscape of assumptions. In *Proceedings of the 2008 Spring Simulation Multiconference*, pp. 81–88. San Diego, CA: Society for Computer Simulation International.

Lynch, C. J., Diallo, S. Y., and Tolk, A. (2013). Representing the ballistic missile defense system using agent-based modeling. In *Proceedings of the Military Modeling & Simulation Symposium*, p. 3. San Diego, CA: Society for Computer Simulation International.

Milne, G. J. (1993). *Formal Specification and Verification of Digital Systems*. New York: McGraw-Hill.

Owre, S., Rushby, J., and Shankar, N. (1995). Formal verification for fault-tolerant architectures: Prolegomena to the design of PVS. *IEEE Transactions on Software Engineering*, 21(2), 107–125.

Pace, D. K. (2004). Modeling and simulation verification and validation challenges. *Johns Hopkins University Applied Physics Laboratory Technical Digest*, 25, 163–172.

Protégé-Ontology. (2007). Knowledge Acquisition System. http://protege.stanford.edu.

Robinson, S. (1997). Simulation model verification and validation: increasing the users' confidence. In *Proceedings of 1997 Winter Simulation Conference*, pp. 53–59. Piscataway, NJ: IEEE Computer Society.

Robinson, S. (2007). Conceptual modelling for simulation. Part I: Definition and requirements. *Journal of the Operational Research Society*, 59(3), 278–290.

Spiegel, M., Reynolds, P. F., and Brogan, D. C. (2005). A case study of model context for simulation composability and reusability. In *Proceedings of the 2005 Winter Simulation Conference*, pp. 8–18. Piscataway, NJ: IEEE.

Titus, J. G. (1999). Rising seas, coastal erosion, and the takings clause: How to save wetlands and beaches without hurting property owners. *Coastlines: Information About Estuaries and Near Coastal Waters*, 9(6), 3–6.

Tolk, A., Diallo S. Y., Padilla, J., and Herencia-Zapana. H. (2013). Reference modelling in support of M&S—Foundations and applications. *Journal of Simulation*, 7(2), 69–82.

Verner, J. M., Overmyer, S. P., and McCain, K. W. (1999). In the 25 years since The Mythical Man-Month what have we learned about project management? *Information and Software Technology*, 41(14), 1021–1026.

Weiss, J. L., Overpeck, J. T., and Strauss, B. (2011). Implications of recent sea level rise science for low-elevation areas in coastal cities of the conterminous U.S.A. *Climate Change*, 105(3/4), 635–645. Doi:10.1007/s10584-011-0024-x

Zeigler, B. (1976). *Theory of Modeling and Simulation*, Vol. 19. New York: Wiley.