Exploring Two Modularity Techniques for Agent-Based Models

Glen E.P. Ropella[1], Brenden K. Petersen[2], and C. Anthony Hunt[2,3]

[1]Tempus Dictum, Inc. Milwaukie, OR 972221, [2]UCSF/UCB Joint Graduate Group in Bioengineering, [3]Bioengineering and Therapeutic Sciences, University of California, San Francisco, CA 94143

Agent-Based Modeling (ABM) is a broad spectrum, informal, modeling method that can provide a common infrastructure for the integration of multiple, heterogeneous Models of Computation (MoC). A minimal inter-agent protocol provides a medium through which agents of various composition, scale, and organization act. At one end of the spectrum, we encounter the agent-first perspective, which is the typical way biomedical ABMs are constructed, as in [1]. The logic of the agents and the phenomena they (collectively) generate are set a priori as model objectives and the inter-agent medium is handled either as another agent or a consequence of agent composition. At the other end of the spectrum, that perspective is inverted. System construction is network-centric. It is a consequence of the communication protocols available to any would-be agent. The choice of perspective (agent-centric, network-centric, or some combination) affects modularization options, i.e. which aspects of the computation can be encapsulated as modules; and modularization affects model granularity. It is most natural for agent-centric ABMs to consist of relatively dense modules of logic, where single-scale models consist of directly programmed agents and multi-scale models consist of coarser-grained agents composed of finer-grained agents. Similarly, single-scale network-centric ABMs are naturally composed of events, transitions, or message objects. And multi-scale network-centric models consist of collections of finer-grained transitions composed into coarser-grained process modules.

Therefore, network-centric models tend to produce primarily temporal, dynamic results whereas agent-centric models tend to produce structural and spatial extent results, where sequential changes in state are mapped to time. Of course, any particular ABM will likely be located between theses spectrum extremes, and will thus exhibit both agent- and network-centric approaches.

In the In Silico Liver project, we have been exploring the modularity consequences of the two construction processes. Our first concrete example is agent-centric and exhibits an interface-based modularity, relying heavily on Object-Oriented Programming (OOP) interfaces as implemented in Java [1]. In this poster, we will present a brief description of interface-based modularization and preliminary ideas for a network-centric modularity. We will also present our initial ideas for a synoptic approach that may help understand appropriate uses for either type.

[1]: Brenden K Petersen, Glen EP Ropella and C. Anthony Hunt. Toward modular biological models: defining analog modules based on referent physiological mechanisms. *BMC Sys Biol*, accepted Aug 04, 2014. http://biosystems.ucsf.edu/publications.html