

Argonne's Symphony: a modular toolkit for composing advanced integrated simulations

Challenge

The challenge for developing a modeling and simulation system in today's environment is how to represent ever-increasing system complexity while still maintaining ease of use and capabilities for rapid prototyping.

Argonne Solution

To answer this challenge, Argonne developed Symphony, a simulation toolkit designed to provide modelers with comprehensive simulation-building components in an easy-to-use point-and-click environment. Symphony provides an entry-level interface for beginning modelers and a progressively more complex set of tools to lead them to the level of more experienced developers. This approach can improve model quality and reduce development time by allowing users who are experts on the systems being simulated to build complex, dynamic, and integrated models without dedicated programmers at their side.

The toolkit includes capabilities for developing and integrating dynamic equation-based models, agent-based simulations, real-time data flows, advanced visualizations, and post-processing tools. Symphony provides drag-and-drop user interfaces for:

- Creating new models using flow diagrams and agent-based model templates;
- Making selections from existing repositories of model components and tools;
- Assigning data sources such as geographic information systems (GIS) and relational databases;
- Defining how components should interact; and
- Controlling how simulations execute.

Hybrid Modeling

The Symphony hybrid modeling approach facilitates the rich, comprehensive depiction of complex systems and

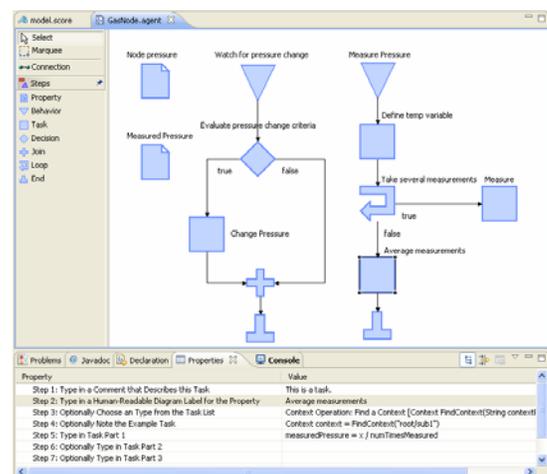
their component parts in several ways. First, it promotes component-based construction of new models. Second, it offers features to link conventional models and reuse existing (i.e., legacy) models and other analytical tools. Third, it offers a rich support library, including tools for agent-based modeling, equation-based modeling, biologically inspired modeling, legacy model integration, and enterprise data integration.

Agent-based Modeling

Symphony was built on the well-developed and widely used Repast toolkit. Repast is a free, open-source system that has been used to model many complex systems, including infrastructures, supply chains, markets, social networks, military command and control systems, political systems, land use, ecologies, biological cells, and computer networks — to name just a few.

Equation-based Modeling

Symphony's rich support library includes tools for equation-based modeling involving both systems dynamics modeling and regression analysis. These tools are configured to allow them to be fully integrated with



Symphony point-and-click model creator

the other Symphony capabilities, such as agent-based and biologically inspired modeling.

Biologically Inspired Modeling

Much like the support for equation-based modeling, Symphony offers a rich library for biologically inspired modeling, including tools for genetic algorithm and neural network modeling. As with equation-based modeling, these tools are configured to allow them to be fully integrated with the other Symphony capabilities.

Legacy Model Integration

Symphony's simulation development capabilities directly support the integration of existing legacy models into agent-based simulations. The integration of models requires both a deep understanding of each model to be integrated and careful consideration of the scientific and engineering appropriateness of the interconnections. The model system integration capabilities within Symphony are designed to decrease the level of effort required, to reduce the chances of errors, and to assist in the preparation of useful documentation of the integration approach. Once Symphony interfaces are developed for these legacy models or applications, they can be reused in other simulations.

Enterprise Data Integration

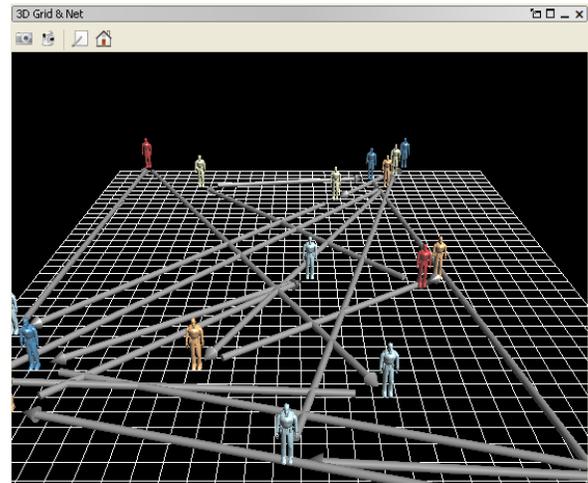
Symphony offers a range of point-and-click "freeze dryers" for storing and recovering complete scenarios. The storage options include text files, XML files, and database systems. Symphony also includes point-and-click logging of intermediate model results to text files.

Putting It All Together

Symphony integrates hybrid models with (1) a point-and-click simulation *creator* that defines what is allowed in a given set of simulation runs and (2) a point-and-click simulation *composer* that defines what is actually in each simulation run.

Simulation Support Tools

For efficient development, the Java-based Symphony system leverages existing technologies, including many free and open-source tools. The careful selection and use of available open-source tools makes Symphony a free and open-source product. These tools are integrated within the Symphony toolkit and provide value-added functionality such as statistical analysis, data mining, and visual report design.



Example Symphony network model

Symphony also offers an efficient approach to handling the spatial aspects of a simulation through a flexible hierarchically nested definition of space, including the ability to perform point-and-click modeling and visualization of the following:

- Aspatial environments;
- 2D environments;
- 3D environments;
- Networks, including full integration with the JUNG network modeling library; and
- Geographic spaces, including full GIS support

Learn more about Symphony and other Argonne modeling and simulation technologies at:

<http://www.dis.anl.gov/>

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