CoreSim Enables Larger Logistics and System-of-Systems Simulations

Contact: Scott A. Mitchell, Computer Science & Informatics, *samitch@sandia.gov*

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The project's goal is to design and develop a discrete-event [1] logistics simulator. The intent of the "CoreSim" software engine is to replace older logistic simulation codes and become the core logistics simulator for the System of Systems Analysis Toolset (SoSAT). CoreSim is also an R&D proof-of-concept project for finding the right balance between generality and specialization, between a generic discrete event simulator and a one-application logistics simulator. Our contribution is to design and develop a new general simulation capability and optimize code performance, including designing efficient algorithms with complexity theory. Partners in Sandia's Defense System and Assessments area lead the parts of the project dealing with customer interactions, requirements gathering, and simulation summary statistics capabilities. Ultimate customers of SoSAT [2] include military and defense contractors, notably the US Army's Program Manager for Future Combat Systems (PM FCS) and the Program Executive Office for Ground Combat Systems (PEO GCS).

The primary challenge was to find the right balance between the generality and specialization of features and implementation. A logistics simulator that uses a completely generic discrete event simulation engine typically runs slowly. At the other extreme, the external community has developed some very specialized logistics simulators that can only be used for one application. The old piece of logistics simulation code that CoreSim replaces has some fundamental design choices that, while providing generality and extensibility, severely impact code performance. CoreSim achieves a 3 to 5 order of magnitude speedup, through specialization of certain types of events, careful algorithm design and complexity analysis, as well as traditional code tuning.

CoreSim's main discrete event loop (Figure 1) achieves near-constant time enqueue and dequeue operations despite irregular event times by using a novel hierarchical variant of calendar queue [3]; see the figure for more detail. As another algorithmic speed up example, consider work-shifts. Their periodic start and end times could be handled by explicitly placing them as events on the event queue. CoreSim, however, is able to represent these events implicitly, because they occur in a predetermined manner. Another example of CoreSim's efficiency is related to scheduling, specifically, starting queued work-tasks. When a work-task completes, the resources (equipment, personnel) it was using are released, which might enable other waiting work-tasks to start. CoreSim uses sophisticated data structures to facilitate an efficient determination of which queued work-tasks, if any, should start next. (Choosing which task to start depends both on the resources and user-selected prioritization rules.)

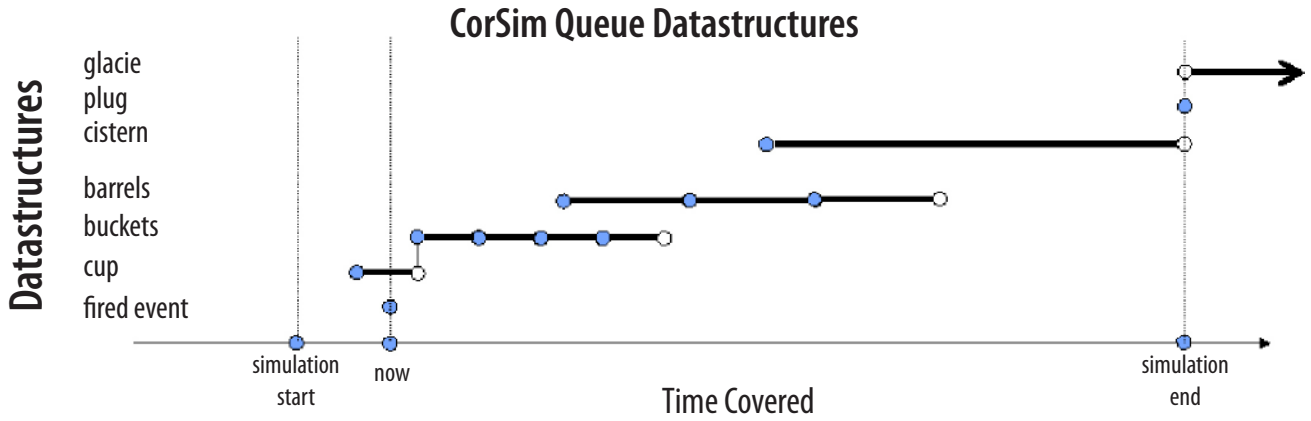

Figure 1. CoreSim's main discrete event loop employs a bucketing heuristic for queued events that dynamically exploits the frequency distribution of events. This gives added efficiency by avoiding maintaining a heap of large numbers of events, and instead performing sorts over small numbers of events just before they occur.

CoreSim achieves a speedup of 3 to 5 orders of magnitude, while maintaining approximately the same degree of flexibility in the types of scenarios it can simulate, over the older logistics component it replaces. A key simulation from a Lockheed Martin Joint Strike Fighter (JSF) project went from batch mode to interactive: its run-time decreased from over one day to a few seconds. CoreSim's software was carefully designed to be extensible, meaning new features can be added in response to what scenarios and trade studies customers need. The design team is also attempting to anticipate customer needs by making new features as general-purpose as practical within the specialization and efficiency requirements. Our quick turn-around efforts have been critical to this customer-focused project's success.

References

1. Schriber, T. J., and Brunner. D. T. (1997). Inside Discrete-Event Simulation Software: How it Works and Why it Matters, *Proceedings of the 1997 Winter Simulation Conference*, eds. S. Andradóttir, K. J. Healy, D. H. Withers, and B. L. Nelson, (http://www.informs-sim.org/wsc97papers/0014.PDF).

2. For more information about SoSAT and Sandia's role in the Army's Future Combat System, contact Bruce Thompson, Manager Systems Readiness & Sustainment Technologies Department, bmthomp@sandia.gov.

3. Siangsukone, T., Aswakul, C., Wuttisittikulkij, L. (2003). Study of Optimised Bucket Widths in Calendar Queue for Discrete Event Simulator, *Proceedings of Thailand's Electrical Engineering Conference (EECON-26)*, 6-7 November 2003, Phetchaburi. (http://pioneer.netserv.chula.ac.th/~achaodit/paper5.pdf).

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