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High Performance Computing Enhancement of Agent-Based Economic Models

Authors : Amit Gill, Lalith Wijerathne, Sebastian Poledna

Abstract : This research presents the details of the implementation of high performance computing (HPC) extension of agent-based economic models (ABEMs) to simulate hundreds of millions of heterogeneous agents. ABEMs offer an alternative approach to study the economy as a dynamic system of interacting heterogeneous agents, and are gaining popularity as an alternative to standard economic models. Over the last decade, ABEMs have been increasingly applied to study various problems related to monetary policy, bank regulations, etc. When it comes to predicting the effects of local economic disruptions, like major disasters, changes in policies, exogenous shocks, etc., on the economy of the country or the region, it is pertinent to study how the disruptions cascade through every single economic entity affecting its decisions and interactions, and eventually affect the economic macro parameters. However, such simulations with hundreds of millions of agents are hindered by the lack of HPC enhanced ABEMs. In order to address this, a scalable Distributed Memory Parallel (DMP) implementation of ABEMs has been developed using message passing interface (MPI). A balanced distribution of computational load among MPI-processes (i.e. CPU cores) of computer clusters while taking all the interactions among agents into account is a major challenge for scalable DMP implementations. Economic agents interact on several random graphs, some of which are centralized (e.g. credit networks, etc.) whereas others are dense with random links (e.g. consumption markets, etc.). The agents are partitioned into mutually-exclusive subsets based on a representative employer-employee interaction graph, while the remaining graphs are made available at a minimum communication cost. To minimize the number of communications among MPI processes, real-life solutions like the introduction of recruitment agencies, sales outlets, local banks, and local branches of government in each MPI-process, are adopted. Efficient communication among MPI-processes is achieved by combining MPI derived data types with the new features of the latest MPI functions. Most of the communications are overlapped with computations, thereby significantly reducing the communication overhead. The current implementation is capable of simulating a small open economy. As an example, a single time step of a 1:1 scale model of Austria (i.e. about 9 million inhabitants and 600,000 businesses) can be simulated in 15 seconds. The implementation is further being enhanced to simulate 1:1 model of Euro-zone (i.e. 322 million agents).

Keywords : agent-based economic model, high performance computing, MPI-communication, MPI-process
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