Chapter 9
Grid Super-Computable General Equilibrium Models

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ABSTRACT

We sketch a large-scale computable general equilibrium model of the macroeconomy that includes modern features such as financial derivatives. This model can be used to examine proposed new economic policies that involve large structural changes in the economy. To simulate and study the model, considerable computational power is required for extensive Monte Carlo simulations. We propose using a grid supercomputer to do these Monte Carlo simulations so that the results can be obtained in a reasonable amount of time. To evaluate the new policy, the supercomputer will run two sets of Monte Carlo simulations: (1) Baseline (2) Supercharged. Both sets contain trillions of stochastic simulations. After running both the baseline and supercharged simulations, the social welfare in the two possible scenarios can be compared to see if economic welfare was improved by the proposed supercharged economic policy.

GRID SUPERCOMPUTING

Today grids enable the masses to participate in supercomputing. In the past the printing press helped spread reading to the masses. More recently the Kelso ESOP and 401K helped spread capital ownership to the masses. This paper shows how to use the grid supercomputing to help study an economic policy aimed at more capital ownership by people who have been excluded from the capital markets. So the new freedom of grid supercomputing can expand the freedom to own some of the capital that makes grid supercomputing possible. The disruptive grid supercomputer technology can study a disruptive Kelso supercharged economic policy that supporters claim is Pareto optimal—i.e. will increase the welfare of all humans in the economy.

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Grid computing is a proven success. Low cost grid supercomputing has allowed more scientific problems to be studied. Folding@Home® runs on 350,000 computers around the world using 7 operating systems reaching speeds of 5 PFLOPS to study protein folding for scientists researching numerous diseases. Seti@Home® was released to the public in 1999 and by 2009 ran on 2.4 million computers in 234 countries in its search for extraterrestrials. MilkyWay@Home® has 44,900 users in 170 countries with average computing power of 1.38 PFLOPS. These compare favorably to supercomputers although grid computers cannot run LINPACK on the large problem that is the benchmark by which supercomputers are measured. The fastest supercomputer in the world is the Cray® Jaguar® at 1.759 petaflops at Oak Ridge National Laboratories Tennessee USA. The second fastest supercomputer in the world is the Dawning® TC3600 Blade® at the National Supercomputing Center in Shenzhen China (Top500.org, June 2010).

Grids link together separate computers to make a virtual super-computer. The separate computers may be widely dispersed geographically but are linked together by conventional network interfaces such as internet or ethernet. The separate computers are usually complete computers and may run different operating systems. This distinguishes *grid* computing from *cluster computing, concurrent computing, parallel computing, distributed computing, and traditional supercomputing.* These have more standardized compute nodes and often faster networks linking the nodes. Sometimes the compute nodes are specialized for particular applications and thus can be much faster than grid computers for those applications. Dedicated supercomputers may have field-programmable gate array (FPGA) chips on compute nodes that are specially designed for particular financial algorithms (Mackin, 2009) that can achieve a tenfold speed increase while cutting electrical power consumption in half (Mackin, 2008). *Reconfigurable computing* is the use of a FPGA as a coprocessor to a more general-purpose computer (Kelley, 2011). In a similar manner *grid* computing can benefit from the graphics cards in many distributed complete computers which are also powerful processors. *General purpose computing on graphics processing units* (GP-GPU) use fact that GPUs have been heavily optimized for computer graphics processing which is dominated by the parallel operations of rendering pixels independently and extensive linear algebra manipulations.

Technologies of *grid, cluster, concurrent, parallel, distributed computing* overlap to some extent while undergoing rapid development. Word definitions have not become extremely precise so in this book we use the term *grid* computer liberally. A *distributed* system is any set of autonomous computers that communicate through a network in order to achieve a goal. The problem is divided into sections that can be computed by the separate machines. In *parallel* computing all processors have access to a shared memory that can be used to exchange information between processors, but they do not have local memory, as does the *grid*. For supercomputers, "Systems with global shared memory allow access to all data in the system's memory directly and efficiently, without having to move data through I/O or networking bottlenecks. The impact can be dramatic ... the latency for messages through system I/O are 1000 to 10000 greater than communication within the memory domain" (SGI, 2010). In *distributed* computing, each processor has its own private memory (distributed memory). Information is exchanged by passing messages between nodes. A *massively parallel processor* (MPP) is a single computer with many networked processors with specialized interconnect networks. *Clusters* use commodity hardware for networking. MPPs tend to be larger than *clusters* with more than 100 processors. In MPP each CPU contains its own memory and copy of the operating system and application. In a *distributed-shared-memory computer* memory is physically distributed among the many processors, but can be programmed as if it were shared (UCAR, 1999).

Grid computing is the most distributed form of parallel computing. Grids are most cost effective on "embarrassingly parallel" tasks that require little communication between nodes. Grid computing harnesses the oversupply of computers to accomplish needed computing by grabbing spare cycles when computers are idling. Sometimes

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