Acceleration of Multi-Agent Simulation based on FPGA

Lintao Cui, Jing Chen, Bryan Hu
Dept. of Electrical and Computer Engineering, University of Alberta, CA

Abstract—Multi-agent simulation (MAS) is widely used in modeling real world systems, ranging from ants colony foraging to online trading. The performance of existing MAS software, however, suffers when simulating large-scale multi-agent systems on traditional serial processing processors. In this paper, we propose a FPGA based framework to significantly improve the performance of MAS.

I. INTRODUCTION

A multi-agent system is comprised of multiple autonomous interactive intelligent agents and each agent makes its own decision based on current situation and a set of rules. Complex or unanticipated behavior patterns could be generated through simple rules. The repetitive and complicated interaction between agents, which is out of the reach of pure mathematical models, could be explored in an efficient way through computer simulation. Multi-agent simulation, or agent-based modeling, is a class of computational models to simulate such systems, and it has been adopted in a wide range of research areas, including animal group behavior analysis in biology, and social network and criminal network analysis in sociology.

There are a number of MAS software available in the public domain that provide a programmable platform for simulating multi-agent systems, such as StarLogo, SWARM, and MASON, all running on a general-purpose CPU. The performance of those toolkits is, however, unbearable when the number of agents simulated becomes increasingly large. This is particularly troublesome in cases like criminal network and emerging infectious diseases analysis, both of which usually involve a large number of agents and need almost an instant result. Therefore, an acceleration platform based on parallel execution is desired to fully exploit MAS capabilities.

In this paper, we propose a FPGA-based acceleration approach for MAS. We discuss its implementation and experimental results that show significant speedup.

II. BACKGROUND

One of the earlier researches in accelerating MAS is based on cluster with speedups between 11 and 14 using a cluster of 16 workstations [1]. But the power of cluster resides in high speed computing with non-interactive workloads, making it less efficient when the interaction among agents occupies a significant part of system overhead, which is common in MAS.

Another recent work for acceleration employed multiple GPUs and obtained 30x speedups when compared to a CPU-based implementation [2]. Though the improvement is significant, the disadvantage of GPU is its large power consumption.

In contrast, we employ FPGA to reduce power consumption, but with a comparable performance speedup.

III. OUR FRAMEWORK AND PRELIMINARY RESULT

Our goal is to develop a general-purpose megascale MAS platform based on FPGA. The framework is shown in Figure 1.

Fig. 1. MAS on FPGA Framework

Dozens of Processing Element (PE) could be implemented on one FPGA chip, constituting PE array. Scheduler reads data from the host CPU and dynamically schedules PEs for parallel execution of those assigned tasks. Also, the fine-grained PE could easily utilize the inherent parallelism in each task. On-chip local memory is used as cache to overcome the speed bottleneck of accessing external memory.

We have implemented the classical Game of Life as a demo application in this platform. With 32*32 grid and 1024 agents, we achieve 40x speedup with frequency at 150MHz on a Xilinx Virtex-5 board when compared to running the same application on a laptop with AMD Athlon 2.9Ghz Quad-core CPU with 6GB RAM.

IV. CONCLUSION AND FUTURE WORK

Our preliminary results show great promise for FPGA-based MAS acceleration with significant speedup. Our future work is to develop a general and easy-to-use MAS acceleration platform through FPGA.

REFERENCES