Journal of Advanced Computing Research Vol. 5, Issue 1 (2023) 6-8

Parallel Processing - A Case Study of Biological Brain as Massively Parallel Computer

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***Abstract*—Modern computers are work at huge speeds which are able to perform more than 10^{13} instructions per second. So, the connectivity of the brain inspires in the development of a massively parallel million core computer which meet the requirement to the modelling of large scale spiking neural network. The modelling of big systems is demanding because of communication and processing power. So, changes of project occur from Manchester Baby (1948) to SpiNNaker ARM968 CPU node (2011) which take 63 years of progress to improve computer performance where SpiNNaker ARM968 CPU node is better than Manchester Baby due to the efficiency. In this paper, it describes about all models that can be used in massively parallel computer due to its benefits such as provide concurrency, save time and cost, solve complex problem and make well use of fundamental parallel hardware. In addition, to compute neural computation there are three steps which are communication, processing and storage. Moreover, in this paper shows a die photograph of the Blue Gene/Q Compute (BQC) chip since it gives high performance computing of massively parallel.**

***Keywords*: Massively parallel computer, biological, BQC**

I. Introduction

Nowadays, supercomputing use of parallel processing to solve computationally-intensive-problems. Several so-called scalable architectures, which offer corresponding increases in performance as the number of processors is increased have been designed in the last few years. Massively parallel computer (MPP) is refers to the large number of processors to commit a set of coordinated computation in simultaneously which is in parallel. Parallel computing role is to complete a computational problem with use multiple compute resources which are complication is separate into discrete parts. To get sequence of instructions each part must be separate. Then, instruction execute on dissimilar processors with simultaneously and general coordination or control mechanism is employed.

The main reasons why massively parallel computer is used because to save money and time where parallel computer can develop from commodity, cheap, take shortest time to complete the tasks and can solve complex problems.

The connectivity of the brain gives inspiration in the development of a massively parallel million core computer which are meet the requirement to the modelling of large scale spiking neural network. In 1970 until 1990, supercomputers are referred as massively parallel computer. IBM’s Blue Gene/L is supercomputer which is fifth fastest in the world. The modelling of big systems of spiking neurons is computationally very requesting in terms of communication and processing power. Neuron in the brain process information in parallel. Brain is known as massively parallel computer because retina in human eye consists millions of neural cells which is called rods and cones and all information process in parallel. Bipolar cells and ganglion cells also process visual information in parallel. In human brain has 100 billion neurons and each neuron is a several-input-single-output device. There are some debate about the part of the more several glial cells that built the structure upon which are the neurons form the brain and in certain, the part of astrocyte cells [1].

II. Literature Review

In the natural world, many related events and complex are happening at the same time but in a temporary order. Parallel computing is better than serial computing which is suited for simulating, understanding complex, real world phenomena and for modelling. Massively parallel computer gives many benefits and can solve complex problem easily, save cost and time. So, many developments of model are now depending on massively parallel computer. Many people are now use massively parallel in their research. For example, [2] states that the modelling of large system is very demand in terms of communication and processing power. They proposed the Spiking Neural Network architecture (SpiNNaker) is a massively parallel computer system that provide flexible simulator for neuroscience experiments and cost-effective. The SpiNNaker Chip Multiprocessor (CMP) is the fundamental building block with 18 ARM968 processor nodes residing in synchronous islands. Biological inspired massively parallel computer is definition of SpiNNaker. SpiNNaker is designed to easier the modelling and large-scale spiking neural networks simulate between inter-neuron connections in biological real time.

Furthermore, the author [3] also proposed the SpiNNAker but the point of the research are not same which is in massively parallel chip multiprocessor is mapping neural networks. The purpose of this design is to bear big scale spiking neural network simulations. The system can support neural simulation with different degree of connectivity from thousand neurons to millions where this system is extremely scalable. To reach sturdy distributed computing, the processing cores are arranged in identical Chip-Multiprocessors (CMP) and independently functional where get this inspire by the structure of brain. To achieving the goal of SpiNNaker in biological real time in simulating 1% of the human brain will need effective communication, a big memory capacity and a big number of processing cores. In processing, 10 processing cores operate at a token frequency of 200 MHz are needed to simulate 10 synapses and 10 neurons. They state that [4] these approximations are based on Izhikevich where Izhikevich is example of medium complexity neuronal model. In communication, biologically neurons communicate mainly through spike events and information can only get if neuron fire and when it fires. By using Address event representation (AER), massive interconnectivity can be modelled effectively as packet which is based on spike communication [5]. Spikes can only bring information in timing events. They indicates that [6] communication is a large-scale neural simulation rather than certain emphasis is assign on the communication mechanisms utilize, compute-bound and the design of the SpiNNaker CMP.

TABLE I

Spiking Neural Network simulations (SNN) [2]

	Exp. 1	Exp. 2	Exp. 3
Neurons per population	1,000	100	100
Populations	16	16	64
Incoming projections/pop.	1	5	5
Synapses/population	10^6	50,000	50,000
Total number of neurons	16,000	1,600	6,400
Total number of synapses	16×10^6	800,000	3.2×10^6
Spikes/population/s	4,000	10,000	10,000
Total spikes/s	64,000	160,000	640,000
Total connections/s	64×10^6	80×10^6	320×10^6
Mapping			
Cores used	16	16	64
Chips used	1	1	4
Processing and communications per core			
Neurons	1,000	100	100
Neuron updates/s	10^6	100,000	100,000
Instructions/neuron update	33	93	93
(Neuron up.) instructions/s	33×10^6	9.3×10^6	9.3×10^6
Synapses	10^6	50,000	50,000
Connections/s	4×10^6	5×10^6	5×10^6
Instructions/connection	6	6	6
(Connection) instructions/s	24×10^6	30×10^6	30×10^6
Total instructions/s	57×10^6	39.3×10^6	39.3×10^6
Packets processed/s	4,000	50,000	50,000
Energy efficiency			
Power/neuron (nJ/ms)	12	44	45
Energy/connection (nJ)	4	4	4

Table 1 shows the results from three experiments. Among the populations there are interconnections with projections and populations are groups of neurons [7]. The results show that small-scale SpiNNaker encounter their SNN simulation performance targets system and programmability of the system by modelling networks and highlight the flexibility. So, the results confirm that small-scale of SpiNNaker systems meet their SNN simulation highlight the flexibility and performance targets and programmability of the system by modelling networks with different regimes, dynamics, topologies and characteristics.

III. METHODOLOGY

Figure 1 shows the Blue Gene/Q Compute (BQC) chip. Blue gene/Q chip is built because to develop high performance computing of massively parallel [8]. Furthermore, to build the massively parallel which is perform power efficient in resulting, floor-space-competent systems and cost efficient.

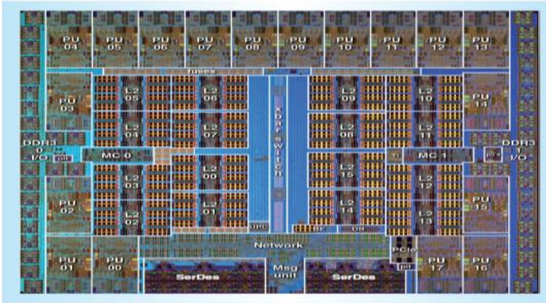

Fig. 1. A die photograph of the Blue Gene/Q Compute (BQC) chip

Moreover, [9] state that the size of the network that can be simulated is reduced if use Hodgkin–Huxley model. Hodgkin-Huxley model is used to describe the dissimilar spiking phenomena of a neuron. Although the complexity of HH model make that model is expensive but this model has advantages which is it can model many kinds of neurons and not require a lot of work. If massively parallel use simple neuron models, then it is cannot accurately simulate the extensive diversity of neuron types and biological neurons.

Hence, the model also performs on massively parallel computers which is large eddy simulation model. Large-Eddy Simulation (LES) can be done on single processor machine but there are a lot of obstacle in boundary layer research demanding greatest computational power [10]. By using massively parallel computers it can overcome this problem easily. LES studies will be running faster after combines with massively parallel computer.

In the computational structures, trees are an important class [11]. Tree structure with different from the parallel computer processor interconnection that can contribute mapping problems increase. MasPar's MP-2 is stand for massively parallel. Interconnected between processor of MasPar's MP-2 with the X-Net neighbourhood two-dimensional mesh and the various globally. In the hexagonal array, the pyramid networks and hypercube are example mapping tree-structure which has been broadly studied. The hierarchical hypercube network (HHN) used for massively parallel computers was recommend since the hypercube is not suitable for large system. This is because the connection of wires will take full system space. Hence, when applying in large multicomputer systems, it is important to reducing the number of links. The HHN is suitable for establish massively parallel computers due to small node degree. A hierarchical network for large system which is hierarchical hypercube network (HHN) which is several parallel algorithm can be applied easily, can have several levels of hierarchy and complexities of time for this network same with the hypercube [12]. They state that [13] with using hypercube network a number of research and commercial have been built. A processor element (PE) cluster is collected of 16 processor memories and 16 PEs [14]. The difference between global router and X-Net is the global router is more general purpose and it is slower compared than X-Net. Thus, X-Net neighbourhood mesh and the global multistage crossbar router network are used to show trees of mapping scheme on the MasPar MP-2.

They study [15] to make artificial neural networks (ANN) algorithms run on massively parallel computers and design for new parallel systems tuned up for ANN computing. ANN computations are the most popular models which it can be mapped rather expeditiously onto existing architectures. However, sparse distributed memory (SDM) is some example model that need a massively or highly parallel computer that able to performing tailored but operations in parallel, maintaining a very big amount of storage and simple. The sparse distributed memory (SDM) who claims that it is biological [16]. So, it shows that the useful of massively parallel in many aspects.

IV. CONCLUSION

In this paper it shows that the scale simulation of human brain is now achievable on massively parallel supercomputers. The connectivity of the brain gives inspiration in the development of a massively parallel million core computer which are meet the requirement to the modelling of large scale spiking neural network. Massively parallel is high performance, provide concurrency, save time and cost, solve complex problem and make well use of fundamental parallel hardware. So, massively parallel computer is important because to know more detail about how the brain process and represents information.

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