Building a PC Cluster for Parallel Computing

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Abstract

This article gives an example on how to build a cluster of personal computer for scientific computation. This type of cluster is much chearper than a supercomputer but gives better cost per performance ratio than of supercomputer. We also show an example of its application that a computational fluid dynamic simulation.

Introduction

Complex problem simulations, such as computational fluid dynamic simulation, molecular dynamics simulation or weather simulation, etc., require massive memory computers with fast parallel CPU. Since supercomputers are expensive, most researchers cannot afford the cost of these powerful tools. Recently, parallel and powerful computing with a cluster of PC has emerged as a new practical technology with enough power to solve these complex problems.

Parallel Processing with Master-Slave Model

This type of parallel processing starts with the master processor divides work into smaller tasks. Then it distribute tasks to all connected processors known as slaves. All computing slaves work simultaneously before sending results to their master. Basically, there are two typical parallel computers. The first type is a shared memory system, which all processors share the same memory via a bus or a switch. Examples of this types are SGI, HP, PC, IBM, SUN, etc. The other type is a distributed memory system which each processor has its own memory. Examples of this type of memory system are Compaq, SP2, PC or a workstation cluster.

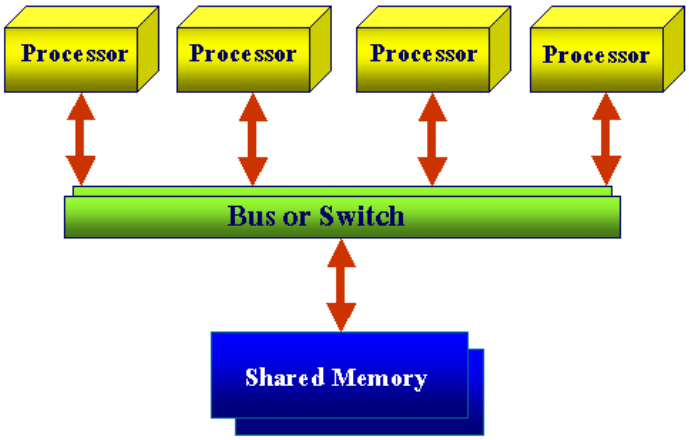

Figure 1. Shared Memory Systems (SMP)

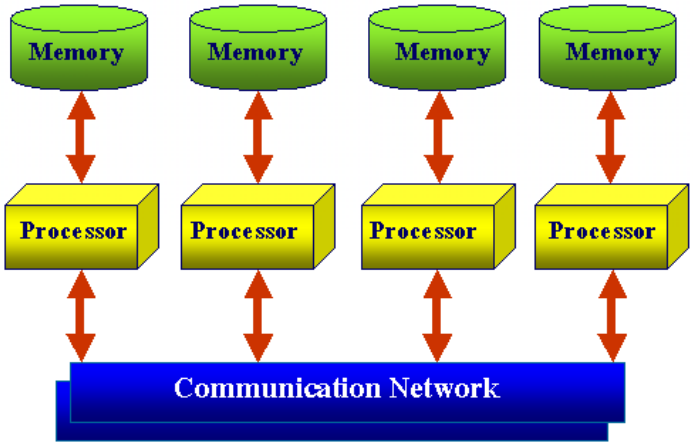

Figure 2. Distributed Memory Systems (MMP)

A PC Cluster

A PC cluster is a group of personal computers connected by a local network. A PC cluster feature composes of hardware, software and performance. For hardware, any PC can be used to build up a PC cluster, we can make use of available resources that can be found in local computer hardware market. Since the hardware is so common, it is easy for us to manage or repair. And it is also inexpensive. Free and open-source software specification can also be used in building up a PC cluster, we can make use of available source codes. The performance of a PC cluster can reach as far as a supercomputer performance on a specific task by the best cost.

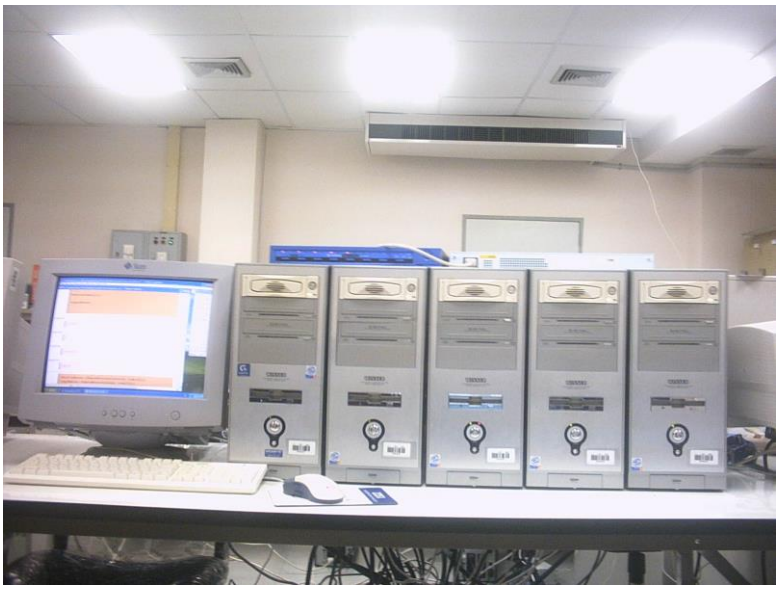

Figure 3. WACP4 Cluster is a PC cluster built up with 4+1 nodes computer at Grid and Cluster Laboratory, Walailak University.

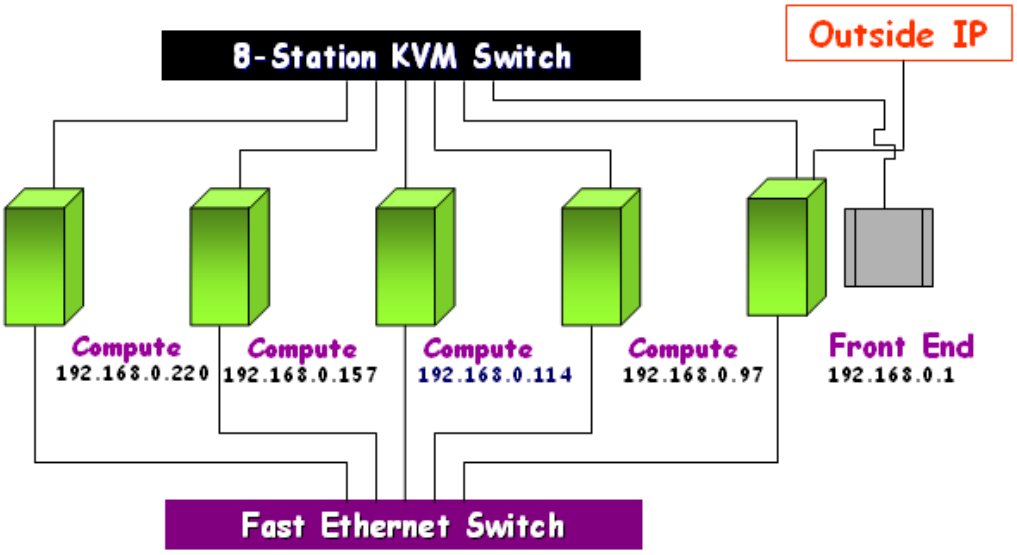

Figure 4. Configuration of WACP4 Cluster

An Example of Hardware Configuration

1) One front end node or master nodes : Intel Pentium 4, 2.4 GHz CPU and 1.00 GB RAM, one VGA card and one monitor.
2) 4 computing nodes : Intel Pentium 4, 2.4 GHz CPU and 1.00 GB RAM.
3) Two Fast Ethernet Switch 10/100/1000 mbps
4) 8-Station KVM Switch

Software Configuration

5) Operating system: Linux Redhat 9, Windows XP Profession
6) Parallel computing software: Parallel Computing Toolkit
7) Computational software: Mathematica 5

WACP4 cluster has only one monitor connected via an 8 port KVM switch. The master node is connected to four slave nodes via a gigabit ethernet switch.

An example of high performance computing demanding application

A Two dimensional cavity flow simulation of 100×100 to 1000×1000 points was run on WACP4 PC cluster. After the hardware was set up, Mathematica was installed on all nodes, then the Parallel Computing Toolkit was installed on the master node. Before running any commands, the first step is loading the Parallel Computing Toolkit and the package with the parallel commands. The second one is making a passive connection and the status were checked. In the third stage, the cavity flow program was executed. The next stage is checking results. Then comes the last stage of closing down the slave nodes. The cluster were tested with one, two, three and four nodes on the same problem respectively.

Results and discussion

Testing result from the Cluster which built up with more powerful computers show computing time to increase as the number of point increases. For 2 nodes and 3 nodes , computing time decreases drastically. We also see a little significant decreasing time between three and four nodes.

We can draw the conclusion that cluster computing is faster, but not at the factor of node numbers. In fact, there are always time used in communication among nodes with the master node and writing a program. Three nodes are sufficient for running a cavity flow program and the more powerful PC's take less time in computation.

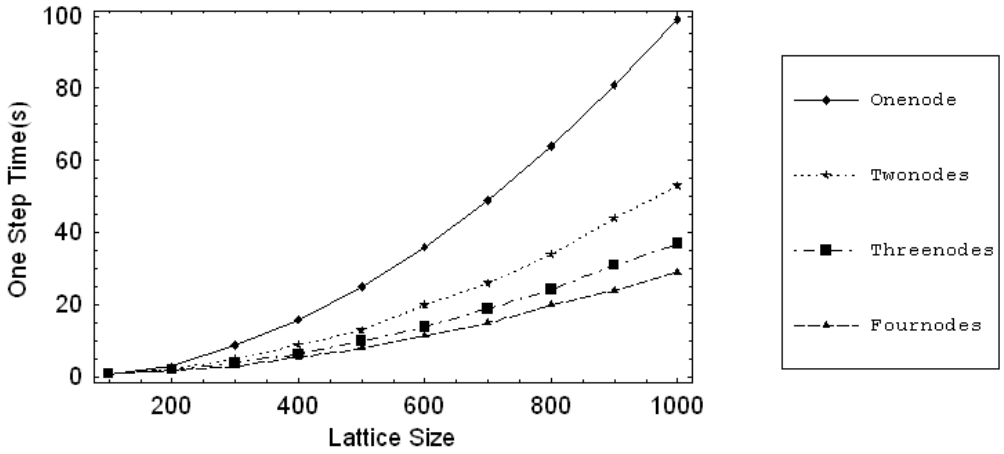

Figure 5. Computing time of WACP4 cluster

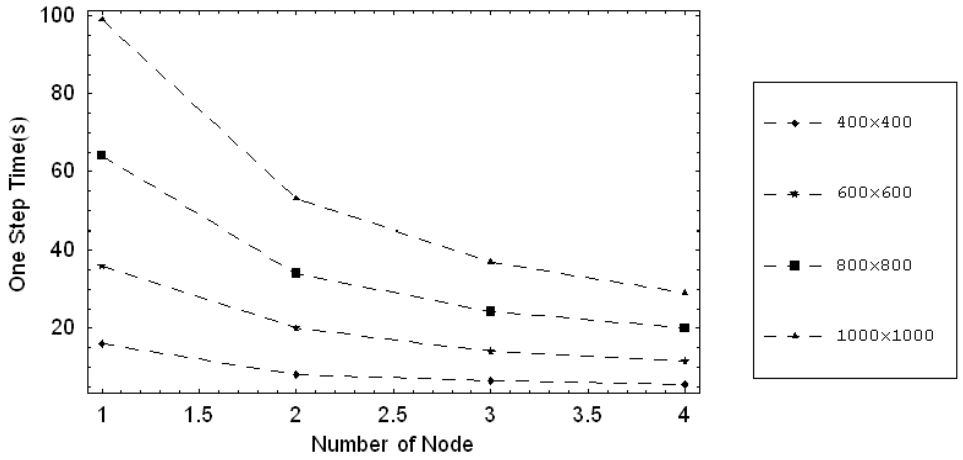

Figure 6. Computing time of WACP4 cluster

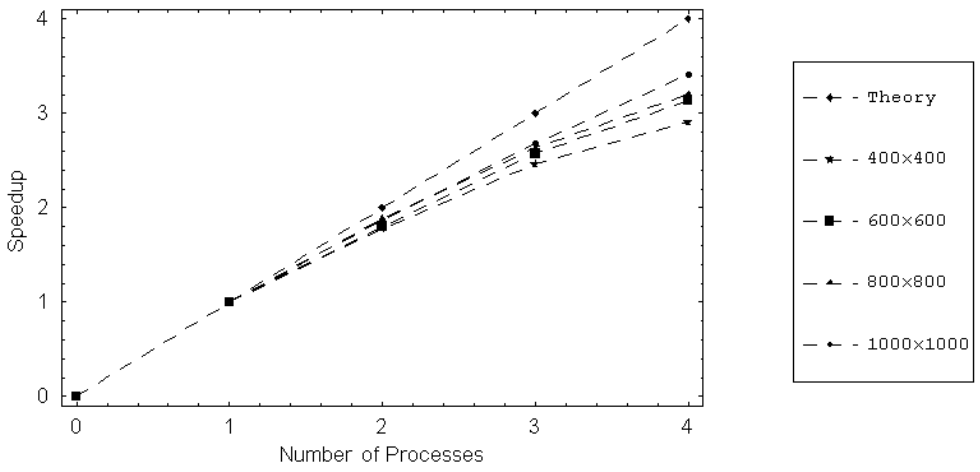

Figure 7. Speedup (T_1/nT_n)

Parallel performance on a PC Cluster

Number of lattice nodes	n: Number of rocessors	T_n:CPU time (sec/per iteration)	Parallel efficiency (T_1/nT_n,%)
400×400	1	16.0	100.00
	2	8.0	100.00
	3	6.5	82.05
	4	5.5	72.73
600×600	1	36.0	100.00
	2	20.0	90.00
	3	14.0	85.71
	4	11.5	78.26
800×800	1	64.0	100.00
	2	34.0	94.12
	3	24.3	87.79
	4	20.0	80.00
1000×1000	1	99.0	100..00
	2	53.0	93.40
	3	37.0	89.19
	4	29.0	85.34

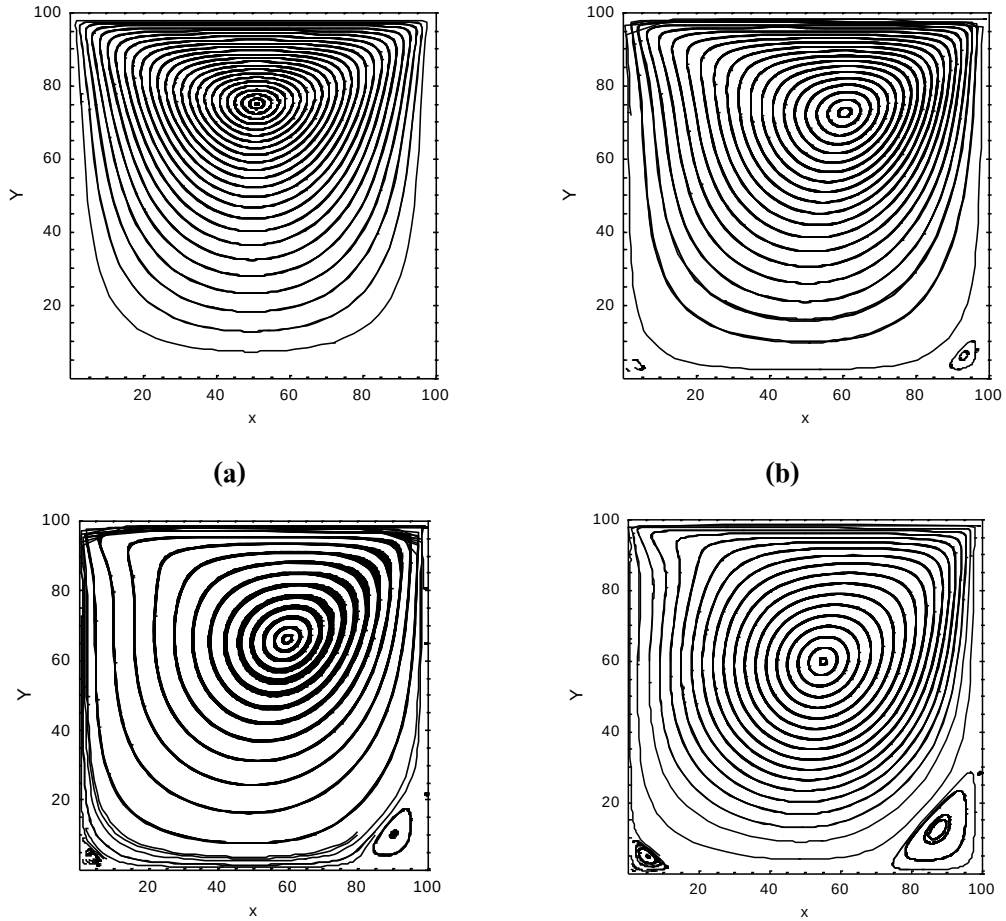

Figure 8. Streamlines of fluid flow. Reynolds number (Re) were set to 10, 100, 200, and 400 for (a), (b), (c) and (d) respectively.

Fluid streamlines are show in Figure 8 when the system reaches steady state with 100×100 lattice size for different Re. We observe the primary vortex moving to the centre when Re grows higher. From the plots, circular streamlines for high Re are noted.

Conclusions

WACP4 cluster have been built, modified and tested with an example problem. The results show the superior ability of cluster computer over a single PC for complex task.

Although this piece of work is only example for us to examine, there are still numerous points for us to study in detail, not only for parallel computing but also for further technology.

Acknowledgements

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