High Performance Computing Applications In Korean Trainer Development Program

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Abstract

CFD has been used in aircraft development and broaden its influence in various fields of industries. This paper briefly introduces the historical trends of computing system, the overview of CFD applications in Korean Supersonic Trainer Development Program and the demand for CFD software in industry points of view.

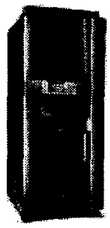
1. Introduction

The rapid evolution of the computer leads to massive grids and fast calculation. At results, the role of CFD rises up in comparison with wind tunnel test and flight test during aircraft full scale development period when CFD is widely used for many fields like flow characteristics analysis, airload estimation, unsteady simulation, lift-drag estimation, inlet/outlet analysis, thermal analysis and so on. The demands of CFD engineer for commercial CFD software are rapid grid generation, low cost parallel computation, compatibility of format of input and output, less memory algorithm solver and easy transformation of CAD geometry.

2. KAI Computing System for CFD

At the beginning of T-50 FSD (Full Scale Development), 1997, KAI constructed the CFD computing system using 8-CPUs SGI origin2000 system and several SGI Octane workstations. This mainframe is focused on multiple jobs processing by plural users rather than parallel processing by single user. The personal computer has made rapid progress in computation speed, memory capacity and storage capacity during FSD. It is preferred to be used to solve the engineering problems because personal computer is more convenient than UNIX based mainframe like origin2000. However standalone personal computer cannot be solution for the large scale engineering case due to limitation of memory capacity and computation speed. The LINUX based clustering system became good counter-solution for the demand of huge memory usage and fast computation speed. KAI began to construct LINUX based clustering system at 2004, currently acquires total 22-CPUs and 60GB memory.

Table 1. KAI Computation System for CFD

	1st Stage(1997~2005)	2nd Stage(2004~)	
System	Origin 2000 	HP DL140  Total 7	Samsung ZSS230  Total 2
OS	Unix (IRIX)	Linux Redhat Enterprise AS	
CPU	R10000 CPUs Total 8	Xeon™ 2.40GHz Total 14	Xeon™ MP 3.66GHz Total 8
Memory	2GB	28GB	32GB
HDD	SCSI HDD Total 50GB	IDE HDD RAID (0+1) Total 1.6TB	
Backup	Tape Backup		

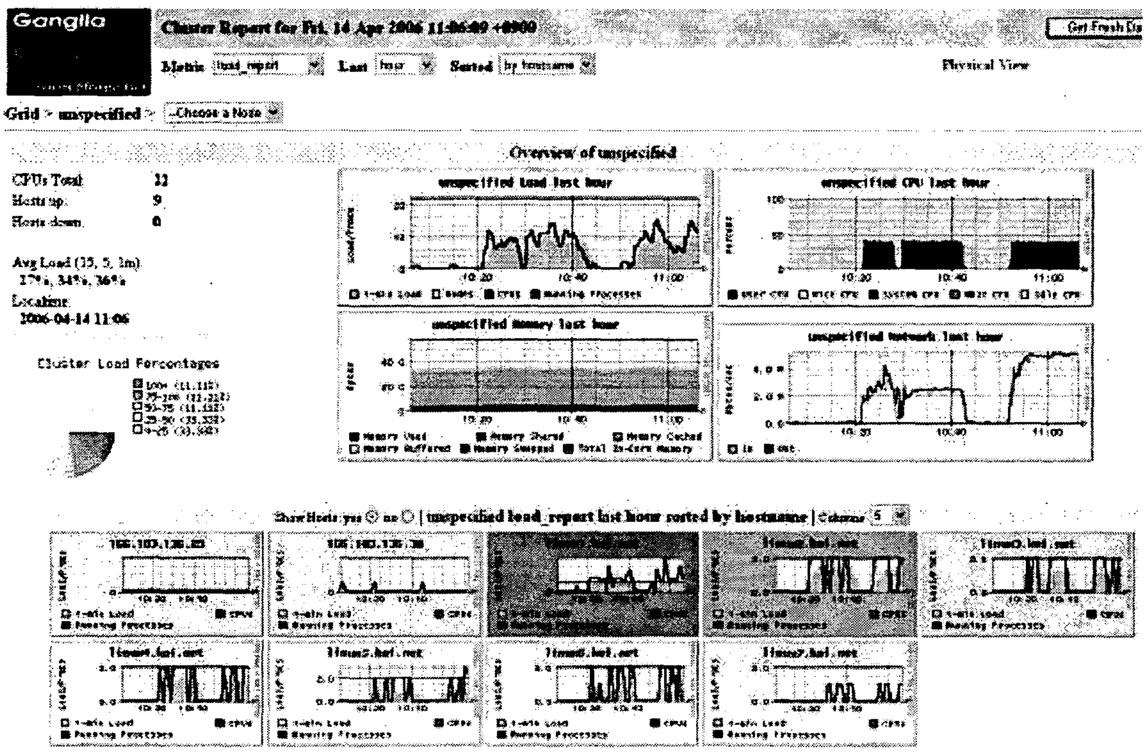


Figure 1. System Monitoring by Ganglia

Ganglia is used for monitoring load of CPU, memory and network of clustering system.

3. CFD Applications in Korean Trainer Development

CFD work for T-50 development can be categorized by three fields – configuration design support, wind tunnel test support and flight test support. Simple CFD code using panel method or VLM make a key role conceptual and detail design because of the fast computation and relatively accurate data. Euler and NS CFD code do not only provide the qualitative design direction but also quantitatively accurate data for configuration design. Before OML (outer mold line) of aircraft is frozen, the configuration changes are frequently occurred. CFD is very powerful tools to quickly check the impact of configuration change on surrounding flow fields. CFD has been applied to design of forebody/ strake, forebody/inlet, inlet/duct, aftbody/nozzle, wing/LEF/TEF, secondary inlet/outlet, small antennas and miscellaneous cases.

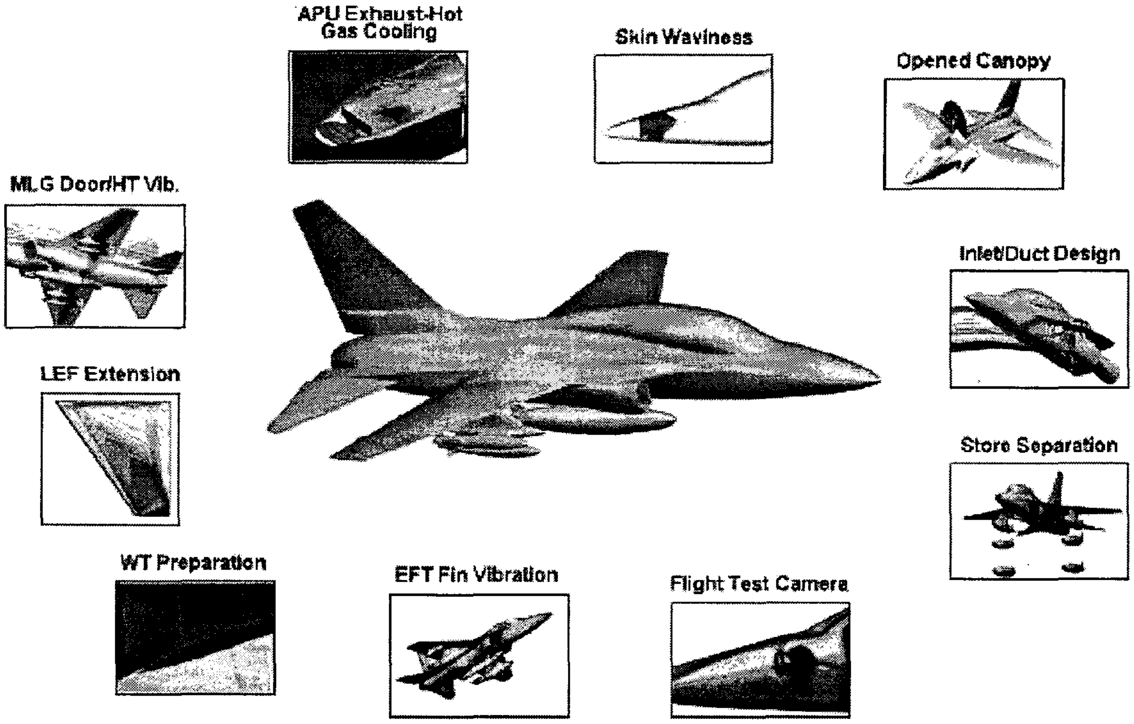


Figure 2. Example of CFD Applications to T-50 Development

Wind tunnel test usually takes long time about 6~8 months to prepare the test model and conduct test. Before and after the test, small or partial configuration change cannot be reflected in the test. In this case, CFD could provide useful engineering data to advance design works. Especially the airload wind tunnel test would take long time to prepare the complicate airload test model and be expensive. During T-50 FSD, airload wind tunnel test was conducted just once. The lots of configuration change occurred after the airload wind tunnel test like forebody section shape, strake planform, wing-body fairing, LEF size, gun bump shape and vertical tail tip. The air load of newly designed configuration was obtained by CFD saving lots of money and time in comparison with wind tunnel test. CFD was also applied to design wind tunnel test model supporter, sting and other extraneous devices used for the test.

During flight test, the unexpected problems usually occur. This kind of problems might be related with safety and progress of the test. CFD can help to find out the root cause of the problems and provide the solutions. CFD help to solve following problems and progress the test during T-50 flight test. - large error of AoS, fuel tank fin vibration, aircraft vibration with multiple stores at inboard, MLG door vibration, APU hot gas exhaust, external camera positioning, store separation estimation and air data sensor characteristics.

4. Demand for CFD software

In industry points of view, CFD software should satisfy not only the confidence of solution but also the efficiency of laboring time and output. In order to enhance the efficiency and confidence of CFD work, followings are recommended.

First, the grid generation time should be reduced. As known, the grid work is very time-consuming work and its quality is critical to accuracy of solution. Large percent of whole CFD work time was occupied by grid work. Oncoming CFD software should consider rapid grid generation algorithm.

Second, the computation time should be reduced. The LINUX clustering system is successfully introduced to CFD world and become more generalized. Oncoming CFD software should provide the low cost policy of parallel computation. Currently the parallel computation of commercial software using massive number of CPU is not generalized due to high cost.

Third, viscous moving grid should be available via easier way. Structured chimera method has many limitations to solve the viscous moving grid in complex geometry. The method for unstructured moving grid with mesh deformation should be further enhanced to meet commercial software requirements.

Others, compatibility of grid file/output file between CFD software is recommended. Maybe societies related with CFD can contribute to standardize the input and output format. The developer of CFD code will consider the standard of input and output format. Less memory computation algorithm is required. It relaxes the limitation of memory usage and enhances computation efficiency. Exact and easy transformation of CAD geometry is also required for grid generation.

5. Conclusions

- LINUX cluster is good counter-solution for huge memory usage and fast computation speed.
- CFD made a key role at Korean Supersonic Trainer Full Scale Development.

- It is recommended that oncoming CFD software satisfy,
  - Rapid grid generation
  - Low cost parallel procession
  - Compatible input and output file
  - Viscous moving grid
  - Less memory algorithm
  - Easy transformation of CAD geometry

REFERENCES

[1] Edward N. Tinoco, (1990). “The Role of Computational Fluid Dynamics (CFD) in Aircraft Design”, AIAA1990-25175

[2] F.Ron Bailey, Horst D. Simon, (1992). “Future Directions in Computing and CFD”, AIAA-92-2734-CP

[3] R.R.Cosner, (2000). 믧 ssessment of Vehicle Performance Predictions Using CFD”, AIAA2000-0384

[4] C.McClinton, R.Bittner, P.Kamath, (1991). “CFD Support of NASP Design”, AIAA-91-14472

[5] Luciano Fornasier, Werner Kraus, Herbert Rieger, (1997). “CFD-Based, Application-Oriented, Integrated Simulation Environment for Rapid Prediction of Aerodynamic Sensitivities of 3-D Configurations”, AIAA PAPER 97-5606