

ADVANCED MANUFACTURING GRID SUPPORTING AVIATION INDUSTRY EXTENSIVE COLLABORATIVE DESIGN AND SIMULATION

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Abstract

China Aviation Industry is face to seriously challenge and good opportunity in the large China domestic market. The one of important way to action the challenge is using high-tech to improve the ability of China Aviation Industry. An GRID technology application project in China aviation industry is supported by China National High-tech 863 Program, the application project has provide a good information platform for the aircraft development and has also improve the industry management. The aviation GRID technology application solves the hardware computation capability share, also providing the software and information resource share based on the Service Oriented Architecture (SOA). The experience is show that the GRID technology will strengthen the computation capability and collaboration working ability of China Aviation Industry in research and development; also will support China Aviation Industry to join the international corporation.

1 Background

The strong market demands are providing great opportunity for China Aviation Industry (AVIC) and show a good future. The Boeing New Aircraft forecast of China airline providing 2007-2026 is 3380. The total cost is 340 \$billion in the 20 years. Among 82% is serviced inside China.

The growth Rate of Person-Kilometer (RPK) of air travel normal is double rating of the Gross Domestic Product (GDP) rate of the national. The RPK is reflected the growth rate of GDP.

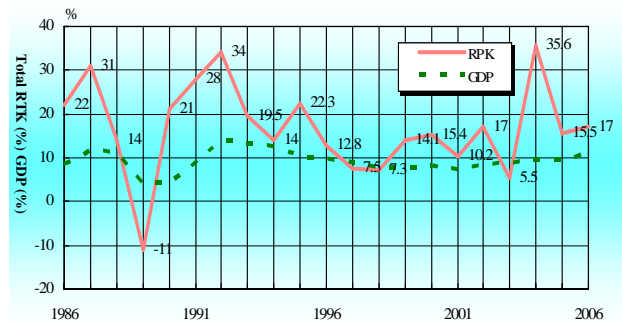


Fig.1. China Growth Rate (Total RTK) of Air Travel and GDP (1983-1998) [1]

In other side, AVIC is also faced the challenge of distributed jointed aircraft development, because those aircraft manufactory companies located in different parts of China with thousand kilometer distance. It needs to solve the jointed projects development and shares the resource problems. To reduce the long aircraft development schedule, high product live circle cost for new projects also need to solve the problem of collaborative design, manufactory and simulation.

There is strong requirement for using information technology in AVIC, as following:

- A. To create platform for the enterprise collaborative development in deferent locations;
- B. To share the resource between the aviation enterprises.

China National High-tech 863 program has supported the Grid technology application in China industry [5], including aviation industry.

2. The Requirement for Grid Technology

More computation resources are required when the simulation technology is used in AVIC enterprise. One hand is resources are shortage,

because the requirement of computation resource is big increased when more new simulation tools have been used in aircraft development live cycle. The other hand is the resource still not very efficiency used. Some period enterprise needs occupy large resource, but a lot of time the resource has not been fully used. The computation resources, which including “hardware resource”, “software resource” and “data resource”, need to share.

2.1 Software resource

Following fig. is shown a curve for most aviation enterprise. It shows the required operated CAD resource during an aircraft development live cycle in a design part and a manufactory part. In the detail design stage, the design part needs about 400-500 CAD systems, but in the most time only require it less than 100. The curve peak point of CAD system resource for the manufactory is moved to latter stage than design part. The CAD system is including workstation and software licenses. The license cost is much high than workstation. There are more than 3000 licenses in AVIC, but each company has less than 200 licenses.

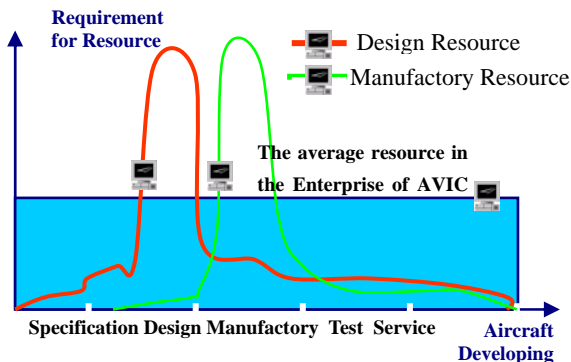


Fig. 2. Requirement of Resource Sharing in Aircraft Development

The software tools for analysis and simulation in each company also has similar situation as CAD systems and each company need some manpower to maintain those tools. To share the software resources and use Service Oriented Architecture (SOA) in AVIC become very strong requirement.

2.2 Hardware resource

Advanced aircraft development need to do great amount digital computation analysis to optimize and simulate the design. It needs super computers and long computation time. For example, the time consumer for optimization a wing aero-elastic problem using genetic algorithm is 550 hours (23days) running in a large computer. It is not accepted by engineers. Share the hardware becomes strong requirement in Aviation industry.

2.3 Information resource

The distributed aircraft development faces to share the drawing, the analysis, design, manufactory data and documents. The supply chain is very huge and long for a aircraft project, more than thousand suppliers will share some information for jointed development. The different PDM, PM, SCM, CRM and ERP systems used in different enterprises also has interoperability problem for the information exchange and keep the single data resource for a jointed project. To solve the information share is strong required for China aviation industry also.

3 Advanced Manufacturing Grid Supporting Extensive Collaborative Design and Simulation

Face the requirement on hardware, software and data share, an advanced manufactory Av-Grid platform has been developed to support the extensive collaborative design, manufactory and simulation using Grid technology in AVIC. The Av-Grid prototype started development in 2004 supported by National High-tech 863 program and AVIC also. The Grid system tool is based on the PLATFORM Company product[2] to create the integrated platform for Av-Grid system. The system is including “Grid Platform[3]”, “Grid Management system” with Accounting system, “Security system”, “Common portal” and several “applications”. The applications of Av-Grid are including in data grid, high performance computation and software sharing supported by Grid platform with common portal.

The Av-Grid architecture is in following diagram.

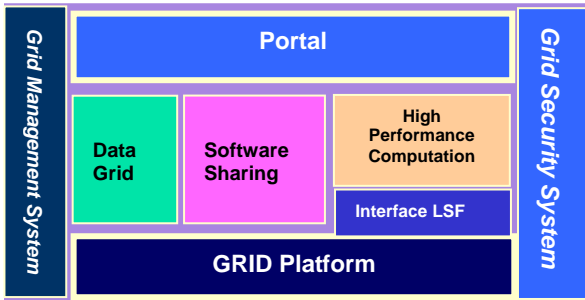


Fig. 3. Architecture of Av-Grid

The Av-Grid function is in the following:

- Hardware resource sharing the multi-clusters for high performance computation
- Software resource sharing the license floating and application software tools for reducing the software cost and maintains cost
- Information resource sharing the common used data for collaboration jointed development
- Grid management and security system including accounting system are for system manages and security.
- Common portal is integrated the all system into one user interface.

The research team has developed Av-Grid based on the requirement of jointed aircraft development after 2 years efforts.

The Av-Grid pilot application has run and tested in Beijing AVIC-II headquarters, Hafei Aviation Group in Harbin city and Hongdu Aircraft Group in Nachang city. Those cities are located more than thousand kilometers away.

3.1 High-Performance Computing

Av-Grid uses the Multi-Cluster tool to connect the clusters located in the deferent cities of China.

The key research for reach this goal in Av-Grid is following points: 1) Grid system needs to go though each enterprise firewalls and to connect those multi clusters but keep the firewall's function; 2) To create a multi cluster management system for the hardware resource management and accounting the cost; 3) A common portal for Av-Grid is need to

developed and integrated with applications. The multi cluster platform has been created and it has been running in AVIC intranet successfully after one years. The computation capability has increased greatly after share those cluster resource.

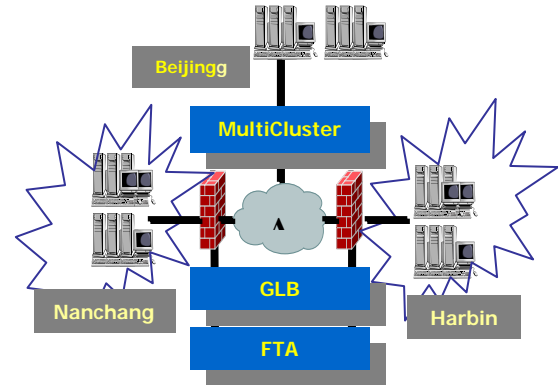


Fig. 4. First Step AVIC-II GRID System Hardware Share Structure

3.2 License Floating and Software Sharing

The Av-Grid has license pool for AVIC share CAD floating license. The license in the pool could be floating into each enterprise partners after its applied. The license floating is supported by a license management system and accounting system to running operation service in Av-Grid system.

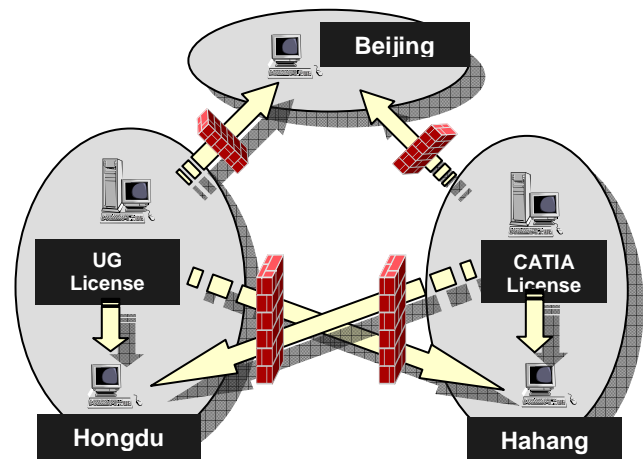


Fig. 5. Software Sharing^[3] Concept

The Av-Grid also supports the customers in each enterprise to share analysis software by SOA model. The system providing an application service list for all users in the Av-Grid portal, user can access the service located

in deferent cities and felling like in the local, if he has been authorized..

The Av-Grid portal is providing customers to create workflow, to operate the license floating, to share software application.

The security system is authority to deferent user for operation right and to keep the system safety.

3.3 Data Grid

A data grid system of Av-Grid has been developed to support the data sharing for collaborative developing and to keep single data resource. Different PDM systems have been chosen in AVIC deferent companies, such as aircraft companies use Wind-chill and ENOVIA; engine companies use TEAMCNETER and IMAN. To manage those common used data in PDM and non-structure data in analysis and simulation become stronger requirement. The data grid system is based on ORICL database and to manage all application files in the system. The concept of the data grid is that each company has a local public database, which is store the data for partner using mainly from private data base and it is the base on the data grid. The advantage of the concept is that the public database is managed by local company and shares the data for whole system in Av-Grid.

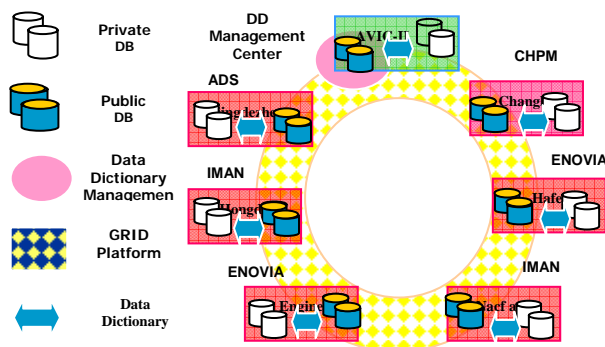


Fig 6. Concept for Data Grid of Av-Grid

The data is stored in file format like in PDM data. There is a data list to show the data file basic information in all public databases. Users can get those data information from the list and select required data. The project creates a Common Coding system with 72 digits to keep single data resource. The all date in the public

database using common coding, and in the user interface portal is shown the original coding information which user can easy to understand the key information. When a new file uploaded to a local public database, the system will check the coding first to keep single coding in the list, otherwise the file could not be accepted to upload. The data list will be updated automatically when a new file is uploaded into the system.

A Data Dictionary (DD) has been developed to exchange the common coding and the original coding. The relation between the common coding and the original coding system has been defined in the data dictionary. The data dictionary will be updated when a new coding system has been used.

There is a local public database administrators in each company, he authorities its company users and manage the local public database. One data dictionary administrator is pointed in the Av-Grid to manage the dictionary and to release the new version dictionary to all partners.

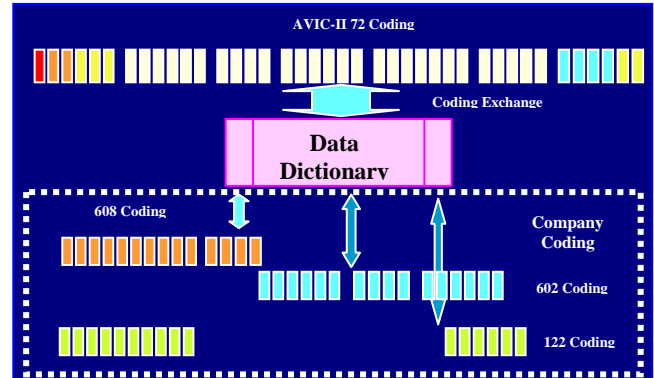


Fig. 7. Concept for Data Dictionary

3.4 Grid Portal

A common Av-Grid portal has been developed. Users can access and operate the system from the interface. The portal also developed by tools of PLATFROM Company. The portal has the function to create workflow and providing the all cluster running information. The all applications are integrated in it as following fig. There is some graphic display function in the portal. It shows the operation information and the some simulation results to make it friendly.

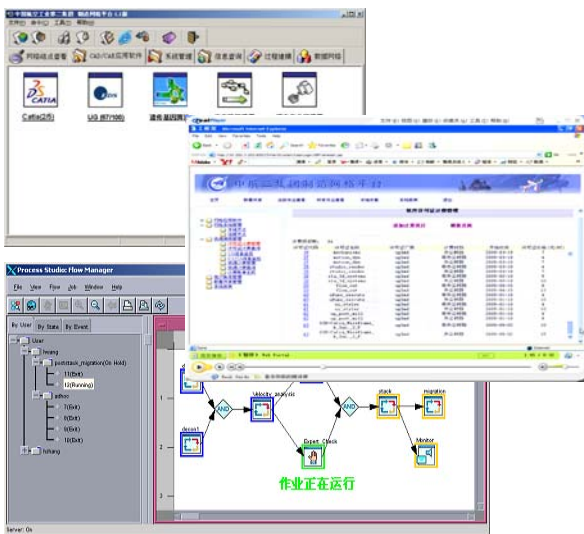


Fig. 8. User Friendly Grid Portal

An accounting system providing by PLATFORM [4] is used for business operation between partners. The accounting rule needs to be defined by the partners, such as the cost for resource consumption in daytime or night or for the priority use. The cost model is based on the statistic data of each resource consumption and accounting rule. The accounting system has very good user interface to show the cost model. It is difficulty tasks to get the rule agreed by all partners.

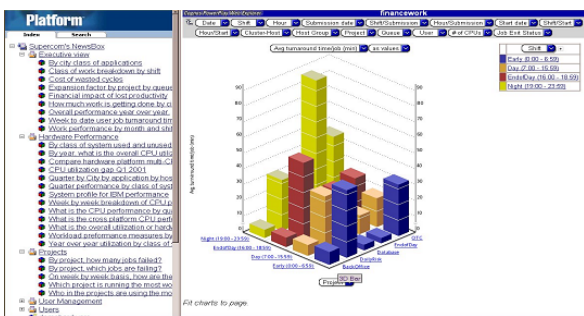


Fig. 9. Graphic Display for Accounting System

4 Pilot Application in Av-Grid

A pilot application is running in four AVIC aircraft enterprises located in four cities (Beijing, Harbin, Nanchang and Jindezheng) in China. Those companies have jointed developing some projects. They have also strong requirement for using Grid technology for resource sharing.



Fig. 10. Pilot Application Location for Av-Grid

The Pilot application is successfully to realize hundred licenses floating for share software resource, high performance computation for share the four clusters hardware, the Data Grid jointed with three public databases for collaborative design. The management of Av-Grid has been tested to use Service Oriented Architecture.

The application of software, hardware and Data Grid have been tested. One of examples is Genetic Algorithm Optimization (GAO) application. The system architecture is show in Fig. 11. GAO tools and analysis application service is running in Av-Grid in tree cities multi-clusters, the portal is integrated the workflow for the optimization. A wing structure optimization for aero-elastic tailor using GAO is tested in the system. The test is show that the running time of optimization has been 90% reduced in the multi clusters Grid system compare with single computer and the resolute is same as before.

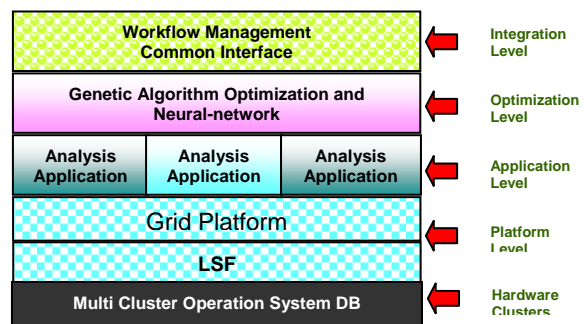


Fig. 11. Genetic Algorithm Optimization architecture in Av-Grid

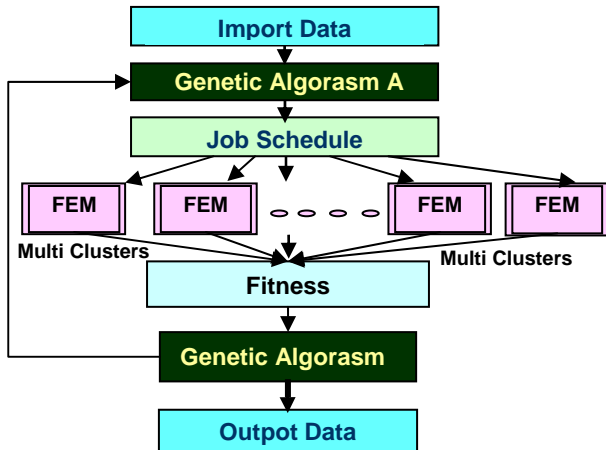


Fig. 12. Wing structure optimization flow using GAO for aero-elastic tailor

Following table is show the time reduction for a GAO application to design a wing in aero-elastic tailor. In this application, three clusters in three cities have been running FEM analysis application and jointed to reach the wing structure optimization simulation.

Table 1. Computation time for wing using Genetic Algorasm method [6] for optimization analysis

Situation	Single computer	Grid in a cluster	tree cluster in Av-Grid
Analysis Time (hours)	760	140	80

The data grid is tested by application in the three companies and the concept has been approved..

5 Conclusions

The application of Grid technique in China aviation industry is just beginning and the concept of Av-Grid in aviation industry has been approved. Av-Grid has shown a great benefited for design and manufactory in China aviation to share resource, to create SOA model for collaboration work, to realize the high performance computation during aircraft design and manufacture. Av-Grid are going to work in this direction to improve the Grid Platform; added more application services to meet the industry license floating and analysis service requirement and to improve the data grid.

The most important issue for the system

running is to create business operation model. To accept the Grid concept by industry partners needs to solve the new rule for the management model and cost model. To solve the management problem and economic balance gap between all partner companies during Av-Grid running are more difficulty than technique issue. It takes time and efforts to accept the business operation model by all partners and to change the management model and cost model. Av-Grid fully application will have long way to go, but the technology and results of Av-Grid has been used inside those companies to share their internal resources and collaboration development. This exploration has created better foundation for further Av-Grid running between enterprises.

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