High Performance Computing for Complex Fluid Flows

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Complex Flows ?!

Single fluid/phase non/reacting flows at moderate speed over simple geometries can be considered as being not too complex

Flows can be considered not too complex as long as we don’t have a specific interest to enter into the details
Complex Flows
Examples – general fluid dynamics

16 WN
1 Mpoints
1 Gb raw data
~20 h CPU time
~1 h post-proc.
Examples – wall turbulence & SJ

LES/DES
5 Mpoints
100 h CPU time
100 Gb raw data

URANS
2.5 Mpoints
50 h CPU time
250 Gb raw data
Examples – DDT flows

5 Mpoints
100 h CPU time
100 Gb raw data

URANS
Examples – Nuclear Power Plant

100 Mpoints multifluid reacting > 512PE
Examples – New Techniques

- **Cantitative flow analysis using schlieren pictures**

- **Real time flow analysis using video data acquisition**

- **Hybrid schlieren/RANS analysis**
How to Investigate?

Numerical simulation

- Models
- Algorithms
- Strategies

Experiments

- Dedicated experimental facilities
- Data acquisition
- Data Postprocessing
What Tools Do We Need?

Problem/Solution orientated tools:

- Preprocessing
- Solver
- Postprocessing

Computational/experimental environment tools:

- Interfaces
- Middleware
How Do We Use Our Tools?
Modern Field Code Cluster

(1) Turbulence Models
k-eps/k-omg/RNG/ARS
VLES/LES-SGS/DES

(2) Combustion Models
EDC/PDF Models
FLamelet/DDT Models

(A) Fluid Dynamics FV Codes

(3) Multifluid/Phase Models
Euler Flow Models
Langrange Particle Models

(4) Fluid/Structure Models
Elastic Material Models
Plastic Material Models

(B) Fluid Mechanics FE Codes

(5) Numerical Methods/Solver Techniques
Hybrid-Grids and Vari. Diff./Solver-Schemes with Multi-Processing

(C) Pre-Processing

(D) Post-Processing

(6) High-Performance Computing/Grid Networking
Multi-Blocks/Domain Partition/Message Passing Interf./UNICORE
Grid Infrastructure

SADDAM

- 32 Procs. XP2100+
- 16 Gbytes RAM
- 1.3 Tbytes HDD

- LINUX
- MPICH/MPI
- PVFS
- OpenPBS

- CFD - DXunsP
Mobile GRID Computing – INCAS Concept

INTERNET

CA Authority

Pre Processing

High Speed Network

Solver Unit

SOLVER

INTRANET

Mobil Client

GRID Access Point

MFCC Repository

Post Processing

User Space

Aplication Space
Complex CFD Analysis

RANS/LES in aeronautics

- 5 Mpoints
- 3D unstructured thets
- 32 domains
- CPU time: >50 h
- 12.5 Gb data files
Combustion and DDT Analysis

Flame Scenario Codes

- CFX
- AIXCO
- SHOCKIN
- DET
- IFSAS
- DYNAC

- Slow Flame
  - subsonic
  - Deflagration
  - Acceleration

- Fast Flame
  - turbulent, sonic
  - Explosion
  - Transition DDT

- Rapid Flame
  - supersonic
  - Detonation
  - Propagation

- Combustion Loads
  - Pressure, Impulse
  - Hazard
  - Potential

AICC-Pressure
Shock-Pressure
CJ-Pressure
Some Requirements for Current Activities

- Concept & geometry
  - Draft configuration for target design : 1 day
  - Refined configuration : 1 week
  - Detailed configuration for CFD/FEM : 1 month
  - Digital mock-up : 1/2 year

- Analysis
  - Flight dynamics analysis : 1 day
  - Full 3D flow analysis : 1 week
  - Stress analysis : 1 week
INCAS Grid Web Services

Welcome to INCAS Grid Web Services!

What's New

The purpose of this web is to enhance the support services we provide to our partners for GRID activities. We've provided a number of resources here to help you resolve problems, suggest improvements and learn about our activities.

- CSGS-14 Presentation
- COMPO-301 Presentation
- xGRID Project (INFOSOC 2003/06)
- More...

Technical Support Information

Technical support is offered Monday - Friday from 8 a.m. to 5 p.m.

Phone: 0340 427 430 (037)
E-Mail: crise@auris.inac.ro

F.A.Q.

This page contains answers to common questions handled by our support staff, along with some tips that we have found useful and personally found helpful.

Downloads

Here we provide all the tools you need in order to use resources available from INCAS. Note that you need to register to use the GRID services.

- Basic Resources Needed to Use the GRID
- How to Use the GRID
- Application Submission
- Additional Software Requirements

International ICFA Workshop, Sinaia, Romania, 13-18 October 2006
INCAS Grid CA

The Certificate Authority (CA) allows to generate the UNICEF users' and servers' certificates.

Steps:

1. Import the CA certificate

   - Click the button to import CA certificate into your OpenPGP/Netsege Browser.
   - Your browser will display a new dialog window. Click Next and select the following options for the certificate:
     - Accept this Certificate Authority for verifying network sites
   - Specify the name for the CA, e.g., INCAS Grid CA in the last window. This name will be used:

2. Create the CA certificate and store it on your local browser.

   - Click the right mouse button over CA certificate and select Save As. Then, from the pull-down menu.

3. Verify optionally that the CA is recognized by Netsege.

   - Click on Security -> Sign certificate and select the name INCAS Grid CA.

   - The highlight certificate window is displayed.

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xGRID – Application GRID

Satellite data
Image procs.

ASR

INCS

Simulation tools
Field Code Cluster

INCAS

HPSC
CA

Sport Data Base
Monitor. Equip.
xGRID – IVAN system

~1…10 Gb

~1 Mb

~10…500 Gb
INCAS in EGEE & SEE-Grid

RO-05-INCAS

16 WN + extra (SE, UI, etc.)
AMD64 3700+, 4Gb RAM, 400 GB HDD
10 Gb/s with RoEduNet

Application level interest → DRMR
Integration Process


INCAS Grid  xGRID  RoGRID  The GRID

INCAS  INCAS  ICI  EGEE
ASR  INCS  UPB  SEE-Grid
INCS  INCAS  UB  INCAS
ICI  IFIN  SIVECO
UPB  INCAS  ICN
SIVECO

12 WN/100 Gb  40WN/ 1Tb  100 WN/ 10Tb  ?
Where Do We Go from Here?

- CFD software developments (*research codes*)
- Real time parallel computing - PARAREAL
- Complex scenario simulation

- VO’s integration
- Knowledge dissemination

- Start to build the credibility of the GRID inside scientific community