Introducing a new Client-Server framework for large CFD models

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Outline

• Introducing HELYX®
• Motivation
• HELYX Client-Server Network Architecture
• HELYX® HPC Usage
• Live Demo
• Future Developments
Our Company

- CAE products and services
- Leverage open-source solutions
- OPENFOAM® developers since 1999
- Solution platforms:
  - CFD → HELYX® / ELEMENTS
  - MDO → HELYX-Adjoint / DAKOTA
- Founded UK 2009
- 5 Offices worldwide
  - UK, Germany, Italy, USA, Australia
- Resellers
  - Japan (2), Benelux, Korea, China, USA

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Our Company

• ENGYS has
  • 14+ years development track-record FOAM/OPENFOAM®
  • 12+ years development track-record GUI/Java
  • Extensive knowledge of OSS and commercial CAE tools
• Mission: develop a professional CFD software solution based on OSS technology derived from OPENFOAM with an easy-to-use GUI
HELYX® | Introduction

- HELYX® is a comprehensive CFD software solution for industry based on proven open-source technologies
HELYX® | Software Components

Features

- Proprietary Meshing
- Incompressible Flow
- Compressible Flow
- RANS/LES/DES
- Heat Transfer
- Multiphase
- Reacting Flows
- Passive Scalars
- Post-Processing

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HELYX® | Software Components

Meshing

- Hexahedral mesh generator
- Created by original \textit{snappyHexMesh} developers
- Features
  - Fully parallel
  - Commercial quality grids
  - Guarantees solver convergence
  - Integrated automatic wrapping

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HELYX® | Software Components

Add-on Modules

- Extend capabilities beyond HELYX® feature list:
  - **Coupled** → fully implicit block coupled solvers
  - **Adjoint** → continuous CFD adjoint for topology and shape optimisation
  - **Hydro** → enhanced VOF multi-phase environment with thermal capabilities
  - **EcoMarine** → ship hull hydrodynamics
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Motivation

• Current interface available in HELYX®
  • Control parallel local and remote executions
  • Shared or Distributed memory
  • Connect to any machine with a network/internet connection
  • Asynchronous client-server
  • Supports queue system for HPC clusters
Motivation

• Current interface available in HELYX®
  • Missing remote visualisation of CFD results data
  • Missing fully synchronous client/server architecture
  • Large datasets not suitable for transfer
• Solution → New HELYX Client-Server
• Development funded by FORTISSIMO EU FP7
  • Fortissimo Project Call 1: *Cloud-based simulation of pipeline components for the Oil and Gas Industry*
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HELYX Client-Server Network Architecture (1)

Main Features
- Only rendered images sent back
- Data transfer minimization
- Security assurance ➔ SSH tunnel
HELYX Client-Server Network Architecture (2)

HELYX® GUI

Events Handling

Communication System

Network

Local Machine

HELYX® 3D Server

Events Handling

Communication System

Network

HELYX® Server

Remote Machine
Application Scenarios

- **GPU Rendering**
  - HELEYX 3D Server
  - Data composition
  - Case Folder

- **Software Rendering**
  - HELEYX 3D Server
  - LLVM-PIPE
  - Case Folder

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LLVM-Pipe Algorithm Performance (1)

Ref: http://www.paraview.org/Wiki/ParaView/ParaView_And_Mesa_3D

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LLVM-Pipe Algorithm Performance (2)

Ref: http://www.paraview.org/Wiki/ParaView/ParaView_And_Mesa_3D

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VTK 7.0.0

- New OpenGL 2 backend (+ 6M GPU primitives)
- Java wrapper support
- Rendering ~350 times faster than v6.x.x
- MPI support
- Off-screen rendering through OSMesa
- Composite rendering
VTK 7.0.0 – ENGYS Edition

- High complexity structures at C++ side modified by ENGYS
- Java side: high-level objects only
- Enhanced efficiency and performance
HELYX® HPC Usage (1)

- Remote execution (via SSH)
- Case data located at server side only
- Lightweight client application
- Computational complexity at server side
- Headless (no GPU) cluster support
- Queue system support (PBS, SGE, etc.)
HELYX® HPC Usage (2)

HELYX® Client

HPC System

Master Node

Execution nodes

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DEMO: HELYX® Usage
DEMO: New Rendering Engine

VTK 6.1 Rendering Engine

VTK 7.0.0 Rendering Engine

Mesh size: 58,260,284 cells
DEMO: Serial vs Parallel Reader

<table>
<thead>
<tr>
<th></th>
<th>Serial</th>
<th>Parallel (Rank 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td># of Processes</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Mesh Size</td>
<td>3.881.803</td>
<td>3.881.803</td>
</tr>
<tr>
<td>Scenario</td>
<td>GPU Rendering</td>
<td>GPU Rendering</td>
</tr>
<tr>
<td>Time [ms] *</td>
<td>124.296</td>
<td>26.936</td>
</tr>
</tbody>
</table>

(*) Inclusive of both reading and rendering time

~4,50 times faster
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Future Developments

- **HELYX®-Server as Web Service**
  - Browser access
  - Mobile Client

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References


• D. DeMarle, B. Boeckel, and C. Atkins., *VTK 7.0.0*. https://blog.kitware.com/vtk-7-0-0/, 2016

• Kitware, *Vtk/api changes 6.3.0 to 7.0.0.*, 2016.


• http://www.paraview.org, 2016
Thank You!

Questions?