A Parallelized Streaming Framework for Simulation and Visualization Grids

Prof. Dr. S. Olbrich, PD Dr. S. Raasch, Dr. S. Manten, and G. Gaus

The visualization of huge amounts of data resulting from high-resolution simulations cannot be handled by traditional methods which contain a separate postprocessing step after the generation of raw data. A scalable approach including flexible support for batch, tracking, and computational steering scenarios is realized by our networked processing chain, the Distributed Simulation and Virtual Reality Environment (DSVR):

1. Data extraction and creation of 3D scenes, which represent features of the raw data, are efficiently implemented by parallel processing of the data parts – using a parallel software library – corresponding to the domain decomposition of the parallelized simulation. This significantly reduces the data volume, while 3D interaction support is preserved.

2. The generated sequence of 3D files is stored on a separate “3D Streaming Server”, which provides RTSP-based play-out capabilities for continuous 3D media streams, especially in high-performance IP networks.

3. The 3D scene sequence is presented as an animation in a virtual reality environment. This step has been implemented as a web-based 3D viewer plug-in, taking advantage of stereoscopic displays and interactive tracking devices.

The parallelized large-eddy simulation model PALM serves as an example application in a coupled scenario of simulating unsteady flows and visualization of the resulting time-dependent scalar and vector fields as navigatable 3D virtual reality movies.

![Simulation of a catabatic flow (fall wind)](image)

Contact DSVR:
Prof. Dr.-Ing. Stephan Olbrich
Zentrum für Informations- und Medientechnologie (ZIM), and
Lehrstuhl für IT-Management
Heinrich-Heine-Universität - Universitätsstr. 1 - 40225 Düsseldorf - Germany
Phone: +49-211-81-13900 - E-Mail: olbrich@uni-duesseldorf.de

Contact PALM:
PD Dr. Siegfried Raasch
Institut für Meteorologie und Klimatologie (IMUK)
Leibniz Universität Hannover - Herrenhäuser Str. 2 - 30419 Hannover - Germany
Phone: +49-511-762-3253 - E-Mail: raasch@muk.uni-hannover.de
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Motivation
• Huge data sets
  - 3D grid: \(-10^9\) data points
  - Non-stationary: \(-10^4\) time steps
  - Data volume: \(-100\) Terabyte
• Volume / Flow visualization
  - Online viewing
  - Computational steering

Technologies
• Parallel data extraction (MPI)
• Delivery over Gbit/s WAN (TCP/IP)
• Real-time streaming (RTSP)
• Replay of animations (OpenGL)
• Perceptual encoding, compression
• Support for C/C++/Fortran
• For major operating systems

Solution
• Visualization middleware DSVR
  - Framework for “Virtual Science Labs”
  - Distributed, parallel, portable, modular approach
• High-throughput dataflow
  - Generation of 3D scenes
  - 3D streaming, remote viewing
• Browser-embedded controls

Challenges
• Scalability and load balancing on massively-parallel computers
• Flexible resolution and multi resolution visualization approaches
• Synchronous composition of different visualization techniques
• Efficient encoding for streaming and storage
• Performance over 10 Gbit/s network

Applications
• E-Science
  - Computational Fluid Dynamics
  - Molecular Dynamics
• E-Learning
  - Exploration / Presentation
  - Collaborative Scenarios

Cooperations
• Center of Information und Media Technology, University of Düsseldorf (ZIM)
• Institute of Meteorology and Climatology, Leibniz University of Hannover (IMUK)
• German High-Performance Computer Center North (HLRN), Project nik00015
• German Research Foundation (DFG), Project EVITA (OL 241/1-1)
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Contact: Prof. Dr. Stephan Olbrich
Forschungszentrum L3S
Deutscher Pavillon, Expo Plaza 1
30539 Hannover, Germany

Email: olbrich@L3S.de
http://www.L3S.de/evita