# 11

# Visualization Systems

# *Modular visualization environments*

Many popular visualization software are designed as so-called modular visualization environments (MVEs):

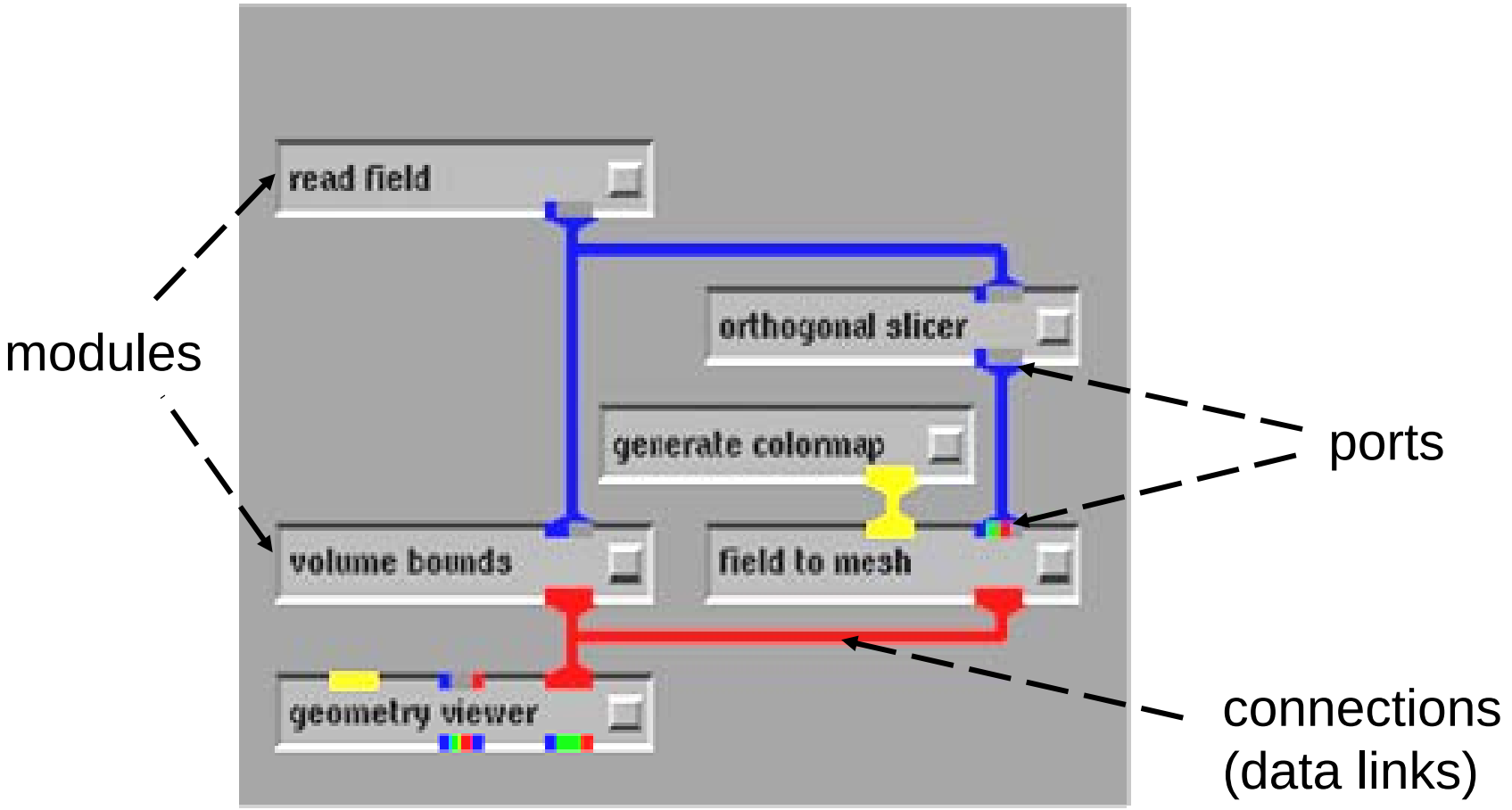
- data flow architecture
- visual programming of applications
- API (e.g. C++) for adding new modules

Examples of products:

- commercial: AVS, Covise
- open source: OpenDX, VTK/Paraview, SCIRun

# Components of an MVE

## (1) Visual programming editor



(2) Modules:

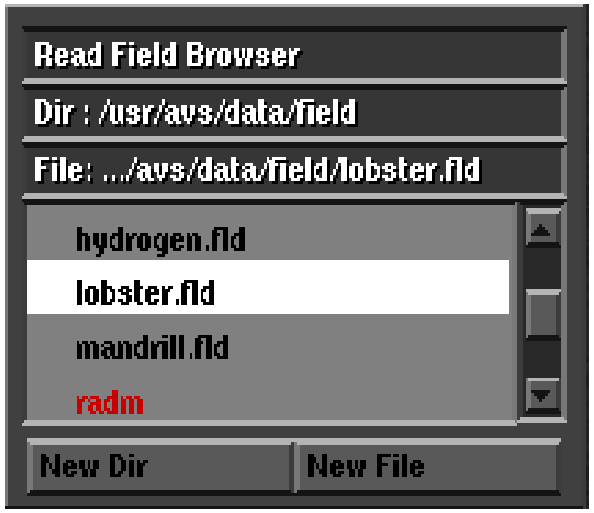
- Categories, typically:
  - Input (reading, generating data)
  - Filters (mapping to the same data type)
  - Mappers (mapping to a different data type)
  - Output (3D graphics, image, or file)
- Module libraries:
  - ordered by category, author, etc.
  - users' community contributed modules
- Implementation:
  - separate processes per module or single process

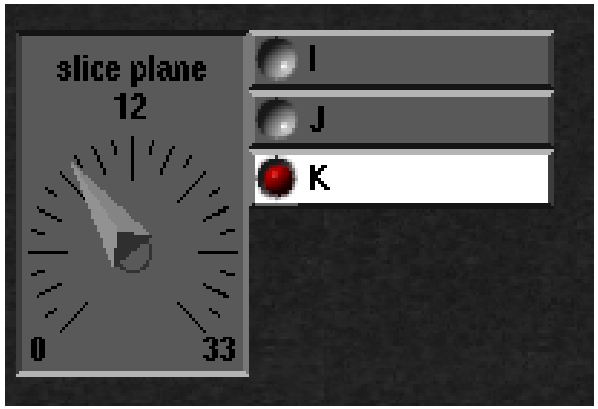
- Actions (callback functions) on:
  - instantiation (loading the module into the application editor)
  - change of input data (at input port)
  - change of parameter (via widget)
  - deletion of the module
  - idle state
- Ports:
  - specification of data types
  - type checking
  - required / optional input ports
  - multiple connections allowed / disallowed
- Connections:
  - to modules on same / different host
  - shared memory or TCP/IP

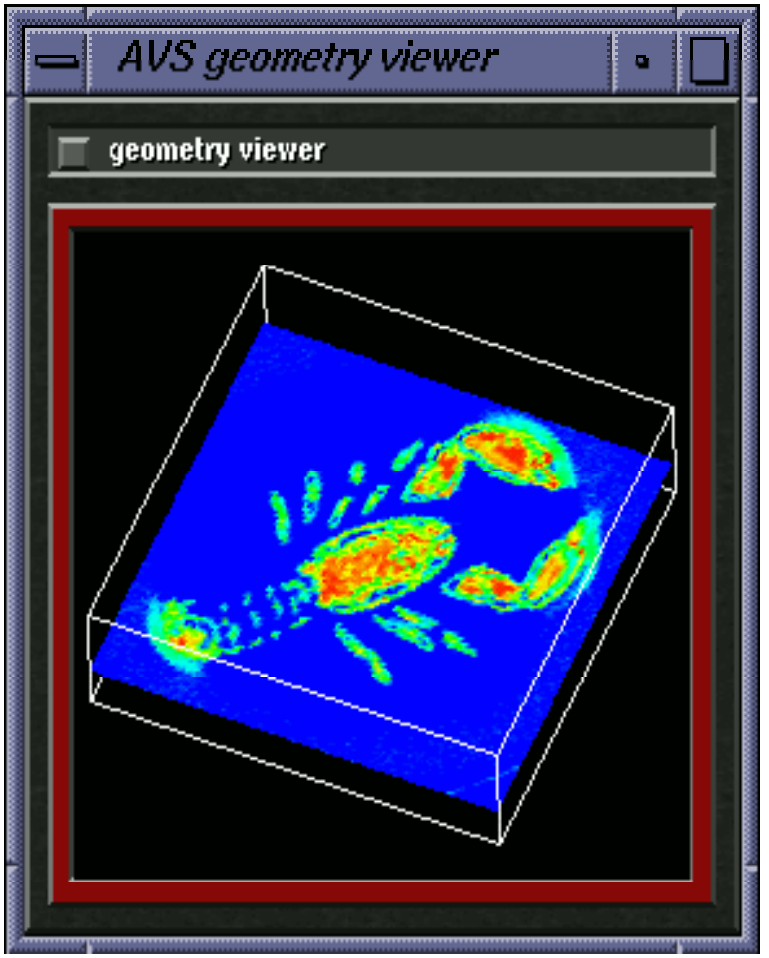
## *Modular visualization environments*

- Visual programs (aka networks, applications, …)
  - directed graphs (usually acyclic)
  - graphical and/or text-based programming
  - scheduler, controlling execution order of modules (sequential or parallel execution)
  - control flow mostly follows data flow (exceptions: picking operation)

# (3) UI widgets (parameters, status, viewers, etc.)



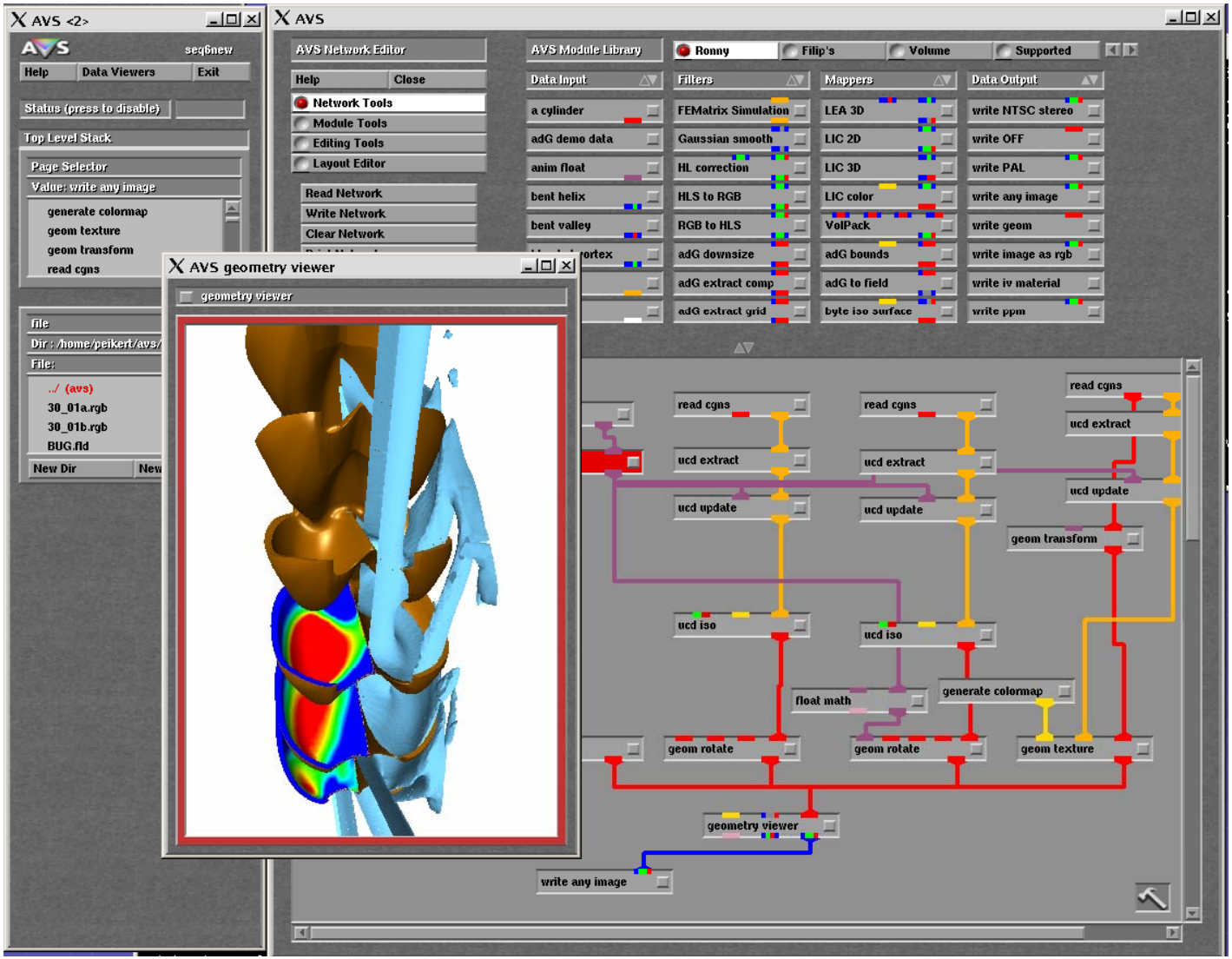



# AVS

Application Visualization System

- Advanced Visual Systems Inc. (originally by Ardent Computer)
- local / remote modules
- Unix / Linux
- products: AVS 5, AVS/Express
- 3D viewer: OpenGL based, supports stereo
- parallel execution of modules possible

# AVS screenshot

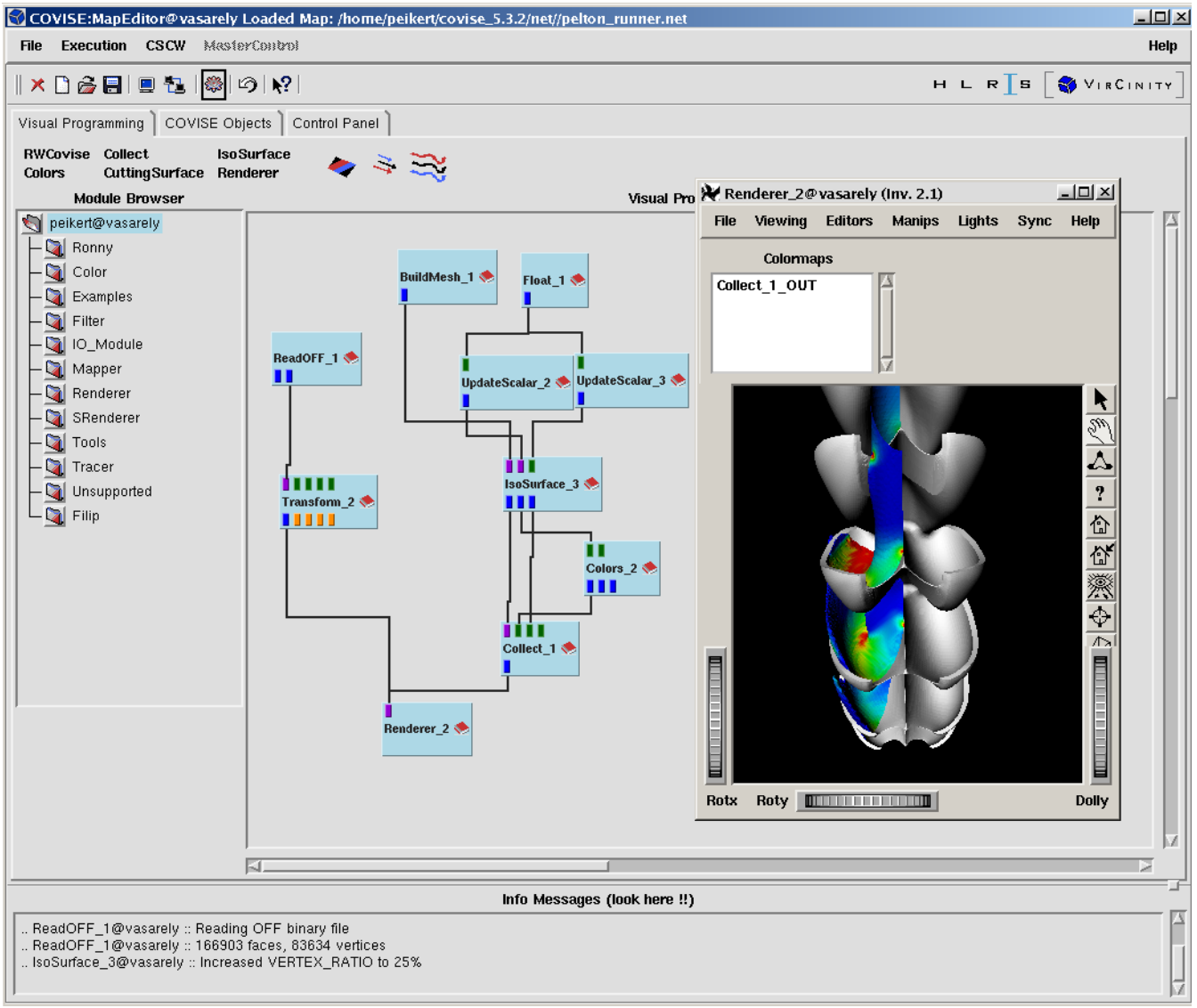


# *Covise*

Collaborative Visualization Environment

- by HLRS, University of Stuttgart
- distributed sessions
  - viewing, modifying of application by remote users
  - master / slave mode, token-based
- 3D viewers
  - OpenInventor-based
  - Performer-based virtual environment renderer. Supports stereo, head tracking, 3D input devices
- arrays
  - modules operating on <datatype> can also handle <array of datatype>

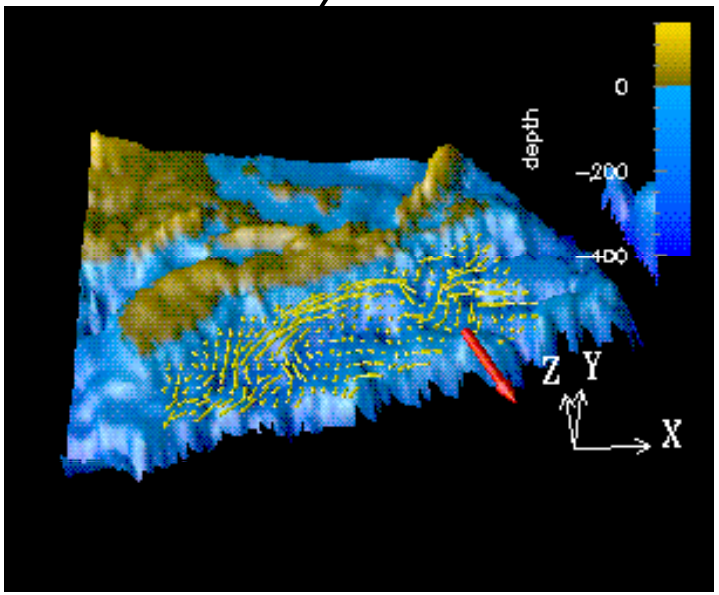
# Covise screenshot

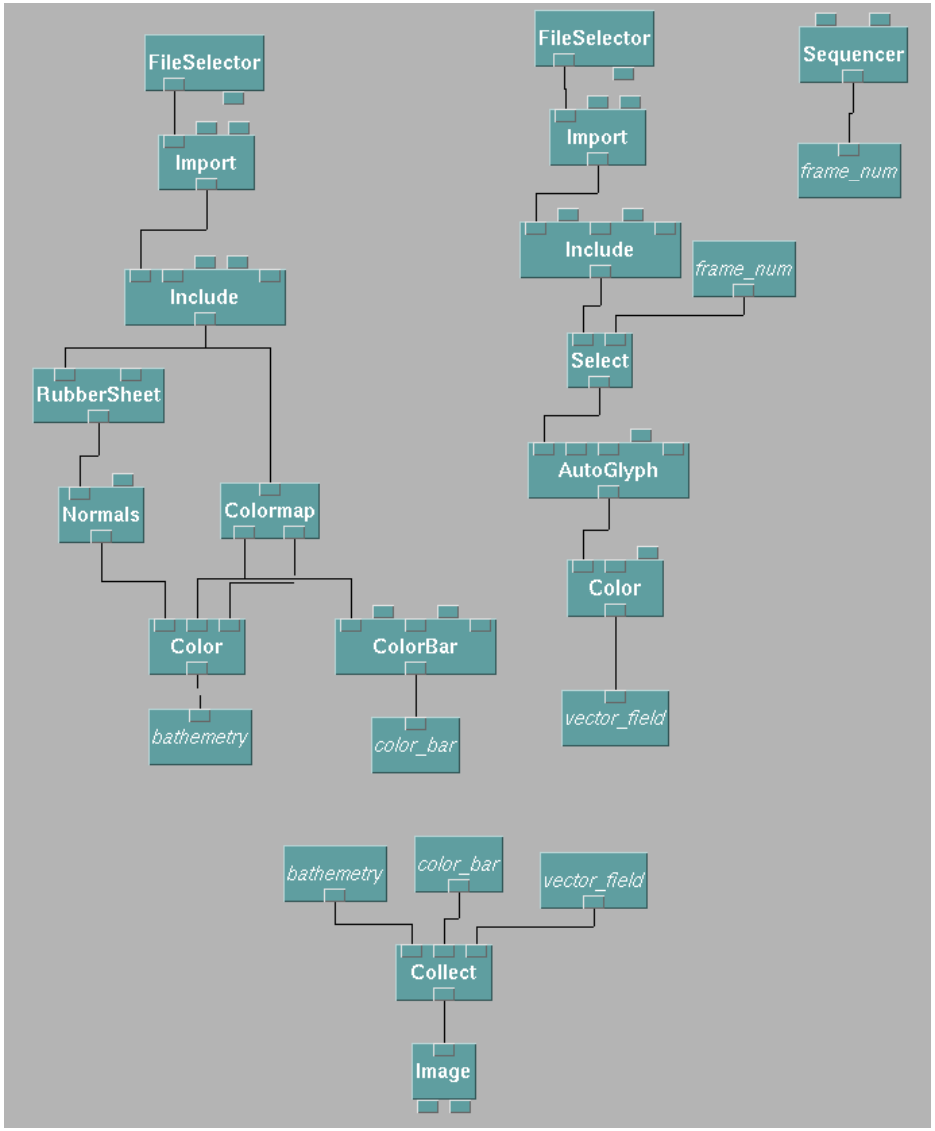


# *OpenDX*

Open Data eXplorer

- formerly IBM Data Explorer
- Linux and Windows
- Open source (but windows version requires commercial X11 server)



Modules can be created in 3 fashions:

- built into the DX executable
- runtime loadable
- stand-alone program (using DX libraries)

Parallelism:

- parallel tasks within a module

Visual programming editor:

- multi-page
- modules and control-panel widgets (widgets are not part of modules)

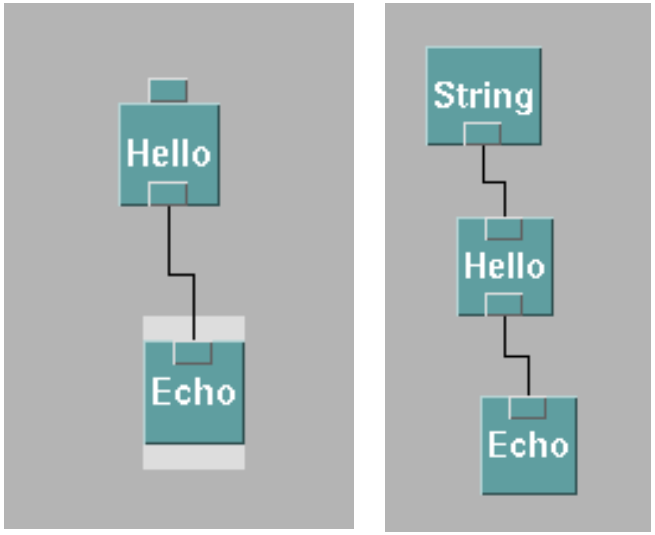
# Module programming

- description file hello.mdf

```
MODULE Hello
CATEGORY Greetings
DESCRIPTION  Prefixes “hello” to the input string
INPUT value; string; “world”; input string
OUTPUT greeting; string; prefixed string
```

- source file hello.c :

```
01   #include <dx/dx.h>
02
03
04   Error m_Hello(Object *in, Object *out)
05   {
06     char message[30], *greeting;
07
08     if (!in[0])
09       sprintf(message, "hello world");
10     else {
11       DXExtractString(in[0], &greeting);
12       sprintf(message, "%s %s", "hello", greeting);
13     }
14
15     out[0] = DXNewString(message);
16     return OK;
17   }
```



# *VTK*

Visualization Toolkit

- by Kitware, Inc. (Schroeder, Martin, Lorensen)
- open source
- scripting (Tcl, Python, …)
- application programming in C++ or Java
- Paraview: extension for graphical application programming
- ITK (insight toolkit): extension for medical vis. (incl. segmentation, registration)

Platforms:

- Unix incl. Linux, Windows

3D Viewers:

- OpenGL, SGI GL, HP Starbase, Sun XGL, VolumePRO

Focus:

- isosurfaces, decimation
- direct volume rendering
- implicit functions
- tensor fields

Module programming:

- C++

Application programming:

- C++, Tcl / Tk, (Python, Java)

Animation

- Loops in C++ or script languages

Example: Render a cube

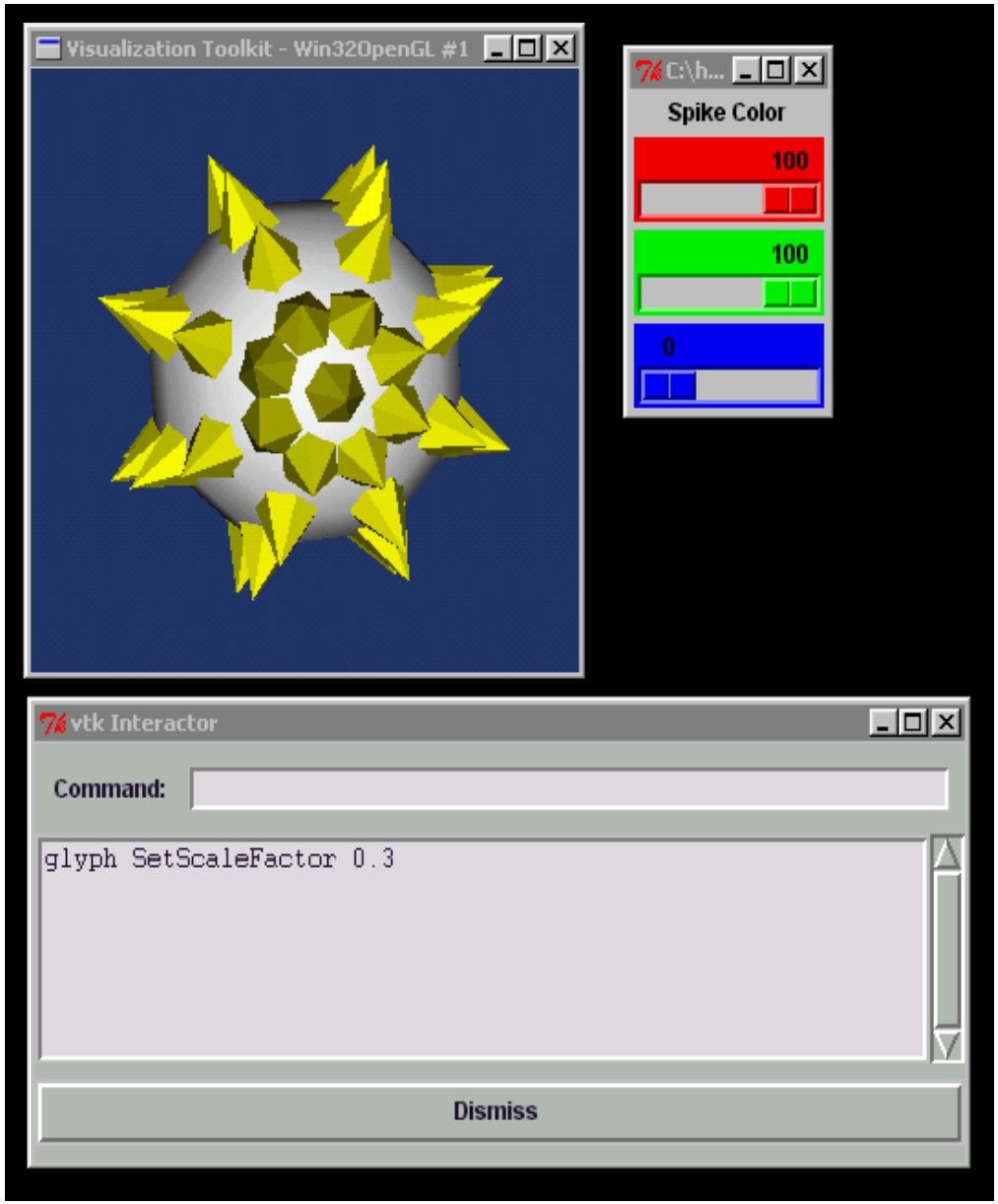
```
// C++ version
#include "vtk.h"
main() {
  vtkRenderer* ren
    = vtkRenderer:New();
  vtkRenderWindow* win
    = vtkRenderWindow:New();
  vtkCubeSource* src
    = vtkCubeSource::New();
  vtkPolyDataMapper* mpr
    = vtkPolyDataMapper::New();
  vtkActor* act
    = vtkActor::New();
  mpr->SetInput(
    src->GetOutput());
  cube->SetMapper(mpr);
  ren->AddActor(act);
  win->AddRenderer(ren);
  win->Render();
}
```

```
# Tcl version
catch {load vtktcl}

vtkRenderer ren

vtkRenderWindow win

vtkCubeSource src

vtkPolyDataMapper mpr

vtkActor act

mpr SetInput [ \
  scr GetOutput ]
act SetMapper mpr
ren AddActor act
win AddRenderer ren
win Render
```

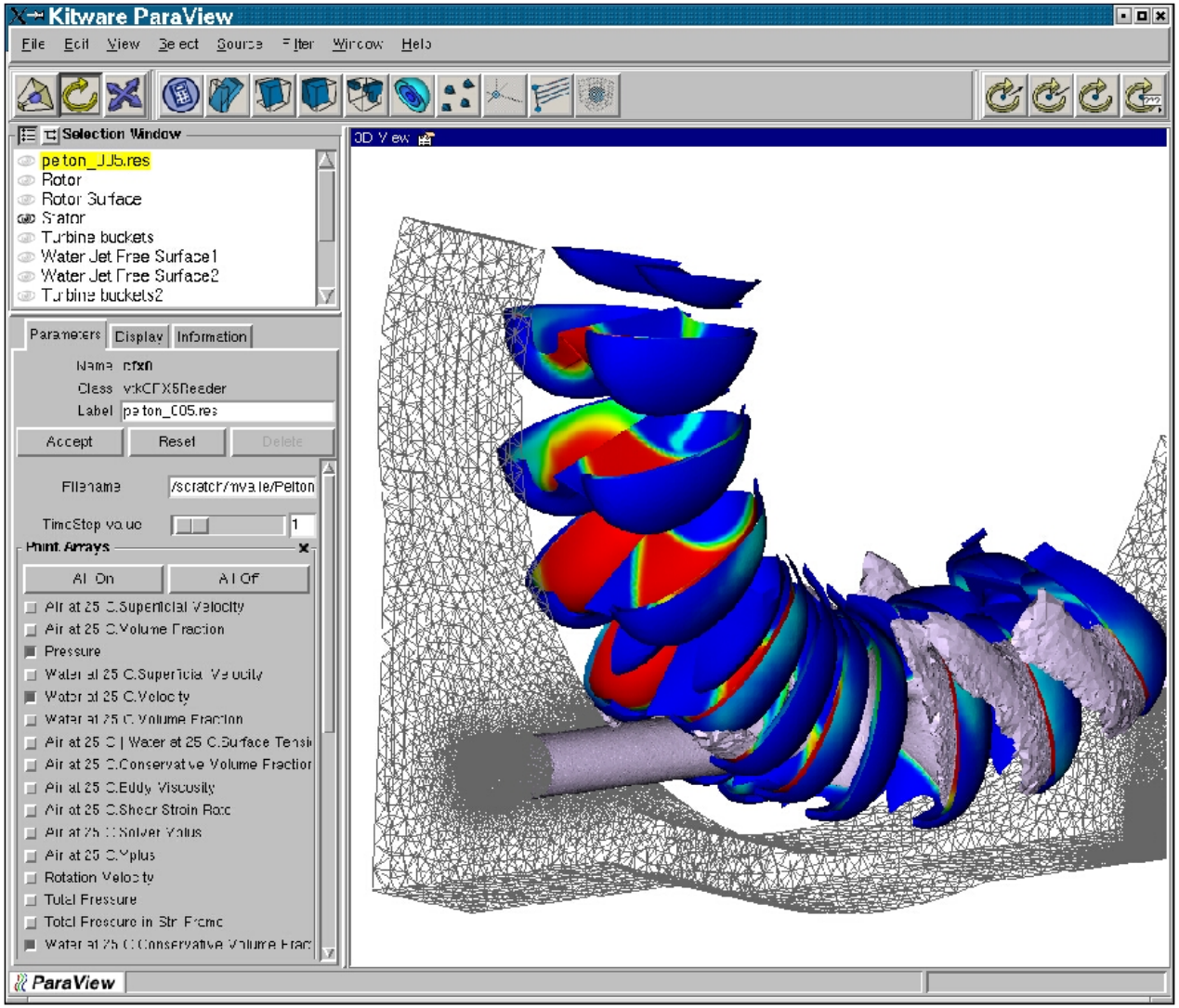
VTK screenshot

- 3D viewer
- control panel
- interactor

(Tcl/Tk widgets)



# ParaView screenshot

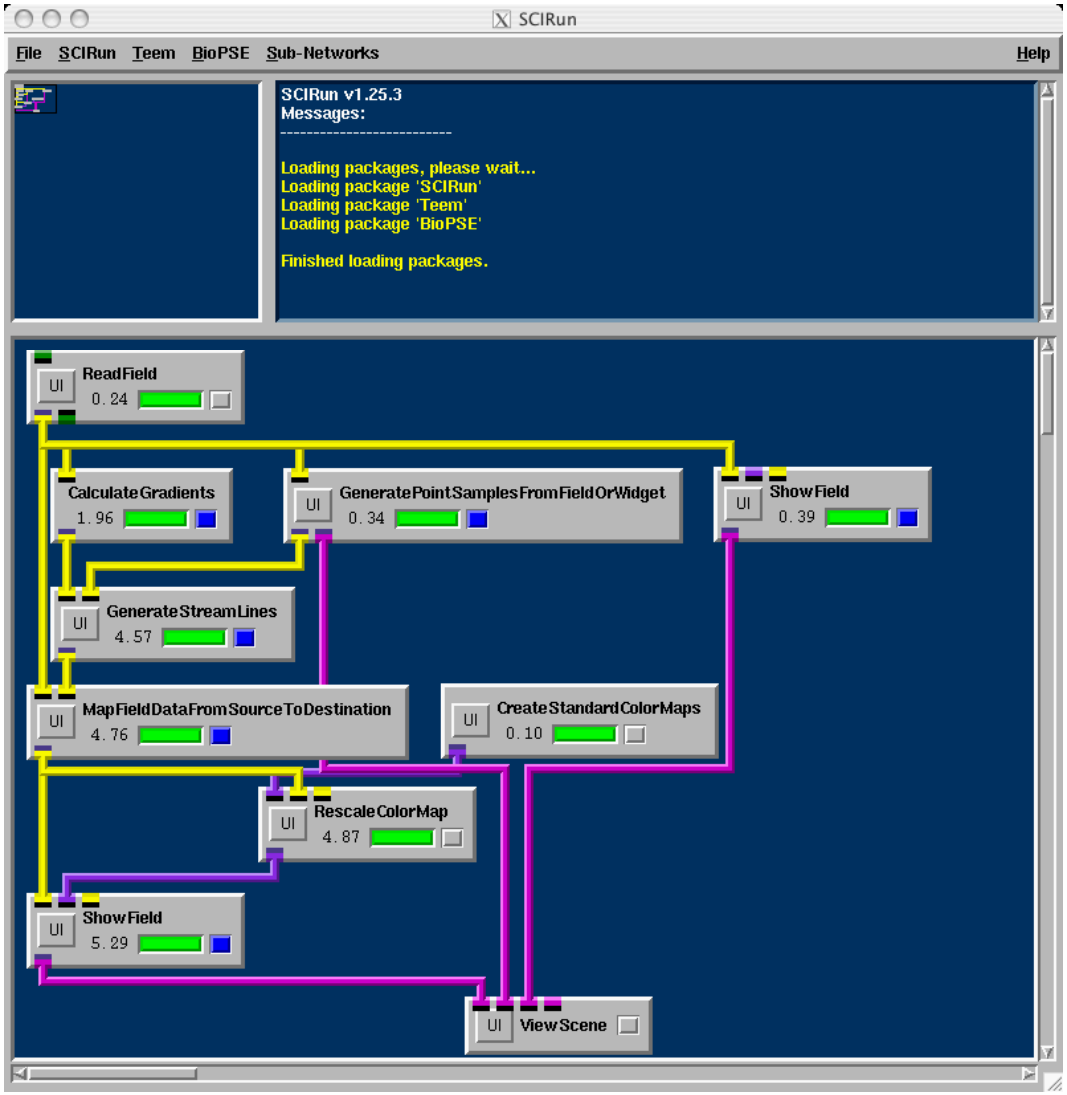


# *SCIRun*

Scientific Computing and Imaging Institute (SCI), Univ. of Utah.

- SCIRun/BioPSE - Problem Solving Environment for BioMedical Applications
- PowerApps
  - BioImage - Application for displaying and analyzing biomedical images
  - BioTensor- Application for displaying and analyzing tensor data
  - BioFEM - Application for calculating electric fields in a FEM mesh
- Seg3D - Volume processing and segmentation software.

# SCIRun screenshot



# *Other visualization systems*

Other (non MVE) visualization systems:

Commercial:

- Amira (Zuse Institute Berlin)
- SimVis (VRVis Research Vienna)
- EnSight (CEI, originally by Cray)
- TecPlot (TecPlot Inc.)

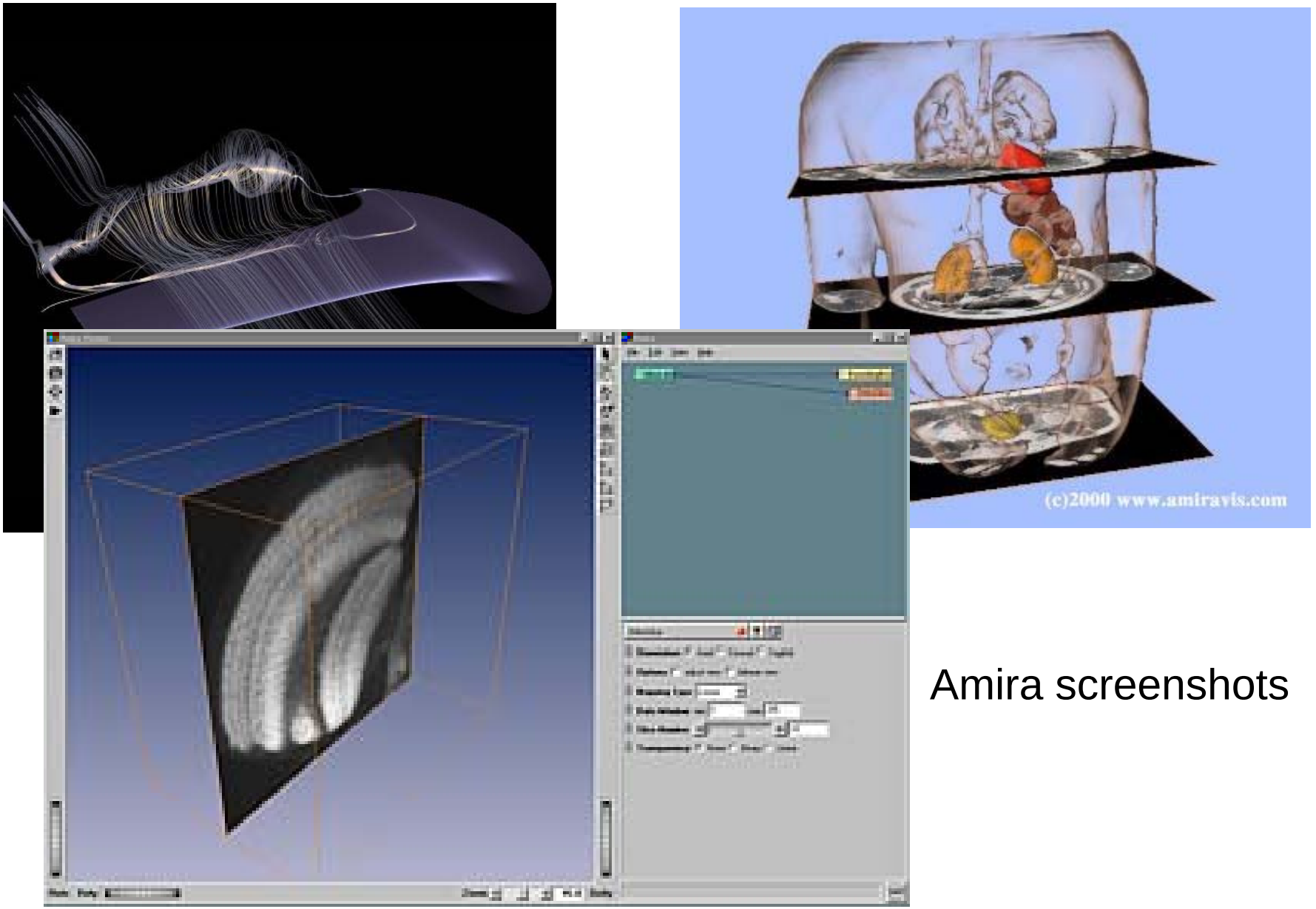
Open Source:

- VisIt (Lawrence Livermore National Laboratory)

# *Amira*

- by Zuse Institute Berlin
- Focus:
  - medical visualization, segmentation, registration
  - flow visualization, topology
- Windows, Linux, Unix
- based on OpenGL / OpenInventor
- Tcl scripting
- not (yet) extendable

# *Amira*




Amira screenshots

# *SimVis*

- by VRVis Research, Vienna
- combines SciVis and InfoVis
- linked views (scatter plots etc.)
- focus+context, brushing with soft boundaries