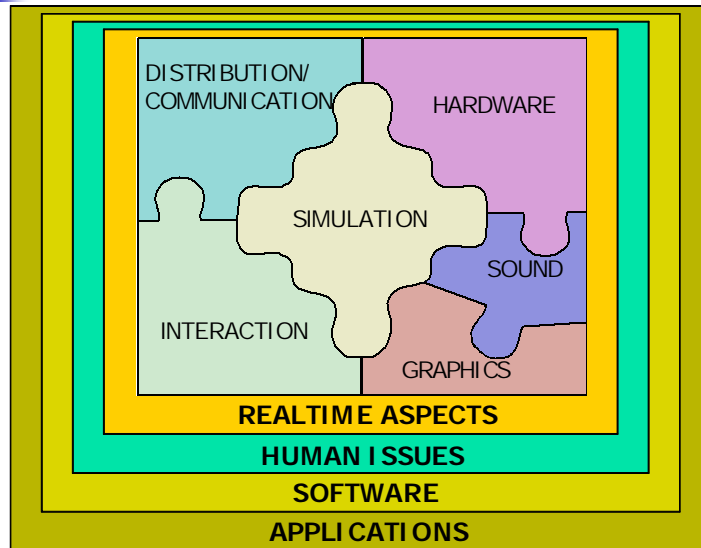


## VR - software, the missing piece?



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## VR system components

- Visual display
- Image generator
- Tracking system(s)
- Sound system(s)
- Interactive devices
- Computing environment
- Network
- Software

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## Integration

---

- Hardware:
  - Physical structure
  - Projectors
  - Computer
  - Peripherals
- Software:
  - Device drivers
  - Support tools
  - Application

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## Some integration issues


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- Compatibility
  - Changing from one tracker to another may demand a total rewrite of the application when poorly done.
- Different report rates
  - Magnetic tracker 30-144Hz
  - A low report rate must not slow the application down.
- Availability
  - What happens if a trackersystem breaks down?
  - Application crash?
- Configuration
  - Different setups for different applications

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## Why software?

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- VR - More than just graphics

*It is an integration of technologies*

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## Software

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- A lot of work to accomplish immersive VR

```
int main(int argc, char **argv) {  
  // Init  
  // Loop forever and do:  
    // Read devices  
    VRdevice_read();  
    // Update objects  
    VRupdate_objects();  
    // Render the Scene  
    VRrender_scene();  
}
```

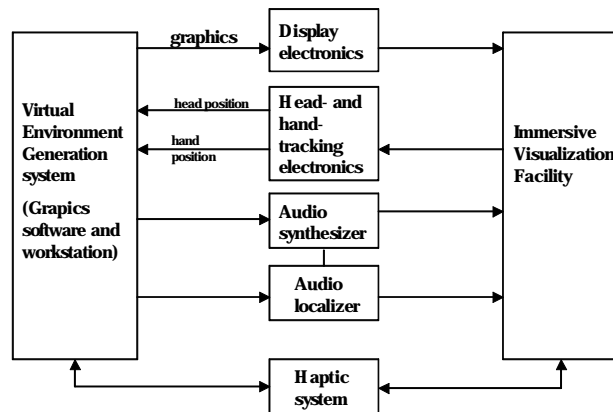
- Tools are needed

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## VE system architecture



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## Software

- There are VR tools for lots of different areas:
  - Modeling
    - Creating the 3D models
  - Translating
    - Converting file-formats
  - Authoring (events, ...)
    - Handling the actions in the application.
  - Device support
    - Communicates with the external VR hardware (trackers...)
  - Rendering
    - Graphics, usually a SceneGraph API on top of OpenGL
  - Distribution/Communication
    - Handling the consistency of a distributed DB.
  - Sound
    - Handling of spatial sound connected to objects
  - Simulation
    - Simulation code for physical /artificial entities.

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## Software - Modeling

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- Multigen
  - Great for real-time modeling
  - Full control over polygons!
- 3D Studio
- Rhino3D
  - Great at NURBS, although low control over polygons
- Alias
- Maya
  - Best for Rendering
- LightWave
- AC3D
- Blender
- ...

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## Software

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- There are also tools that tries to match all of the above points.
- But:
  - Hard to make a general product that lives up to all that.
- Home-brewers way of life:
  - 3D modeling tool (3D Studio, LightWave)
  - Graphics (OpenGL), building a "graphic engine"
  - Home written device drivers, if any.

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# Software

- Tools are in different levels
  - Low-level: API:s
  - High-Level: GUI, drag-n-drop, Word for VR!!
- For prototyping a higher-level tool is often desirable
- Sometime low-level API give you the control you need over details
- Different tools are suitable for different purposes (special purpose tools)

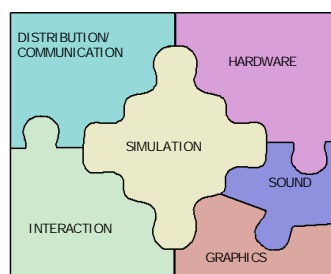
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# Software

- Remember the whole picture



- Very complicated to support all of these areas in an effective but still general way.
- The VR area are missing standards, work in progress.
- Result ⇒ Most VR authoring tools are still in its infancy.

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## Software - File-formats

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- There are a lot of 3D file-formats out there
- Problems arise when trying to convert between them.
- Materials, textures disappear, ...
  - VRML 1 .WRL
    - First standard, no events and such, only geometry
  - VRML 2 .WRL
    - Second standard, contains a lot: interpolation, sound, key framing, ...
  - MultiGen's OpenFlight .FLT
    - The best available real-time format
  - AutoDesk .DXF
    - Contains not textures or materials
  - AutoDesk .3DS
    - 3D studio mesh format.
  - Wavefront .OBJ
  - WorldToolKit Neutral File Format NFF
  - Inventor .IV



## Software - Converters

---

- There are a lot of converters out there too:
  - PolyTrans from Nugraf
  - Crossroads (freeware)
  - ivToflt, wrlToflt, ... (SGI only)
  - Some work, some don't. (In some cases)



## Software - Graphics

---

- Graphic API.
  - OpenGL,
    - Build geometric models
    - View models interactively in 3D space
    - Control color and lightning
    - manipulate pixels...
    - Portable
    - Full control
    - In most cases to low level to start from scratch developing a whole immersive VR application
  - Direct3D
    - See OpenGL except for portability!!
  - OpenInventor
    - One of the first portable graphic API:s, now also OpenSource

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## Software - Graphics

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- Optimizer/Cosmo3D
  - Aimed towards CAD industry
  - Tessellation, optimization, Occlusion culling, multiprocessor support (SGI).
  - NT, SGI (SUN, HP)
- Java3D
  - Support for 6DOF, Stereo, Collision detection, sound..
  - SGI/NT
  - Slow?
- VRML
  - Not an API but still powerful
  - Portable
  - Performance?
  - Outgrowing it self?

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## Software - Graphics

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- Fahrenheit
  - Fahrenheit Large Model Visualization API
  - Fahrenheit Scene Graph API
  - Fahrenheit Low-Level API
  - Shutdown?
- Performer
  - Optimized for SGI (but now exists for Linux)
  - A lot of functionality
  - Multiprocessing
  - System stress and load management
  - Asynchronous database paging
  - Morphing
  - Clip Mapping for handling of really large textures.
  - Fixed-frame-rate capability
  - DVR (Dynamic Video Resolution) (On SGI Onyx)

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## Software

---

- Collision detection
  - A computationally hard problem
  - If all the polygons in one objects have to be controlled to all the other polygons in all the other objects  $O(n^2)$ .
  - Usually done in two steps
    - Check for bounding-box collision
    - Collides? -> check polygon collision
  - Non convex surfaces usually cause problems

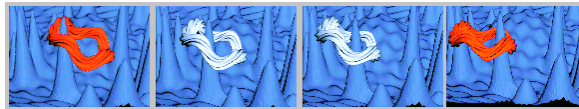
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## Software – Collision detection

- I Collide, (University of North Carolina)
  - exact collision detection library for large environments composed of convex polyhedral.
  - [Video 1](#)
  - [Video 2](#)
- RAPID, (University of North Carolina)
  - Works for arbitrary objects
  - The models may contain cracks, holes, self-intersections.



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## Software - Hardware?

- Device drivers
  - If you choose to program from scratch in Performer, OpenGL, ... for the graphics, you usually have to communicate with the hardware yourself.
  - Different trackers have different ways of communication, different data-structures, ...
  - Makes it hard to write yourself
  - To use finished products help a lot.

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## Software - Hardware?

- Device drivers

- XVS-Link (Xtensory)

- C++ class library.

- XvsFlockOfBirds \*sensor = new XvsFlockOfBirds;  
sensor->open("/dev/ttyd4", 115200, 1);

```
XvsPosition pos;  
XvsEulerRotation rot;  
while(1) {  
    sensor->read(pos, rot);  
    // Use position and rotation  
}
```



- Easy to switch between different hardware.
      - Would have been great if it had worked!!!

## Software

- A VR toolkit should contain most of the following issues

- Real time graphics
    - Level-of-detail, culling, ...
  - Importing models, *filters*
    - CAD models can be surface patches or NURBS or CSG (Constructive Solid Geometry)
  - Model libraries
    - Primitives: box, polygons, spheres, cones, ...
  - Animation
    - Interpolators, movie-clips, ...
  - Collision detection
    - Bounding box, geometry



# Software

---

- Scripting language
  - Where actions are programmed without need for compiling, etc. Trigger for actions.
- Audio
  - Controlling 3D sound sources and listeners, loading of different sound files.
- Simulation
  - Inverse kinematics, rigid-body-dynamics, ...
- Sensors
  - Support for trackers, gloves, ...
- Networking
  - Exchanging minimal level of data over a network so several users can cooperate in a VE.
  - Dead reckoning algorithms
  - Interest groups
- Stereo Viewing

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# Software

---

- Listing of VR software
  - Research
    - CAVElib, Commercial
    - Maverick Open Source, AIG, UK
    - DIVE, SICS, Sweden.
    - Simple Virtual Environment (SVE), Georgia Tech, USA.
    - MR Toolkit, University of Alberta, Canada
    - DIVERSE, Open Source (built on Performer)
    - VR Juggler, Open Source, Iowa State University
    - ...

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## Software

- Commercial
  - IDE/API: Multigen, SmartScene, VEGA
    - VEGA is one of the most competent VR development toolkits available.  
Lots of different modules for:
      - Marine simulation - Dynamic ocean simulation
      - Radar simulation
      - Special effects - Explosions, smoke, fire, missile trail...
      - Terrain generation
    - Sounds a lot like the US Defence to me?



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## Software

- Sense8
  - API: WorldToolKit
  - IDE: WorldUp
  - World2World
- IDE: Eon Reality's ION (former Prosolvia)
- IDE: Superscape VR
- Muse Technologies Inc.
- API: Boston Dynamics Inc.
  - DI guys human simulation
- API: Magma from ReachIn Technologies

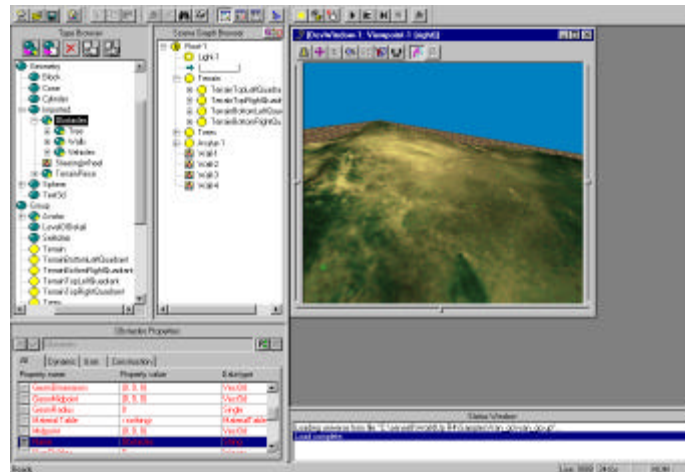
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## Software

- IDE: WorldUp from Sense8



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## Software

- IDE: EAI's Transom Jack
  - Used for ergonomic evaluations
  - Developed at University of Pennsylvania
  - Has 74 segments, 73 joints, 22 segment spine, 150DOF  
Can be customized based on scaling, obeys joint and strength limits taken from NASA studies, T.J.'s dimensions is based on 132 anthropometric studies



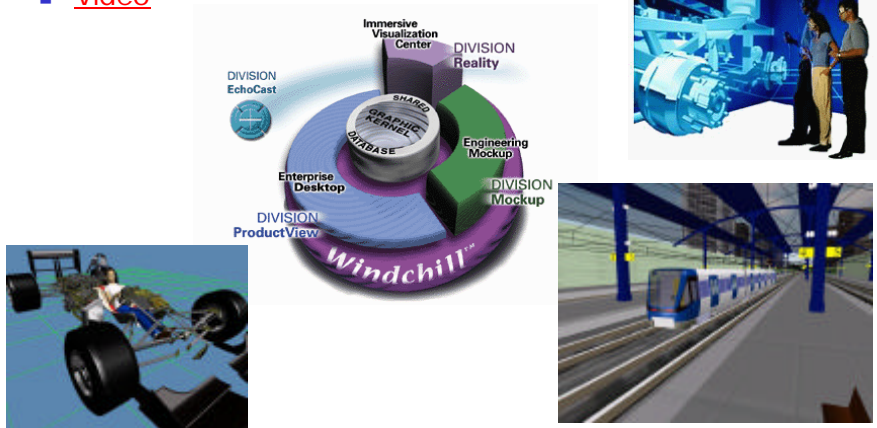
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## Software

- dVise from Parametric Technology Corp (former Division)
- Suitable for CAD prototyping
- [Video](#)



## Software

- A general VR application

```
Init graphics()
SetupScene()
SetupDevices()
SetupActions()
while(1) do
  readDevices()
  callActions()
  updateModels()
  renderGraphics()
enddo
```

# Software

- Simulation driven or graphic driven?
  - Usually the simulation has been pushed away for the graphics.
  - This is undergoing a change. For example the games requires more and more precise simulation underneath. AI, physics, ...
    - This is getting more and more important.
    - It always depends on what you are looking for.
      - In an Immersive Visualization system where people is trying to find pockets of oil from measurements of the earth's soil, maybe an authentic simulation of the friction is not of primarily interest.
      - For a vehicle simulator, where the vehicle's interaction with the terrain is important, it is obvious that some sort of physical simulation is needed.

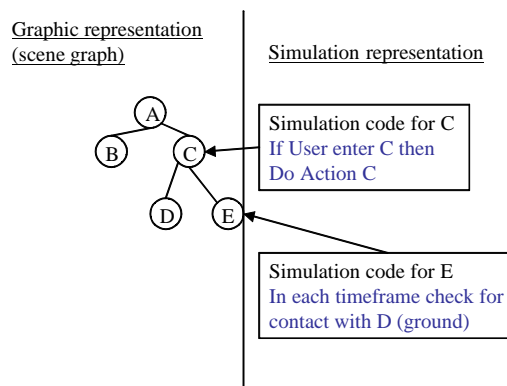
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# Software

- A graphic driven simulation will prioritize the graphics. The attributes of the graphic entity is given to the simulation



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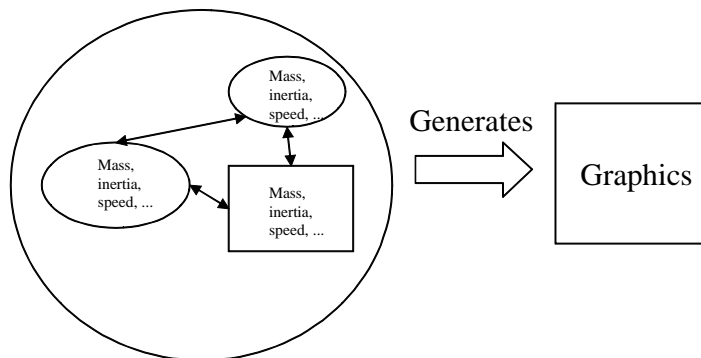
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## Software

- Whereas a simulation driven simulation is based on the entities in the simulation.
- Rather than building the graphical scene and then add dynamic behaviour, there is a simulation which contain all the information needed to simulate and generate the visible parts of the object.



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## Software

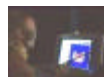
- Some software packages exists with behavioral built into it.
  - EON - Contains springs and multibody



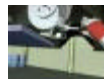
A virtual tour of Tutankhamun's tomb.



A Walk around a town square



Reality Training™ example, where the user is practicing odontological techniques on a virtual patient, utilizing a force-feedback device.



Reality Training™ example, where the user is practicing to dismantle a car brake disc.

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## Software

- MathEngine
  - Physics SDK
  - Aggressive company struggling in the game business. (Kenneth will talk about this).
- Havok
  - Physics SDK
  - Plugins for 3D Studio
- Modelica
  - A research project in Linköping.
- EAI
  - Transom Jack, lots of inverse kinematics and simulation around the soft tissues in the body.

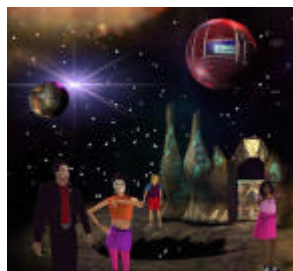
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## And not to mention - the WEB

- 3D chat/model builders
- Real-time multi-user interaction in 3D environments
  - Active Worlds
  - Blaxxun
  - Ultimate 3D Chat
  - TalkWorld
  - Bang
  - V-Chat
  - Deep Matrix



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