# Introduction to X3D

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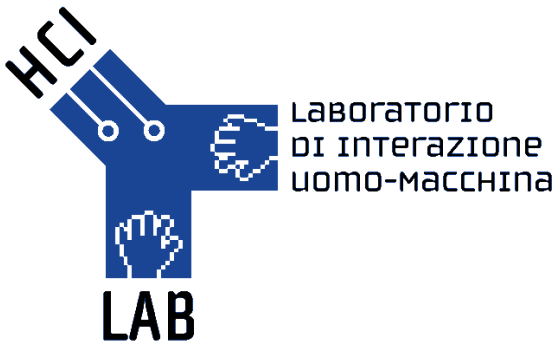


# Outline

- What is X3D?
- X3D basics
  - including some new capabilities and details on the (near) future of X3D
- How the ISO specification is organized
- X3D and VRML97
- Available SW tools


# What is X3D?


- e**X**tensible **3D** Graphics
- ISO open standard for (Web-enabled) interactive 3D content integrated with multimedia
- also an interchange format for integrated 3D graphics and multimedia
- developed by the Web3D Consortium as a successor of the VRML language
- already officially incorporated within the MPEG-4 multimedia standard

# X3D supports ... (1)

- **3D graphics** - Polygonal geometry, *parametric geometry*, hierarchical transformations, lighting, materials and *multi-pass/multi-stage* texture mapping
- **2D graphics** - Text, *2D vector and planar shapes displayed within the 3D transformation hierarchy*
- **Animation** - Timers and interpolators to drive continous animations; *humanoid animation and morphing*
- **Spatialized audio and video** - Audiovisual sources mapped onto geometry in the scene
- **User interaction** - Mouse-based picking and dragging; *keyboard input*

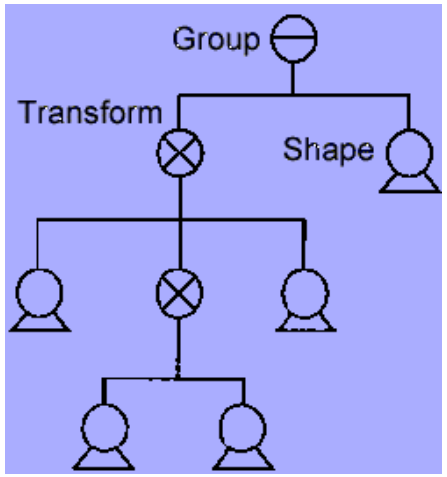
# X3D supports … (2)

- **Navigation** - Cameras; user movement within the 3D scene; collision, proximity and visibility detection
- **Networking** - Ability to compose a single X3D scene out of assets located on a network; hyperlinking of objects to other scenes or assets located on the World Wide Web
- **User-defined objects** - Ability to extend built-in browser functionality by creating user-defined data types (PROTOs)
- **Scripting** - Ability to dynamically change the scene via programming and scripting languages
- **Physical simulation** - *Humanoid animation*; *geospatial datasets*; *integration with Distributed Interactive Simulation (DIS) protocols*

# X3D Basics

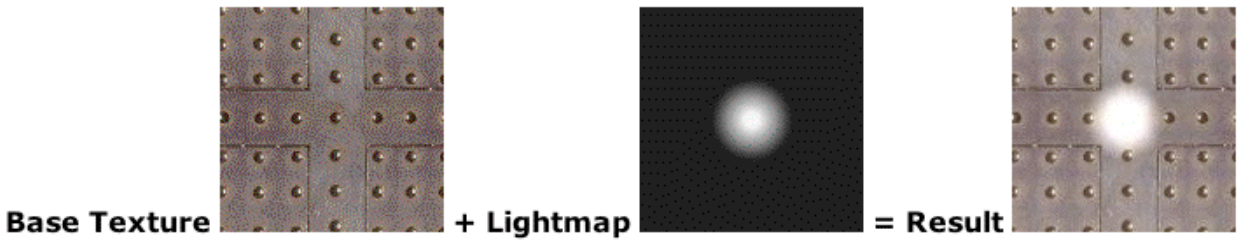
# Scene graph

- A X3D file defines a **scene graph**, i.e. a direct acyclic graph describing the 3D world being created (e.g. 3D objects, interactivity)
- Each node in the graph is an instance of one of the available node types
  - e.g. a *Shape* node defines a shape, a *Transform* node positions, orients and scale its children nodes, a *DirectionalLight* node defines a light source in the world
- Nearly identical to the VRML97 scene graph, but new nodes added to incorporate advances in 3D HW & SW



# New nodes example

- With multitexturing, multiple textures may be applied to a single geometry node and blended according to a predefined set of operations.
  - e.g., for light mapping effects
- Multitexturing is accomplished using the **MultiTexture**, **MultiTextureCoordinate**, and **MultiTextureTransform** nodes




# Language Encodings


- X3D content can be expressed in
  - **Classic VRML encoding**, nearly backward compatible with VRML97
  - **XML encoding**, supported by Schema or DTD
- All encodings are interchangeable

# Encodings example

```
<X3D version='3.0'
  profile='Interchange'>
 <head> </head>
 <Scene>
  <Group>
   <NavigationInfo
       type='"EXAMINE"'/>
   <DirectionalLight/>
   <Transform
       translation='3.0 0.0 1.0'>
    <Shape>
     <Sphere radius='2.3'/>
     <Appearance>
      <Material
        diffuseColor='1.0 0.0
0.0'/>
     </Appearance>
    </Shape>
   </Transform>
  </Group>
 </Scene>
</X3D>
```

**XML encoding**

```
#X3D V3.0 utf8
PROFILE Interchange
Group {
 children [
  NavigationInfo {
   type [ "EXAMINE" ]
  }
  DirectionalLight {}
  Transform {
   translation 3.0 0.0 1.0
   children [
    Shape {
     geometry Sphere { radius 2.3 }
     appearance Appearance {
      material Material {
       diffuseColor 1.0 0.0 0.0
      } } } ] } ] }
```

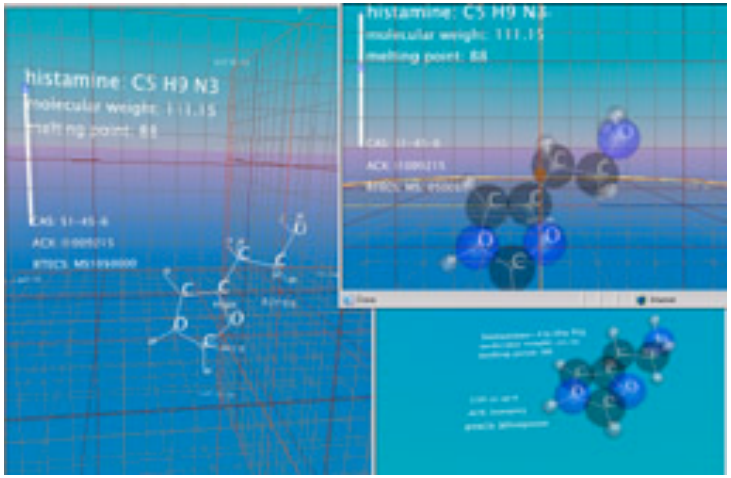
**Classic VRML encoding**

# Why the XML encoding?

- XML provides parsing, validation, XSLT conversion, ..., for free
- Integration with the next-generation web technologies, also exploiting the efforts of the W3C
- **Typical scenario** (also in e-learning apps): X3D, as a format that defines visual information, is the last stage in a production pipeline.
  - using XML stylesheets, one can keep data in some native XML format (which represents concepts, relationships, ...), and obtain a 3D representation as a single transformation step.

# Example: CML to X3D

- CML (Chemical Markup Language) is a XML language for chemistry
- With a properly-written XML stylesheet, one can obtain a X3D representation of ANY CML file (or another visual representation, e.g. HTML)




cml2X3d stylesheet done by Nicholas Polys, VirtuWorlds LLC

# User-defined extendibility

- authors can define new nodes by using **prototypes**
  - e.g., to define application-specific high-level nodes
- A **PROTO** statement defines a new node type in terms of already defined (built-in or prototyped) node types
  - `PROTO Cube [ ] { Box { } }`
- Once defined, prototyped node types may be instantiated in the scene graph exactly like the built-in node types
  - `Shape { geometry Cube { } }`

# Scripting capabilities

- Complex dynamical behaviors in the 3D world can be impossible to implement without the power of a programming languages
- these kinds of decisions are expressed programmatically using the **Scene Access Interface** (**SAI**) internally (from Script nodes) or externally (from other application programs)
- X3D has a single unified API (VRML97 had an internal scripting API plus an external API, called EAI).
- ECMAScript and Java bindings are defined
- ECMAScript is required for conformant applications.

# The (near) future of X3D

- Programmable X3D Shaders
  - more visual realism & efficiency
  - can experiment with them using BS Contact Preview
- CAD Distillation Format
  - extension of X3D designed to distill down high complexity CAD data to low complexity
- Binary Encoding for faster parsing (2-5 times) and downloading times (10-25 times)
  - with both loseless and lossy compression

# How the X3D specification is organized


# How the spec is organized


- X3D is composed by 3 separate ISO specs:
  - **X3D framework & SAI:** describes structural and runtime models, external programming functionality in abstract terms.
  - **X3D encodings:** specifies XML and Classic VRML encodings of X3D files
  - **X3D language bindings:** specifies the binding of the services in the X3D architecture to the ECMAScript and Java programming languages

# Components and Profiles

- X3D objects and services are grouped into **components** (i.e., set of related functionalities)
- Components have **multiple levels** of increasing capability
- **Profiles** are a collection of components at specific levels designed to support particular application domains
- Authors specify required profile and (optionally) additional components at the beginning the X3D file


# Example

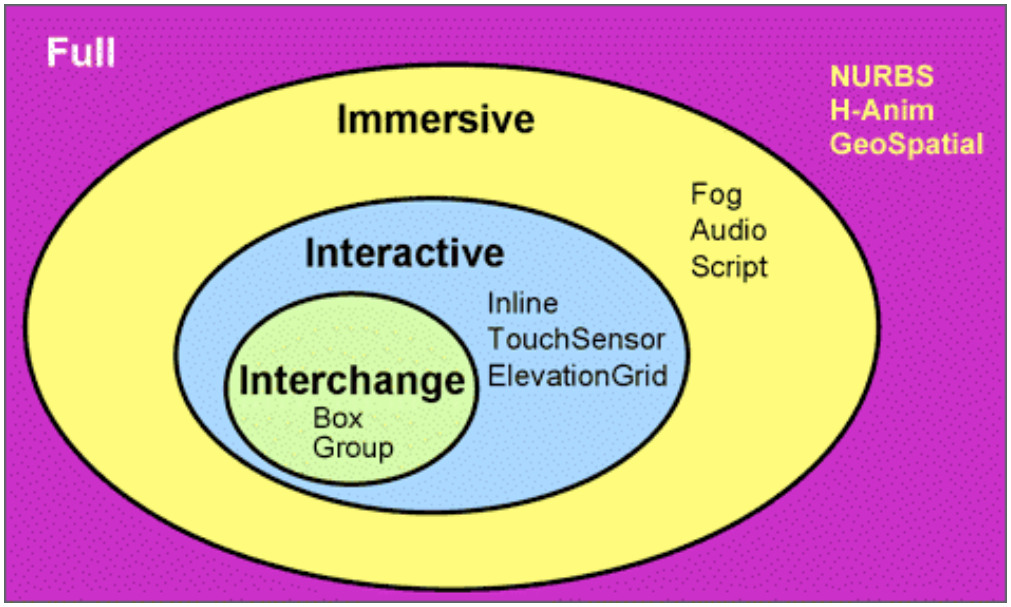
```
<X3D profile='Immersive'>
  <head>
    <component name='Geospatial'/>
    <component name='NURBS' level='2'/>
  </head>
  <Scene>
    <!-- Scene graph nodes are added here -->
  </Scene>
</X3D>
```


# X3D Components


- **Geometry**
  - Shape, Geometry3D, Geometry2D, Text
- **Environment**
  - Sound, Lighting, Navigation, Environmental Effects
- **Animation**
  - Interpolation, Event Utilities
- **Appearance**
  - Rendering, Texturing
- **Sensors**
  - Pointing Device Sensor, Key Device Sensor, Environmental Sensor, Time
- **Structure**
  - Networking, Grouping
- **Other**
  - Geospatial, H-Anim, NURBS, DIS, Scripting

# X3D Profiles

- Interchange
- Interactive
- Immersive
- Full




- MPEG4 Interactive
- CDF (Cad Distillation Format)

# X3D & VRML97

# X3D and VRML97

- Main functional differences:
  - file header (e.g. you need to define a profile)
  - access names for fields have changed (e.g. eventIn → inputOnly, exposedField → inputOutput
  - scripts can have inputOutput (i.e., exposed) fields
  - runtime and programming model for scripting is consistent between programming languages and whether you are inside or outside the browser
  - …


# Converting VRML97 files to X3D


- files that do not contain scripts or externprotos need only minor changes
  - e.g., change the header and insert the new PROFILE statement
- files that contain scripts may require more extensive modifications
- a X3dToVrml97 translator program is available, but not perfect at all
  - e.g. does not perform changes into script code

# Available SW tools

# X3D tools: browsers

- Commercial:
  - BitManagement BS Contact www.bitmanagement.de
  - Flux www.mediamachines.com
  - Octaga www.octaga.com
  - VCOM Venues X3D www.vcom3d.com
- Open-source:
  - FreeWRL www.crc.ca/FreeWRL
  - XJ3D www.xj3d.org

# X3D tools: authoring

- Commercial:
  - VizX3D www.vizx3d.com
- Open-source:
  - X3D-Edit www.web3d.org
  - VRML to X3D translator ovrt.nist.gov/v2_x3d.html
  - Exporters for Maya, 3DStudio (under development), Blender, MilkShape www.web3d.org