Extensible 3D Graphics

X3D

Introduzione

X3D: introduzione

- X3D: e**X**tensible **3D** Graphics
- Lo standard è definito nel documento ISO open standard for (Web enabled) interactive 3D content integrated with multimedia
- X3D specifica anche un formato di scambio tra grafica 3D e multimedia
- E' stato incorporato nello standard MPEG-4 ed integrato con SVG, MathML e CML
- E' stato sviluppato dal Web3D Consortium (http://www.web3d.org) come successore del VRML

X3D

- Lo standard definisce componenti interoperabili e leggeri orientati alle applicazioni per 3D Web e broadcast.
- Combina un motore per la rappresentazione del mondo a run-time ed una sintassi ispirata dal formato dei file VRML 97 con una sintassi propria di XML.
- X3D estende le funzionalità e l'insieme dei nodi disponibili in VRML e rappresenta lo stato dell'arte della programmazione 3D su Web.

Caratteristiche di X3D

Graf ca 3D: geometria poligonale, geometria parametrica, trasformazioni gerarchiche, illuminazione, gestione dell proprietà dei materiali, multi-pass/multi-stage texture mapping

Graf ca 2D: testi, vettori 2D e f gure piane visualizzate nella gerarchia delle trasformazioni 3D

Animazioni: timer e interpolatori in grado di gestire animazioni, animazione di umanoidi e morphing

Spazialized audio and video: sorgenti audiovisive associate alle geometrie della scena

Interazione con l'utente: mouse based picking and dragging, keyboard input

Caratteristiche di X3D (i)

Navigazione: telecamere, movimenti dell'utente nella scena 3D, sensori di visibilità, di prossimità e di collisioni

Networking: capacità di comporre una singola scena 3D mediante componenti delocalizzate sulla rete; hyperlink ad oggetti di altre scene o componenti accedibile via World Wide Web.

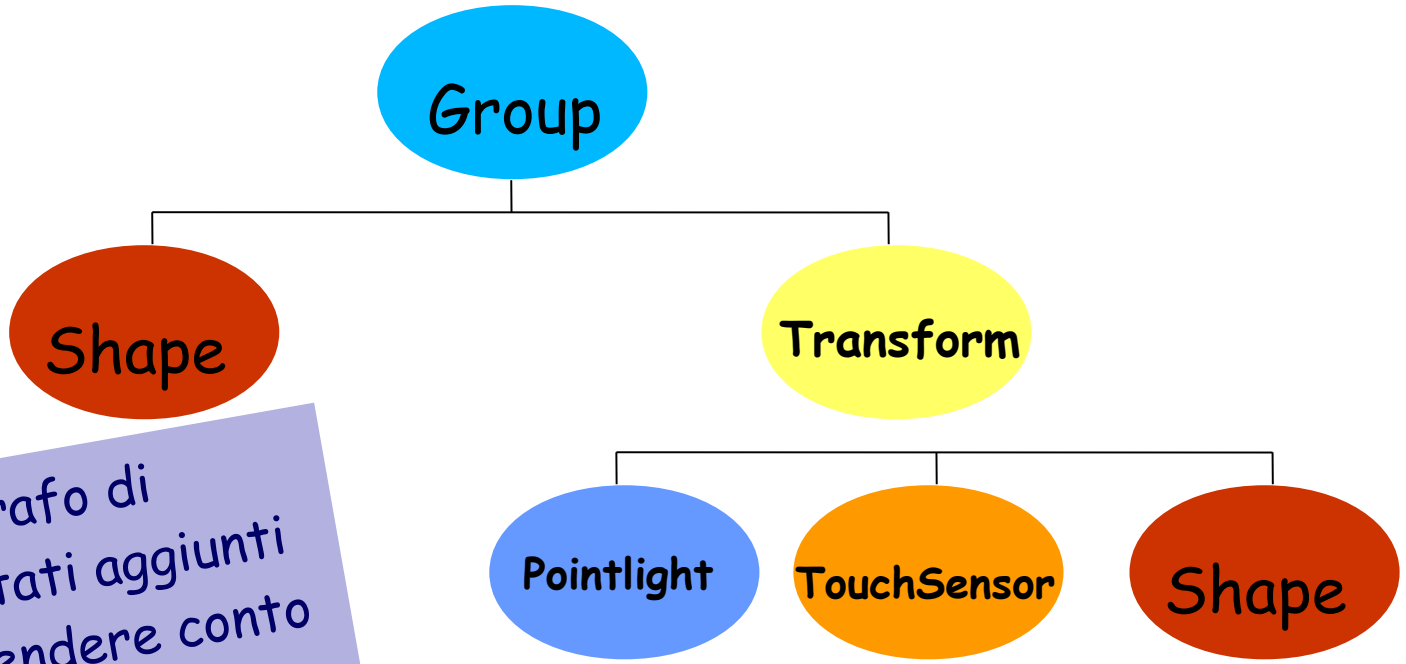
Oggetti def niti dall'utente: possibilità di estendere le funzionalità del linguaggio mediante specif ca di nodi utente, attraverso il nodo PROTO.

Scripting: capacità di modif care dinamicamente la scena mediante programmazione e linguaggi script

Simulazione: animazione di umanoidi; geospatial dataset; integrazione con protocolli *Distributed Interactve Simulations (DIS)*

X3D scene graph

- Un file X3D definisce un grafo aciclico diretto che descrive il mondo 3D che si sta creando
- Ogni nodo del grafo rappresenta l'istanza di uno dei tipi di nodi disponibili nella specifica di X3D



Molto simile al grafo di VRML97: sono stati aggiunti nuovi nodi per rendere conto degli sviluppi hw e sw

Codifica del linguaggio

- Il contenuto X3D può essere espresso come
  - Codif ca VRML classica, fondamentalmente compatibile con VRML97
  - Codif ca XML, supportata da Schema o DTD

- Le codif che sono intercambiabili

Esempio di codifica

```
<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='3.0'\>
           <Appearance>
             <Material
              diffuseColor='1.0 0.0 0.0'\>
           </Appearance>
          </Shape>
     </Transform>
    </Group>
  </Scene>
</X3D>
```

Codif ca X3D

```
#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 3.0 }
         appearance Appearance {
            material Material {
              diffuseColor 1.0 0.0 0.0
                 }
            }
         }
       ]
      }
    ]
}
```

Codif ca VRML-like

Codifica XML

- XML fornisce di per sé una serie di supporti quali parsing, validation, XSLT conversion…
- Integrazione con le tecnologie Web di ultima generazione, collaborando intensamente con il W3C
- X3D, che rappresenta il formato per le informazioni visive, è l'ultimo stadio di una pipeline di produzione
  - Usando XML StyleSheets i dati vengono gestiti in un formato XML nativo (che rappresenta concetti, relazioni, etc) e ottiene la rappresentazione 3D mediante un unico passaggio.

Estensibilità definita dall'utente

- Gli autori possono definire nuovi tipi di nodi mediante **prototipi**
- Un nodo Proto definisce un nuovo tipo di nodo mediante specifica di nodi esistenti (di libreria o prototipali):

```
<ProtoDeclare name='Acqua'>
      <ProtoBody>
            <Material diffuseColor='0 0.6 1'/>
      </ProtoBody>
</ProtoDeclare>
```

- Una volta definito, un nodo di tipo Proto può essere istanziato nella scena alla stregua di un nodo di qualsiasi

```
<Shape>
  <Box size="10 2 0.1"/>
  <Appearance>
    <ProtoInstance name="Acqua" containerField="material"/>
  </Appearance>
</Shape>
```

Script

- I comportamenti dinamici complessi in una scena 3D sono possibili solo mediante la potenza di un linguaggi o di programmazione
- Scene Access Interface (SAI) permette di esprimere questo potere internamente (mediante il nodo `Script`) o esternamente (mediante altri programmi applicativi).
- X3D ha una singola API (VRML ha una API interna più una API esterna, EAI)
- Sono supportati ECMAScript e Java

Organizzazione della specifica ISO

- X3D è composto da tre specifiche ISO separate:
- **X3D framework & SAI**: descrive i modelli strutturali e runtime, le funzionalità di programmazione esterna in termini funzionali
- **X3D encodings**: specifica i tipi di codifica di file X3D sia per la codifica XML che per quella di tipo VRML
- **X3D language bindings**: specifica i collegamenti dei servizi dell'architettura X3D con i linguaggi di programmazione ECMAScript e Java

Componenti e Profili

- Gli oggetti X3D sono raggruppati in **componenti** (insieme di funzionalità collegate)
- I componenti hanno diversi livelli di **capacità**
- I Profili rappresentano collezioni di componenti a livelli specifici, concepiti per supportare particolari domini applicativi.
- Gli autori specificano all'inizio del file X3D il profilo richiesto ed eventuali componenti addizionali.

Esempio

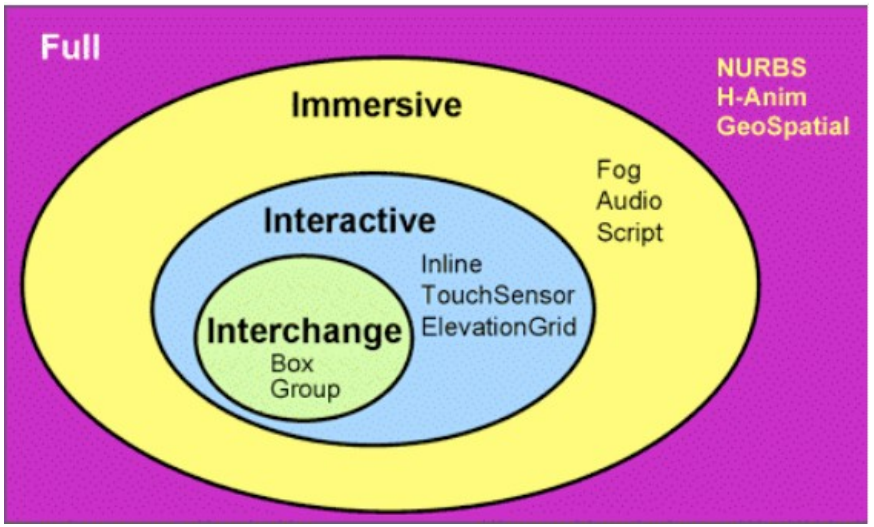
```
<X3D profile='Immersive'>
 <head>
   <component name='Geospatial'/>
   <component name='NURBS' level='2'/>
  </head>
  <Scene>
   <!-- Scene graph nodes are added here -->
    <Shape>
      <Cylinder height='8'/>
    </Shape>
   </Scene>
</X3D>
```

X3D Components

- Geometry
  - Shape,Geometry3D, Geometry 2D, 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, Gruping
- Other
  - Geospatial, H-Anim, NURBS, DIS, Scripting

X3D Profiles

- Interchange
  - Supporta geometry, texturing, basic lighting e animazione
- Interactive
  - Interactive user controls
- Extensible
  - Interactive + Scripts /PROTOs/SAI
- Base
  - Full 3D experience
- Full
  - everything



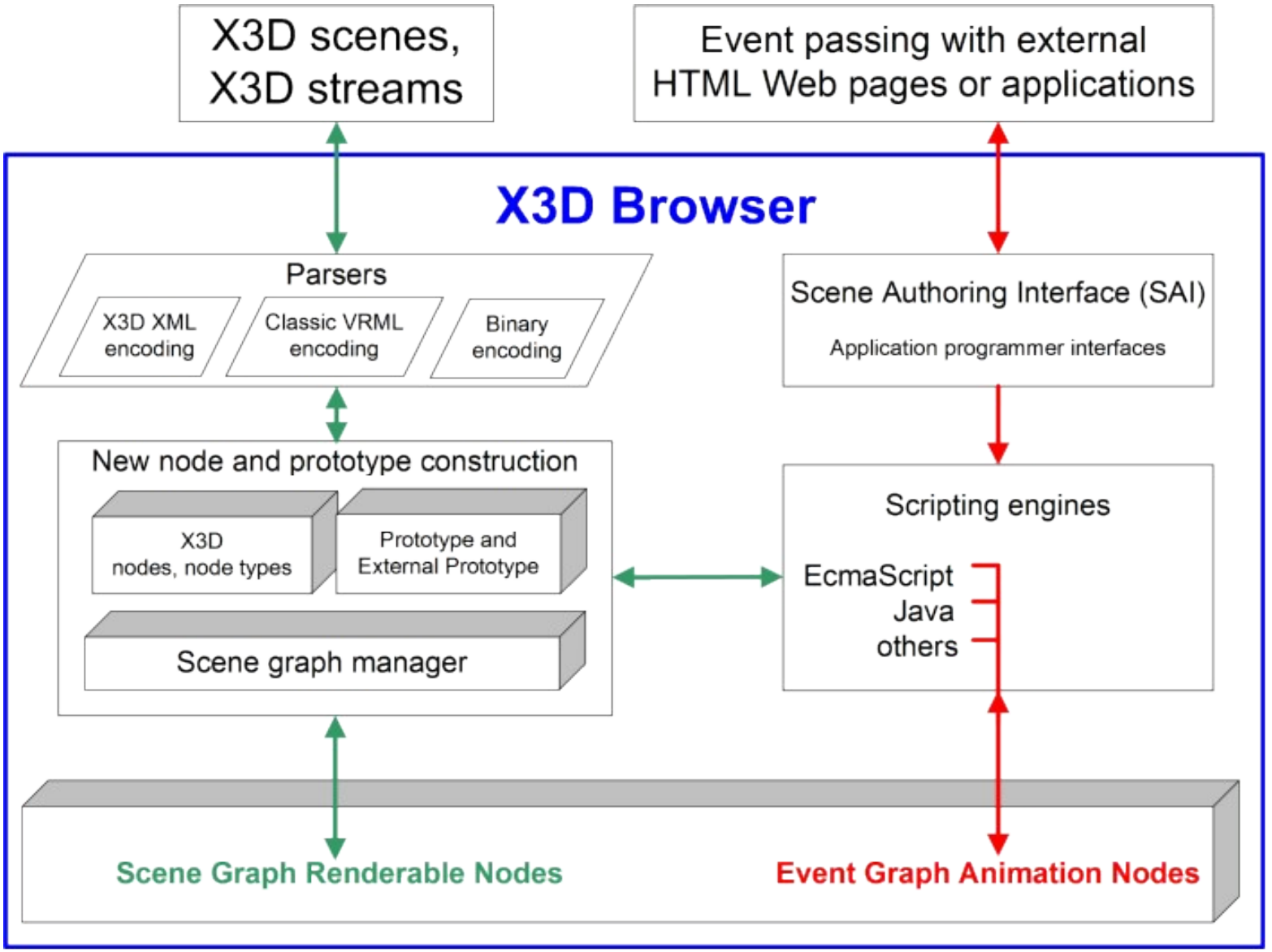
X3D e VRML97

- Principali differenze funzionali
  - File header (ad es: occorre definire un profile)
  - I nomi per l'accesso ai campi sono cambiati (ad es: eventIn → inputOnly, exposedField → inputOutput)
  - I nodi Script possono avere inputOutput
  - Il modello di programmazione e l'ambiente runtime sono consistenti tra linguaggi di programmazione e se si è all'interno del browser o no.
  - I file che non contengono script o externproto necessitano di piccolissime modifiche (cambio header e inserimento PROFILE)
  - I convertitori funzionano, ma con qualche problema. L'ambiente di script va rivisto tutto.

X3D tools: browsers

- Commerciali
  - BitManagement BS Contact www.bitmanagement.de
- FLOSS:
  - Instant Reality www.instantreality.org
  - FreeWRL www.crc.ca/FreeWRL
  - Xj3D www.xj3D.org

X3D browsers (i)



Source: Web3D Consortium

X3D tools: authoring

- FLOSS:
  - X3D-Edit www.web3d.org
  - Submarine www.submarine,unipg.it
  - Blender www.blender.org
  - VRML to X3D translator ovrt.nist.gov/v2_x3d.html
  - Exporters for Maya, 3DStudio, Blender, MilkShape

    www.web3d.org

Basic Nodes

Type	Interchange	Interactive	VRML97
Geometry	8	9	14
Grouping	2	2	5
Interpolating	5	5	5
Light&Sound	1	3	5
Misc.	6	10 (+2)	14
Sensing	1	6	7
Texture	5	5	8

Nodes by Name

Node	Type	Interchange	Interactive	Base
Anchor	Miscellaneous		URL only	URL only
Appearance	Texture	No textureTransform	No textureTransform	No textureTransform
AudioClip	Sound			30sec WAV
Background	Miscellaneous	Single sky color	Single sky color	Single sky color
Billboard	Group‡			†
Box	Geometry	Full support	Full support	Full support
Collision	Group‡			†
Color	Texture	15K colors	15K colors	15K colors
ColorInterpolator	Interpolator	*	*	*
Cone	Geometry	Full support	Full support	Full support
Coordinate	Geometry	65K points	65K points	65K points
CoordinateInterpolator	Interpolator	15K coord/keyValue*	15K coord/keyValue*	15K coord/ keyValue*
Cylinder	Geometry	Full support	Full support	Full support
CylinderSensor	Sensor		Full Support	Full support
DirectionalLight	Light	No ambientIntensity; No scoping	No scoping	No scoping
ElevationGrid	Geometry		Full Support	Full support
Extrusion	Geometry			#Xsec * #Spine < 2501
Fog	Miscellaneous			No Exponential
FontStyle	Geometry			ISO 8859-1 char. set

† 500 children max * 1000 key-value pairs max
‡ No add/removeChildren

Nodes by Name

Node	Type	Interchange	Interactive	Base
Group	Group‡	†	†	†
ImageTexture	Texture	JPEG/PNG	JPEG/PNG	JPEG/PNG
IndexedFaceSet	Geometry	Planar simple polygons, 5K faces	Planar simple polygons, 5K faces	Planar simple polygons, 5K faces
IndexedLineSet	Geometry	15K vertices	15K vertices	15K vertices
Inline	Miscellaneous	Full support	Full support	Full support
LOD	Group‡			>3 levels supported
Material	Texture	Restricted coloring	Restricted coloring	Restricted coloring
MovieTexture	Texture			1 active texture, ignore speed
NavigationInfo	Miscellaneous	No effect	No effect	No effect
Normal	Geometry			15K normals
NormalInterpolator	Geometry			15K normals/ key-value
OrientationInterpolator	Interpolator	*	*	*
PixelTexture	Texture			256 x 256
PlaneSensor	Sensor		Full Support	Full support
PointLight	Light		Linear attenuation	Linear attenuation
PointSet	Geometry	5K points	5K points	5K points
PositionInterpolator	Interpolator	*	*	*
PROTO/ EXTERNPROTO	Miscellaneous		Limited events, fields	Limited events, fields
ProximitySensor	Sensor		Boolean only	Boolean only
ScalarInterpolator	Interpolator	*	*	*

† 500 children max * 1000 key-value pairs max
‡ No add/removeChildren

Nodes by Name

Node	Type	Interchange	Interactive	Base
Script	Miscellaneous		Limited events, fields	Limited events, fields
Shape	Miscellaneous	Full support	Full support	Full support
Sound	Sound			2 active sounds, no spatialization
Sphere	Geometry	Full support	Full support	Full support
SphereSensor	Sensor		Full Support	Full support
SpotLight	Light		Linear attenuation	Linear attenuation
Switch	Miscellaneous		Full Support	Full support
Text	Geometry			100ch x 100str
TextureCoordinate	Texture	65K coordinates	65K coordinates	65K coordinates
TextureTransform	Texture			Full support
TimeSensor	Sensor	min > .01sec	min > .01sec	min > .01sec
TouchSensor	Sensor		Full support	Full support
Transform	Group‡	†	†	†
Viewpoint	Miscellaneous	Position & Orientation only	Position & Orientation only	Position & Orientation only
VisibilitySensor	Sensor			No effect
WorldInfo	Miscellaneous	Ignored	Ignored	Ignored

† 500 children max * 1000 key-value pairs max
‡ No add/removeChildren

Nodes by Group

Node	Type	Interchange	Interactive	Base
Box	Geometry	Full support	Full support	Full support
Cone	Geometry	Full support	Full support	Full support
Coordinate	Geometry	65K points	65K points	65K points
Cylinder	Geometry	Full support	Full support	Full support
ElevationGrid	Geometry		Full Support	Full support
Extrusion	Geometry			#Xsec * #Spine < 2501
FontStyle	Geometry			ISO 8859-1 char. set
IndexedFaceSet	Geometry	Planar simple polygons, 5K faces	Planar simple polygons, 5K faces	Planar simple polygons, 5K faces
IndexedLineSet	Geometry	15K vertices	15K vertices	15K vertices
Normal	Geometry			15K normals
NormalInterpolator	Geometry			15K normals/ key-value
PointSet	Geometry	5K points	5K points	5K points
Sphere	Geometry	Full support	Full support	Full support
Text	Geometry			100ch x 100str
Billboard	Group‡			†
Collision	Group‡			†
Group	Group‡	†	†	†
LOD	Group‡			>3 levels supported
Transform	Group‡	†	†	†

† 500 children max * 1000 key-value pairs max
‡ No add/removeChildren

Nodes by Group

Node	Type	Interchange	Interactive	Base
ColorInterpolator	Interpolator	*	*	*
CoordinateInterpolator	Interpolator	15K coord/keyValue*	15K coord/keyValue*	15K coord/ keyValue*
OrientationInterpolator	Interpolator	*	*	*
PositionInterpolator	Interpolator	*	*	*
ScalarInterpolator	Interpolator	*	*	*
DirectionalLight	Light	No ambientIntensity; No scoping	No scoping	No scoping
PointLight	Light		Linear attenuation	Linear attenuation
SpotLight	Light		Linear attenuation	Linear attenuation
Anchor	Miscellaneous		URL only	URL only
Background	Miscellaneous	Single sky color	Single sky color	Single sky color
Fog	Miscellaneous			No Exponential
Inline	Miscellaneous	Full support	Full support	Full support
NavigationInfo	Miscellaneous	No effect	No effect	No effect
PROTO/ EXTERNPROTO	Miscellaneous		Limited events, fields	Limited events, fields
Script	Miscellaneous		Limited events, fields	Limited events, fields
Shape	Miscellaneous	Full support	Full support	Full support
Switch	Miscellaneous		Full Support	Full support
Viewpoint	Miscellaneous	Position & Orientation only	Position & Orientation only	Position & Orientation only
WorldInfo	Miscellaneous	Ignored	Ignored	Ignored

† 500 children max * 1000 key-value pairs max
‡ No add/removeChildren

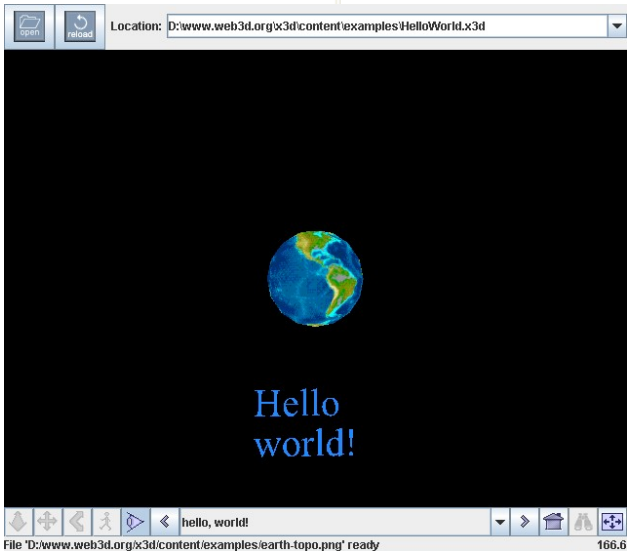
Nodes by Group

Node	Type	Interchange	Interactive	Base
CylinderSensor	Sensor		Full Support	Full support
PlaneSensor	Sensor		Full Support	Full support
ProximitySensor	Sensor		Boolean only	Boolean only
SphereSensor	Sensor		Full Support	Full support
TimeSensor	Sensor	min > .01sec	min > .01sec	min > .01sec
TouchSensor	Sensor		Full support	Full support
VisibilitySensor	Sensor			No effect
AudioClip	Sound			30sec WAV
Sound	Sound			2 active sounds, no spatialization
Appearance	Texture	No textureTransform	No textureTransform	No textureTransform
Color	Texture	15K colors	15K colors	15K colors
ImageTexture	Texture	JPEG/PNG	JPEG/PNG	JPEG/PNG
Material	Texture	Restricted coloring	Restricted coloring	Restricted coloring
MovieTexture	Texture			1 active texture, ignore speed
PixelTexture	Texture			256 x 256
TextureCoordinate	Texture	65K coordinates	65K coordinates	65K coordinates
TextureTransform	Texture			Full support

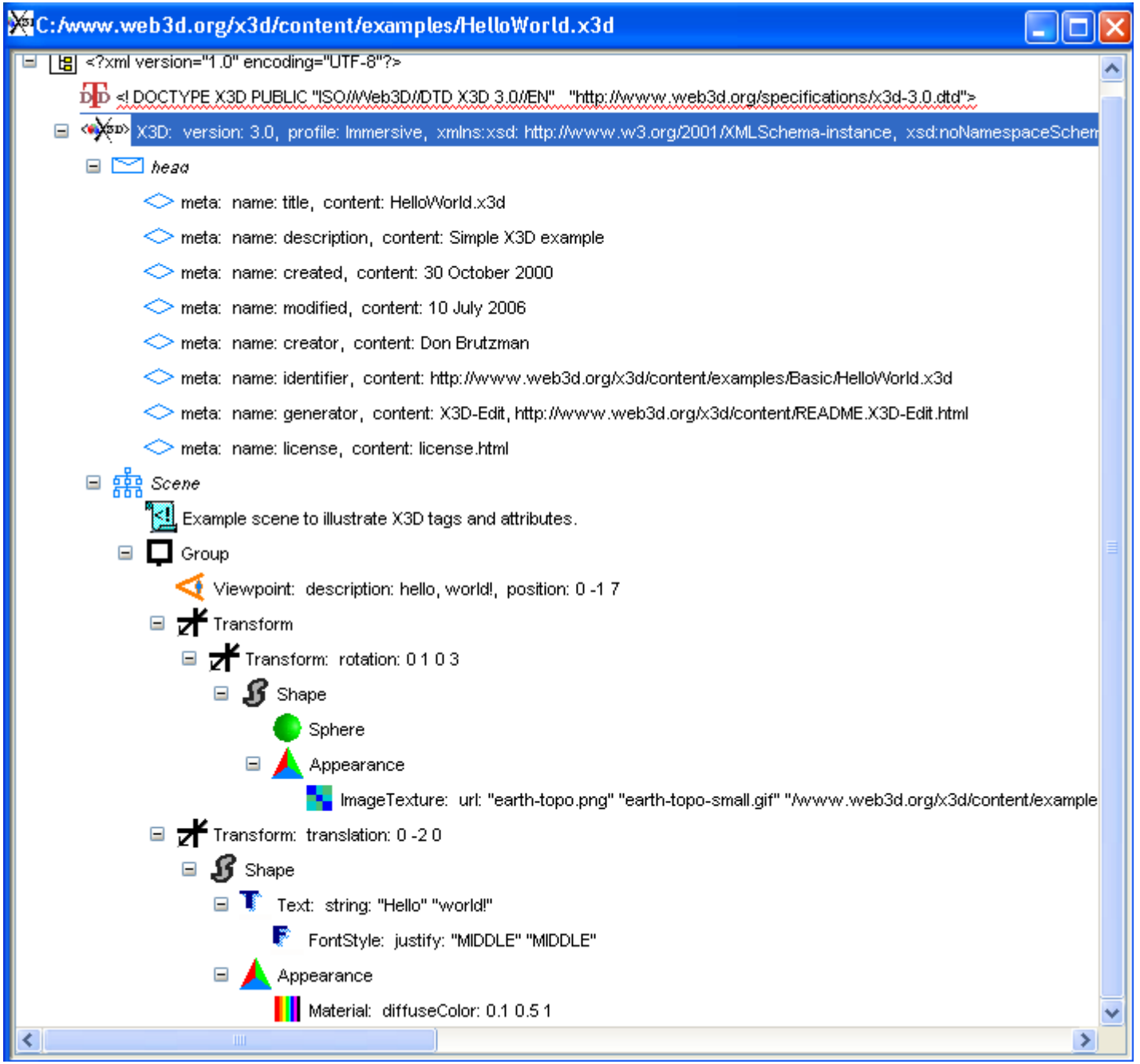
† 500 children max * 1000 key-value pairs max
‡ No add/removeChildren

Esempio: Helloworld.x3d

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE X3D PUBLIC "ISO//Web3D//DTD X3D 3.1//EN" "http://www.web3d.org/specifications/x3d-3.1.dtd">
<X3D version="3.1" profile="Immersive" xmlns:xsd="http://www.w3.org/2001/XMLSchema-instance" xsd:noNamespaceSchema
Location="http://www.web3d.org/specifications/x3d-3.1.xsd">
        <head>
                <meta content="HelloWorld.x3d"    name="filename"/>
                <meta content="Simple X3D example" name="description"/>
                <meta content="30 October 2000" name="created"/>
                <meta content="22 October 2005" name="revised"/>
                <meta content="Don Brutzman" name="author"/>
                <meta content="http://www.web3d.org/x3d/content/examples/HelloWorld.x3d" name="url"/>
                <meta content="X3D-Edit, http://www.web3d.org/x3d/content/README.X3D-Edit.html" name="generator"/>
                <meta name="license" content="license.html"/>
        </head>
        <Scene>
                <!--Example scene to illustrate X3D tags and attributes.-->
                <Group>
                        <Viewpoint description="hello, world!" orientation="0 1 0 1.57" position="6 -1 0"/>
                        <NavigationInfo type='"EXAMINE" "ANY"'/>
                        <Shape>
                                <Sphere/>
                                <Appearance>
                                        <ImageTexture url='"earth-topo.png" "earth-topo-small.gif" "/www.web3d.org
/x3d/content/examples/earth-topo.png" "/www.web3d.org/x3d/content/examples/earth-topo-small.gif" "http://www.web3d
.org/x3d/content/examples/earth-topo.png" "http://www.web3d.org/x3d/content/examples/earth-topo-small.gif"'/>
                                </Appearance>
                        </Shape>
                        <Transform rotation="0 1 0 1.57" translation="0 -2 1.25">
                                <Shape>
                                        <Text string='"Hello" "world!"'/>
                                        <Appearance>
                                                <Material diffuseColor="0.1 0.5 1"/>
                                        </Appearance>
                                </Shape>
                        </Transform>
                </Group>
        </Scene>
</X3D>
```



Helloworld.x3d (X3D-Edit)



X3D-Edit

- **`http://www.web3D.org/x3d`**
- JRE/JDK 1.3.1 (Sun) e superiori
- Xeena (IBM)
- X3D-Edit Distribution (Web3D)
- X3D Examples (Web3D)
- NIST Conformance Suite (Web3D)
- Learning material
- X3D specif cations

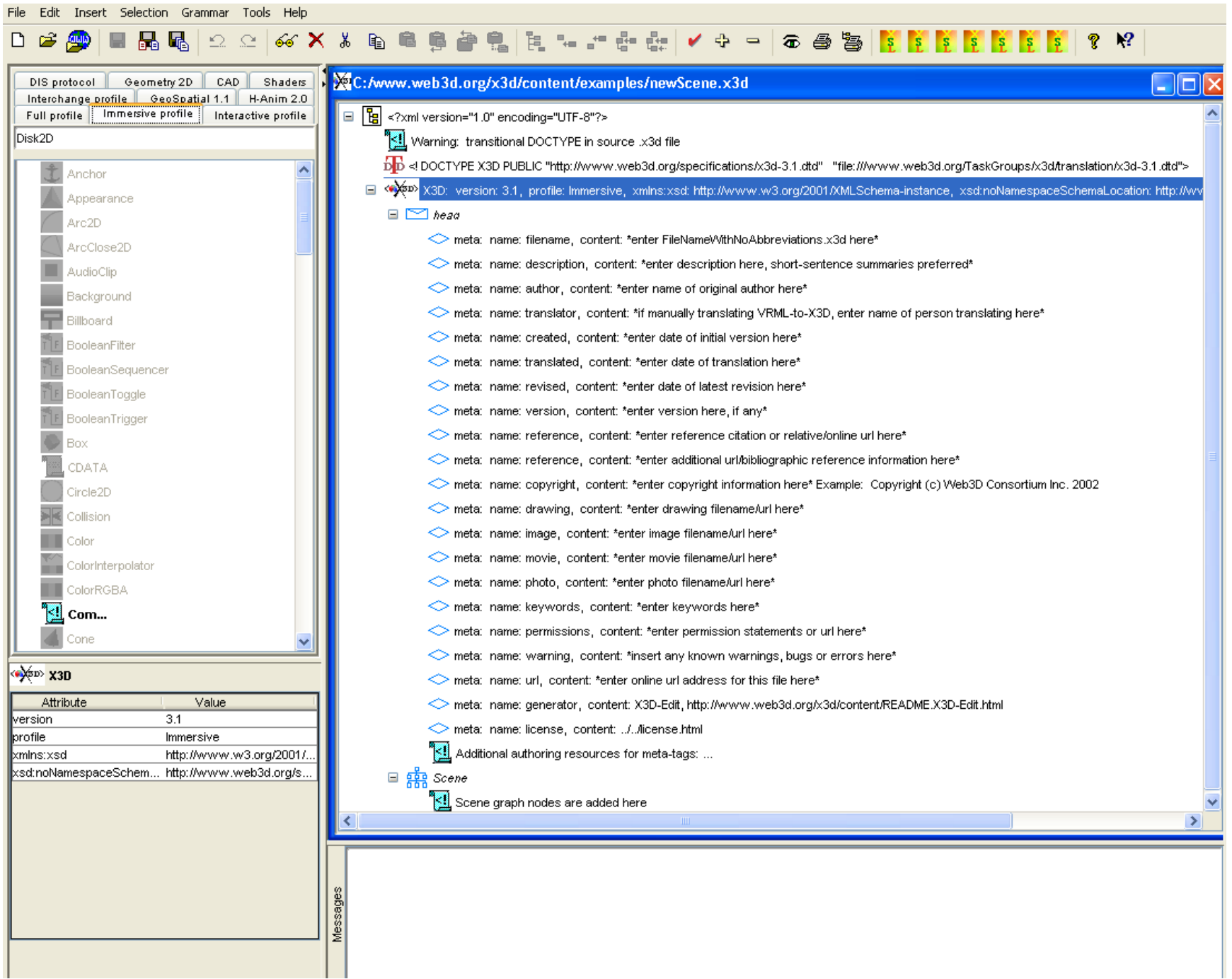
Xeena

- Editor XML sviluppato nell'ambiente di sviluppo IBM alphaWorks
- "Xeena è un editor XML visuale. E' una applicazione Java sviluppata presso il Centro Ricerche IBM di Haifa per l'edit di documenti XML derivati da qualsiasi DTD valido."
- Multi-Platform, Graphic X3D Editor
- http://www.alphaworks.ibm.com/tech/xeena.
  - http://www.web3d.org/TaskGroups/x3d/translation/README.X3D-Edit.txt (X3D-Edit Installation ReadMe)

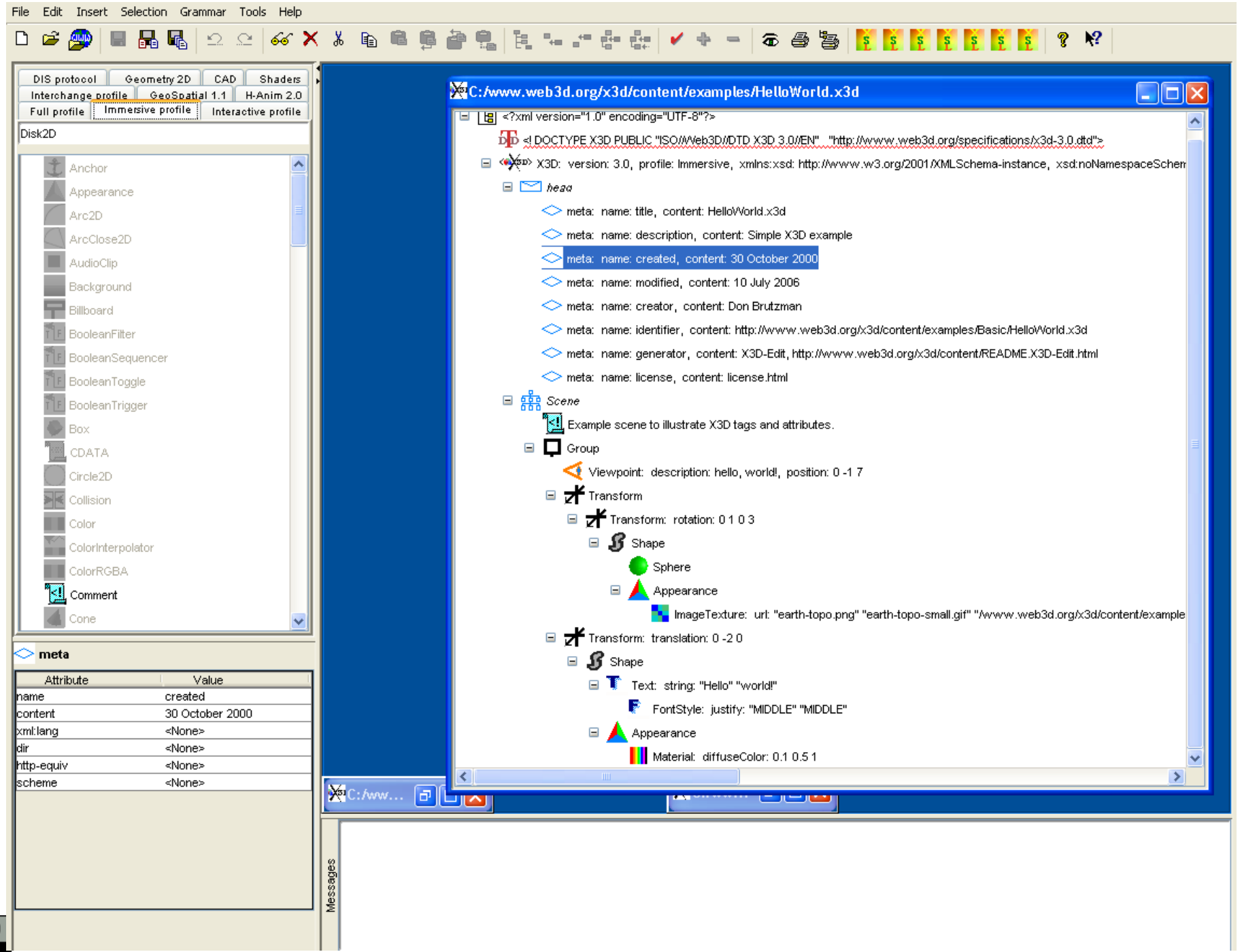
VRML vs. X3D

- Lighting
- Material
- NavigationInfo
- ProximitySensor
- TextureTransform
- Script
- PROTO/EXTERNPROTO

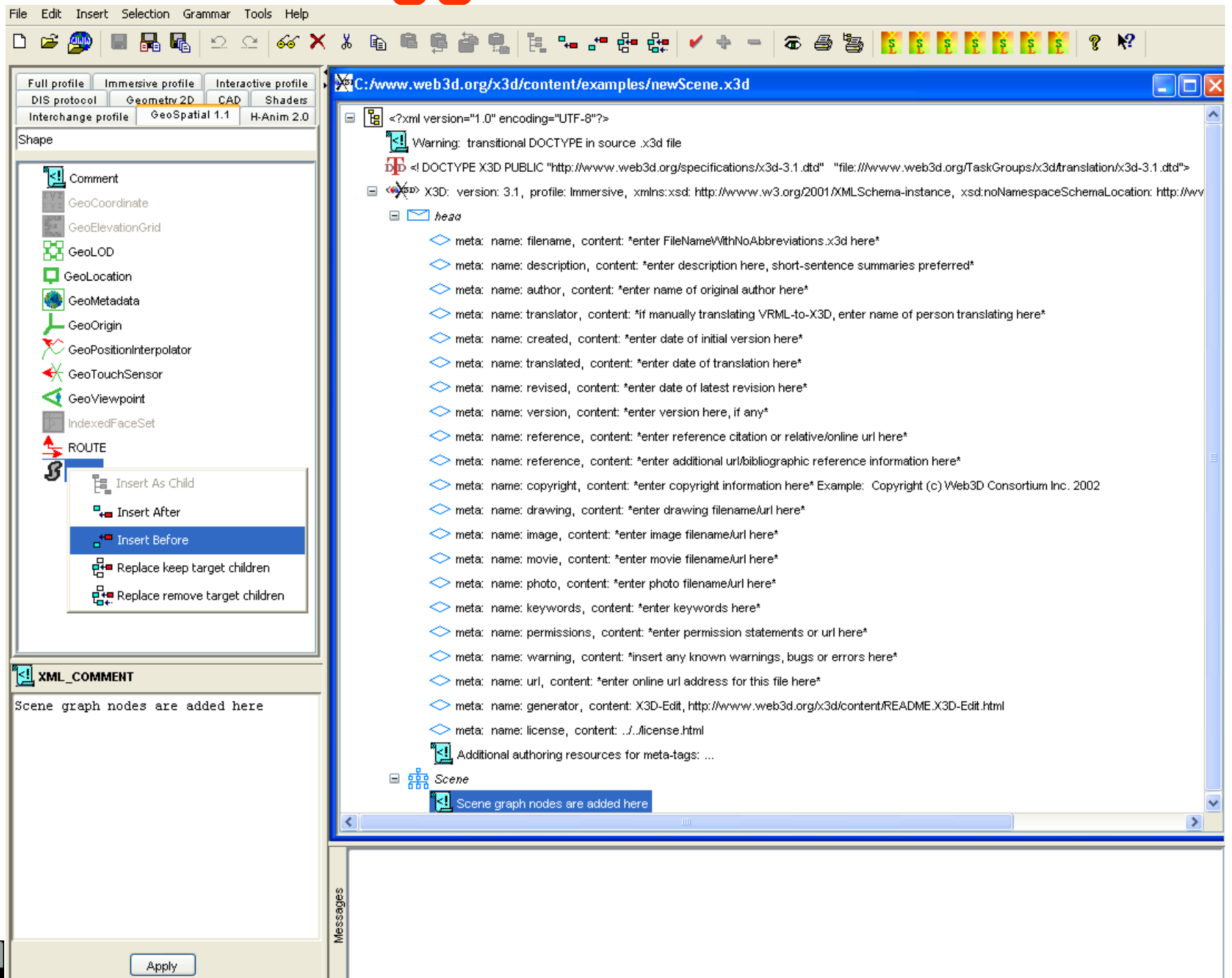
Start up


File Edit Insert Selection Grammar Tools Help
DIS protocol
Geometry 2D
CAD
Shaders
Interchange profile
GeoSpatial 1.1
H-Anim 2.0
Full profile
Immersive profile
Interactive profile
Disk2D
Anchor
Appearance
Arc2D
ArcClose2D
AudioClip
Background
Billboard
BooleanFilter
BooleanSequencer
BooleanToggle
BooleanTrigger
Box
CDATA
Circle2D
Collision
Color
ColorInterpolator
ColorRGBA
Com...
Cone
X3D
Attribute
Value
version
3.1
profile
Immersive
xmlns:xsd
http://www.w3.org/2001/...
xsd:noNamespaceSchem...
http://www.web3d.org/s...
C:/www.web3d.org/x3d/content/examples/newScene.x3d
<?xml version="1.0" encoding="UTF-8"?>
Warning: transitional DOCTYPE in source .x3d file
<! DOCTYPE X3D PUBLIC "http://www.web3d.org/specifications/x3d-3.1.dtd" "file:///www.web3d.org/TaskGroups/x3d/translation/x3d-3.1.dtd">
X3D: version: 3.1, profile: Immersive, xmlns:xsd: http://www.w3.org/2001/XMLSchema-instance, xsd:noNamespaceSchemaLocation: http://ww
head
meta: name: filename, content: *enter FileNameWithNoAbbreviations.x3d here*
meta: name: description, content: *enter description here, short-sentence summaries preferred*
meta: name: author, content: *enter name of original author here*
meta: name: translator, content: *if manually translating VRML-to-X3D, enter name of person translating here*
meta: name: created, content: *enter date of initial version here*
meta: name: translated, content: *enter date of translation here*
meta: name: revised, content: *enter date of latest revision here*
meta: name: version, content: *enter version here, if any*
meta: name: reference, content: *enter reference citation or relative/online url here*
meta: name: reference, content: *enter additional url/bibliographic reference information here*
meta: name: copyright, content: *enter copyright information here* Example: Copyright (c) Web3D Consortium Inc. 2002
meta: name: drawing, content: *enter drawing filename/url here*
meta: name: image, content: *enter image filename/url here*
meta: name: movie, content: *enter movie filename/url here*
meta: name: photo, content: *enter photo filename/url here*
meta: name: keywords, content: *enter keywords here*
meta: name: permissions, content: *enter permission statements or url here*
meta: name: warning, content: *insert any known warnings, bugs or errors here*
meta: name: url, content: *enter online url address for this file here*
meta: name: generator, content: X3D-Edit, http://www.web3d.org/x3d/content/README.X3D-Edit.html
meta: name: license, content: ../../license.html
Additional authoring resources for meta-tags: ...
Scene
Scene graph nodes are added here
Messages

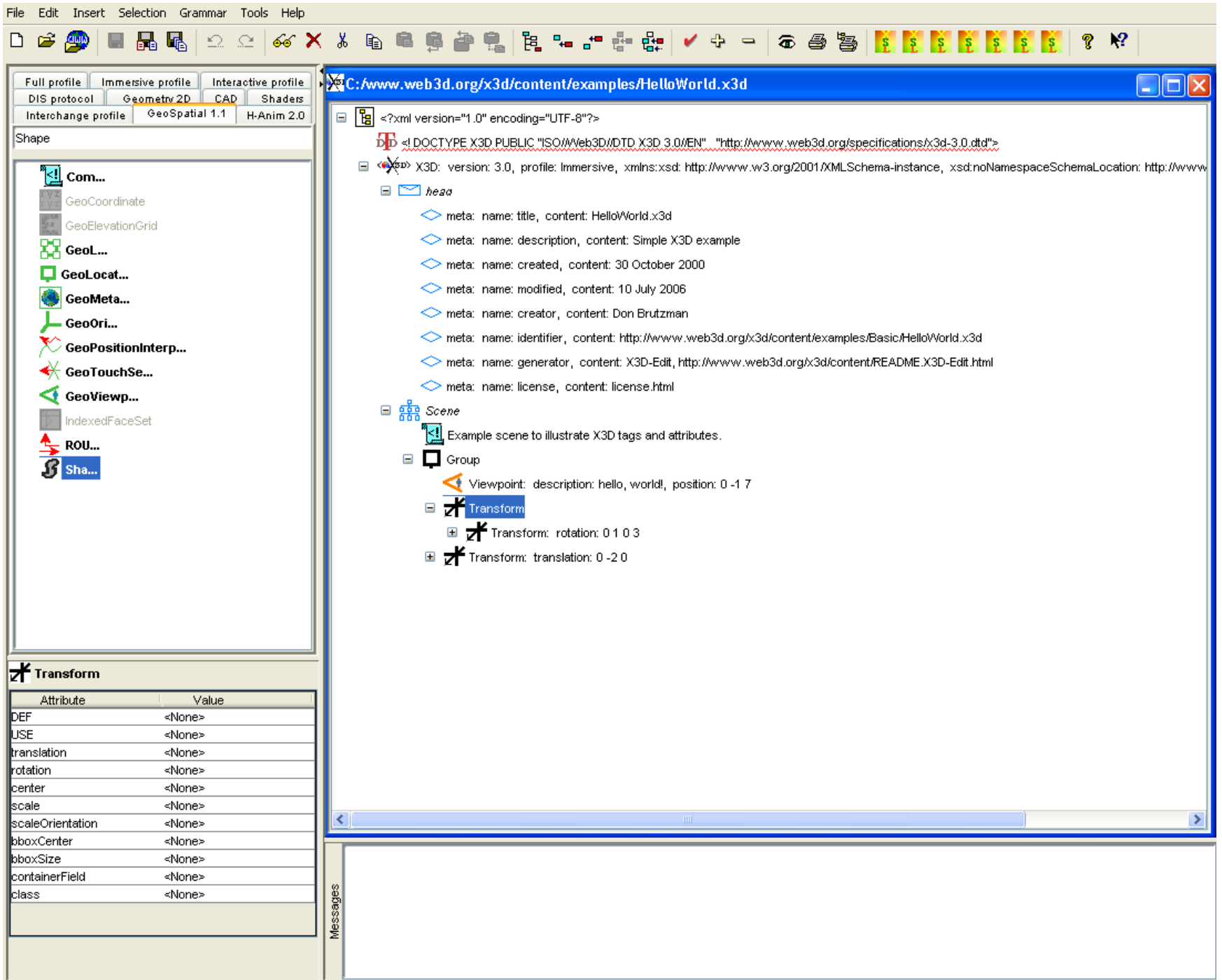
Headers


File Edit Insert Selection Grammar Tools Help
DIS protocol
Geometry 2D
CAD
Shaders
Interchange profile
GeoSpatial 1.1
H-Anim 2.0
Full profile
Immersive profile
Interactive profile
Disk2D
Anchor
Appearance
Arc2D
ArcClose2D
AudioClip
Background
Billboard
BooleanFilter
BooleanSequencer
BooleanToggle
BooleanTrigger
Box
CDATA
Circle2D
Collision
Color
ColorInterpolator
ColorRGBA
Comment
Cone
meta
Attribute
Value
name
created
content
30 October 2000
xml:lang
<None>
dir
<None>
http-equiv
<None>
scheme
<None>
C:/www.web3d.org/x3d/content/examples/HelloWorld.x3d
<?xml version="1.0" encoding="UTF-8"?>
<! DOCTYPE X3D PUBLIC "ISO//Web3D//DTD X3D 3.0//EN" "http://www.web3d.org/specifications/x3d-3.0.dtd">
X3D: version: 3.0, profile: Immersive, xmlns:xsd: http://www.w3.org/2001/XMLSchema-instance, xsd:noNamespaceSchem
head
meta: name: title, content: HelloWorld.x3d
meta: name: description, content: Simple X3D example
meta: name: created, content: 30 October 2000
meta: name: modified, content: 10 July 2006
meta: name: creator, content: Don Brutzman
meta: name: identifier, content: http://www.web3d.org/x3d/content/examples/Basic/HelloWorld.x3d
meta: name: generator, content: X3D-Edit, http://www.web3d.org/x3d/content/README.X3D-Edit.html
meta: name: license, content: license.html
Scene
Example scene to illustrate X3D tags and attributes.
Group
Viewpoint: description: hello, world!, position: 0 -1 7
Transform
Transform: rotation: 0 1 0 3
Shape
Sphere
Appearance
ImageTexture: url: "earth-topo.png" "earth-topo-small.gif" "/www.web3d.org/x3d/content/example
Transform: translation: 0 -2 0
Shape
Text: string: "Hello" "world!"
FontStyle: justify: "MIDDLE" "MIDDLE"
Appearance
Material: diffuseColor: 0.1 0.5 1
Messages

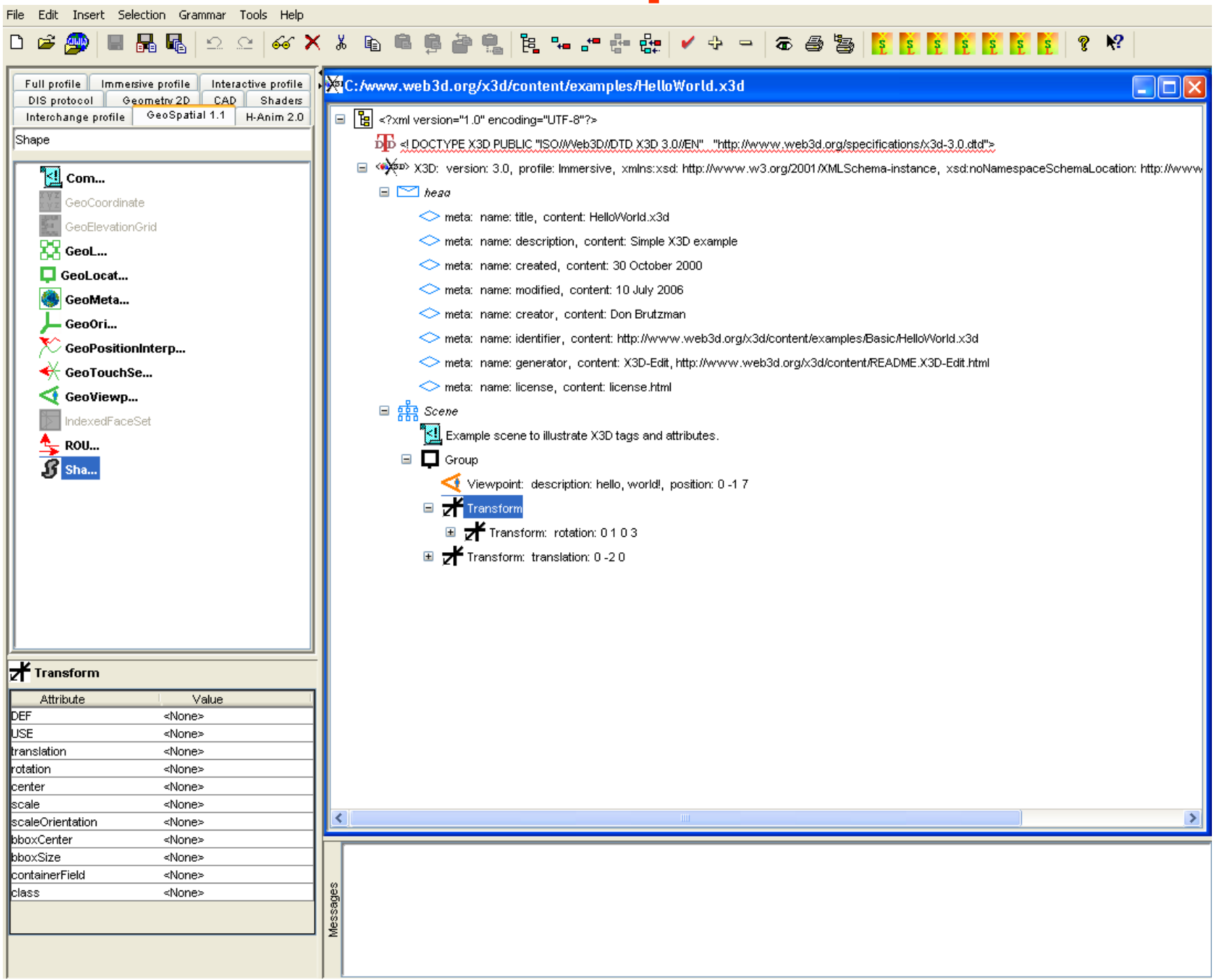
Aggiunta di nodi



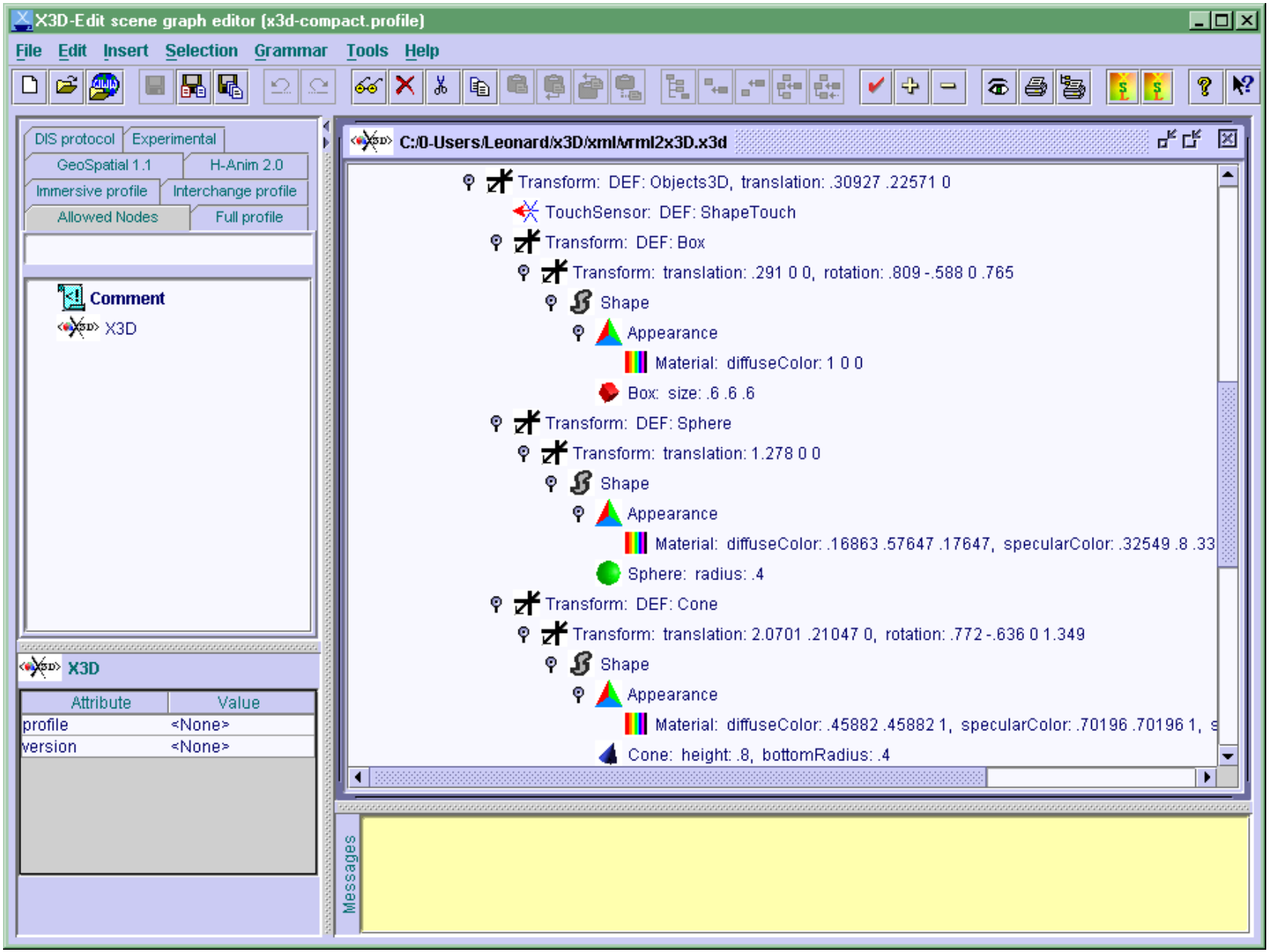
Transform



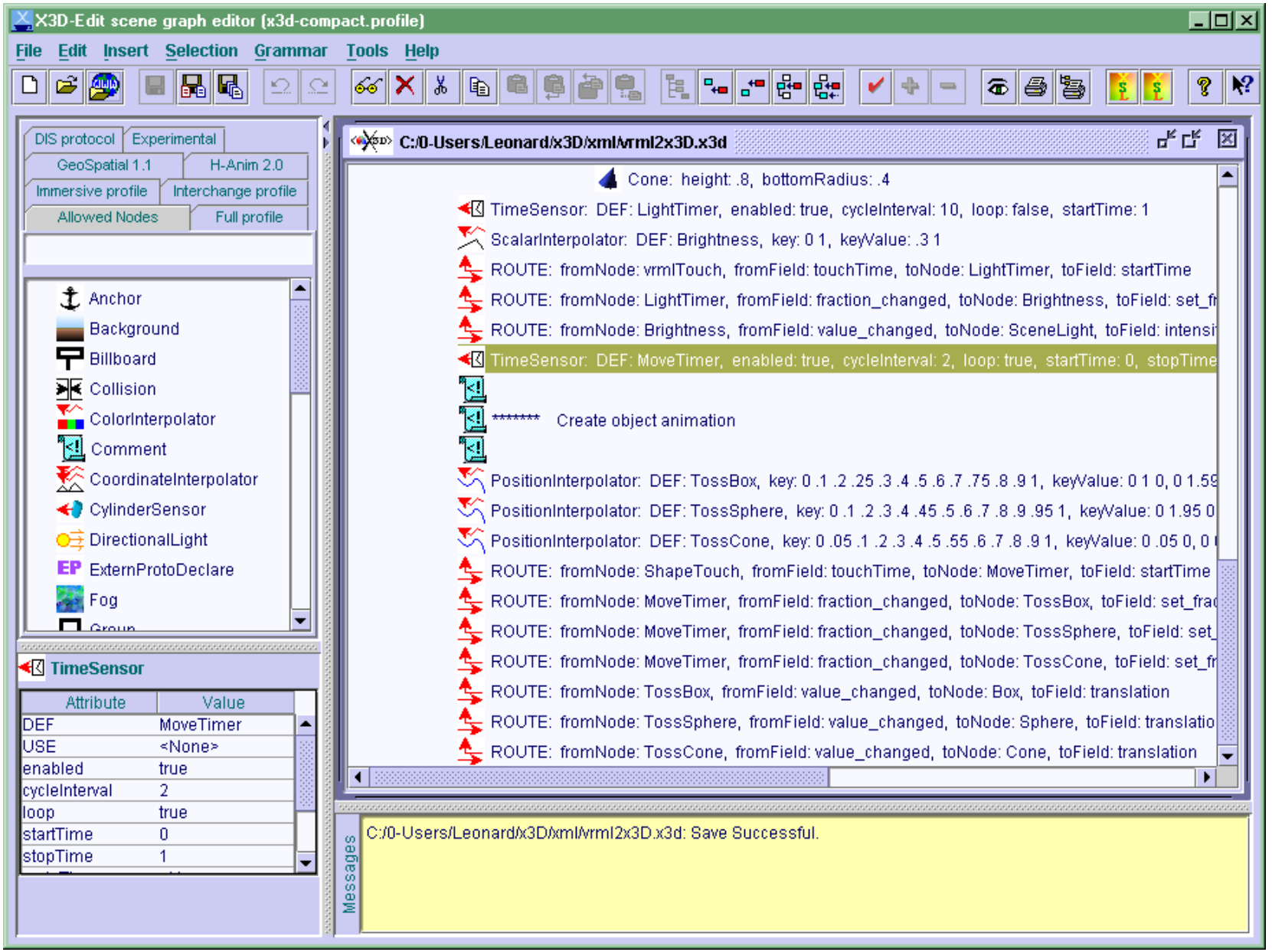
Group


File Edit Insert Selection Grammar Tools Help
Full profile
Immersive profile
Interactive profile
DIS protocol
Geometry 2D
CAD
Shaders
Interchange profile
GeoSpatial 1.1
H-Anim 2.0
Shape
Com...
GeoCoordinate
GeoElevationGrid
GeoL...
GeoLocat...
GeoMeta...
GeoOri...
GeoPositionInterp...
GeoTouchSe...
GeoViewp...
IndexedFaceSet
ROU...
Sha...
Transform
Attribute
Value
DEF <None>
USE <None>
translation <None>
rotation <None>
center <None>
scale <None>
scaleOrientation <None>
bboxCenter <None>
bboxSize <None>
containerField <None>
class <None>
C:/www.web3d.org/x3d/content/examples/HelloWorld.x3d
<?xml version="1.0" encoding="UTF-8"?>
<! DOCTYPE X3D PUBLIC "ISO//Web3D//DTD X3D 3.0//EN" "http://www.web3d.org/specifications/x3d-3.0.dtd">
X3D: version: 3.0, profile: Immersive, xmlns:xsd: http://www.w3.org/2001/XMLSchema-instance, xsd:noNamespaceSchemaLocation: http://www
head
meta: name: title, content: HelloWorld.x3d
meta: name: description, content: Simple X3D example
meta: name: created, content: 30 October 2000
meta: name: modified, content: 10 July 2006
meta: name: creator, content: Don Brutzman
meta: name: identifier, content: http://www.web3d.org/x3d/content/examples/Basic/HelloWorld.x3d
meta: name: generator, content: X3D-Edit, http://www.web3d.org/x3d/content/README.X3D-Edit.html
meta: name: license, content: license.html
Scene
Example scene to illustrate X3D tags and attributes.
Group
Viewpoint: description: hello, world!, position: 0 -1 7
Transform
Transform: rotation: 0 1 0 3
Transform: translation: 0 -2 0
Messages

Forme base


X3D-Edit scene graph editor (x3d-compact.profile)
File Edit Insert Selection Grammar Tools Help
DIS protocol
Experimental
GeoSpatial 1.1
H-Anim 2.0
Immersive profile
Interchange profile
Allowed Nodes
Full profile
Comment
X3D
X3D
Attribute
Value
profile
<None>
version
<None>
C:/0-Users/Leonard/x3D/xml/vrml2x3D.x3d
Transform: DEF: Objects3D, translation: .30927 .22571 0
TouchSensor: DEF: ShapeTouch
Transform: DEF: Box
Transform: translation: .291 0 0, rotation: .809 -.588 0 .765
Shape
Appearance
Material: diffuseColor: 1 0 0
Box: size: .6 .6 .6
Transform: DEF: Sphere
Transform: translation: 1.278 0 0
Shape
Appearance
Material: diffuseColor: .16863 .57647 .17647, specularColor: .32549 .8 .33
Sphere: radius: .4
Transform: DEF: Cone
Transform: translation: 2.0701 .21047 0, rotation: .772 -.636 0 1.349
Shape
Appearance
Material: diffuseColor: .45882 .45882 1, specularColor: .70196 .70196 1,
Cone: height: .8, bottomRadius: .4
Messages

Animation


X3D-Edit scene graph editor (x3d-compact.profile)
File Edit Insert Selection Grammar Tools Help
DIS protocol Experimental
GeoSpatial 1.1 H-Anim 2.0
Immersive profile Interchange profile
Allowed Nodes Full profile
Anchor
Background
Billboard
Collision
ColorInterpolator
Comment
CoordinateInterpolator
CylinderSensor
DirectionalLight
EP ExternProtoDeclare
Fog
TimeSensor
Attribute Value
DEF MoveTimer
USE <None>
enabled true
cycleInterval 2
loop true
startTime 0
stopTime 1
C:/0-Users/Leonard/x3D/xml/vrml2x3D.x3d
Cone: height: .8, bottomRadius: .4
TimeSensor: DEF: LightTimer, enabled: true, cycleInterval: 10, loop: false, startTime: 1
ScalarInterpolator: DEF: Brightness, key: 0 1, keyValue: .3 1
ROUTE: fromNode: vrmlTouch, fromField: touchTime, toNode: LightTimer, toField: startTime
ROUTE: fromNode: LightTimer, fromField: fraction_changed, toNode: Brightness, toField: set_fr
ROUTE: fromNode: Brightness, fromField: value_changed, toNode: SceneLight, toField: intensi
TimeSensor: DEF: MoveTimer, enabled: true, cycleInterval: 2, loop: true, startTime: 0, stopTime
******* Create object animation
PositionInterpolator: DEF: TossBox, key: 0 .1 .2 .25 .3 .4 .5 .6 .7 .75 .8 .9 1, keyValue: 0 1 0, 0 1.59
PositionInterpolator: DEF: TossSphere, key: 0 .1 .2 .3 .4 .45 .5 .6 .7 .8 .9 .95 1, keyValue: 0 1.95 0
PositionInterpolator: DEF: TossCone, key: 0 .05 .1 .2 .3 .4 .5 .55 .6 .7 .8 .9 1, keyValue: 0 .05 0, 0
ROUTE: fromNode: ShapeTouch, fromField: touchTime, toNode: MoveTimer, toField: startTime
ROUTE: fromNode: MoveTimer, fromField: fraction_changed, toNode: TossBox, toField: set_frac
ROUTE: fromNode: MoveTimer, fromField: fraction_changed, toNode: TossSphere, toField: set_
ROUTE: fromNode: MoveTimer, fromField: fraction_changed, toNode: TossCone, toField: set_fr
ROUTE: fromNode: TossBox, fromField: value_changed, toNode: Box, toField: translation
ROUTE: fromNode: TossSphere, fromField: value_changed, toNode: Sphere, toField: translatio
ROUTE: fromNode: TossCone, fromField: value_changed, toNode: Cone, toField: translation
Messages
C:/0-Users/Leonard/x3D/xml/vrml2x3D.x3d: Save Successful.

Bibliografia:

- X3D Working Group
  - http://www.web3d.org/x3d.html
- FAQ:
  - http://www.web3d.org/TaskGroups/x3d/faq/index.html
- Archivi Mail
  - http://www.web3d.org/WorkingGroups/x3d-contributors/hypermail/1999/
- X3D-Edit
  - Usa Xeena, editor XML di IBM
  - Instruzioni per l'installazione: (http://www.web3d.org/TaskGroups/x3d/sun/cvs.html)

Codifica XML

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE X3D PUBLIC "http://www.web3D.org/TaskGroups/x3d/translation/x3d-
compact.dtd" "/www.web3d.org/TaskGroups/x3d/translation/x3d-compact.dtd">
<X3D>
  <head>
    <meta content="VRML2X3D.x3d" name="filename"/>
    <meta content="Visual animated history of Web3D." name="description"/>
    <meta content="Leonard Daly" name="author"/>
    <meta content="Leonard Daly" name="translator"/>
    <meta content="15 Feb 2002" name="created"/>
    <meta
      content="Copyright (c) 2002, Daly Realism.  All Rights Reserved."
name="copyright"/>
    <meta content="http://realism.com/Web3D/x3d" name="url"/>
    <meta
      content="X3D-Edit,
http://www.web3D.org/TaskGroups/x3d/translation/README.X3D-Edit.html"
      name="generator"/><!--Additional authoring resources for
      meta-tags:
      http://www.w3.org/TR/html4/struct/global.html#h-7.4.4
      http://dublincore.org/documents/dces
      http://vancouver-webpages.com/META
      http://vancouver-webpages.com/META/about-mk-metas2.html
      http://www.statelib.wa.gov:80/info_rscrs/dbs_tools/find-it/metadesc.htm
      Additional authoring resources for language codes:
      ftp://ftp.isi.edu/in-notes/bcp/bcp47.txt [IETF RFC3066/BCP47]
      http://www.loc.gov/standards/iso639-2/langhome.html
      http://www.iana.org/numbers.html#L Additional authoring resources
      for country names:  http://www.din.de/gremien/nas/nabd/iso3166ma-->
    </head>
```

Codifica XML

```
 <Scene>
    <NavigationInfo headlight="false"
type="EXAMINE ANY"/>
    <Group>
      <DirectionalLight DEF="SceneLight"
          ambientIntensity=".7"
        direction="1 -1 -1" intensity=".3"/>
      <Transform DEF="VRML:"
          translation="-5 0 0">
        <TouchSensor DEF="vrmlTouch"/>
        <Transform DEF="char_V"
translation="1.416 -.291 0">
          <Inline url="letter_V.wrl"/>
        </Transform>
        <Transform DEF="char_R"
translation="1.946 -.048 0">
          <Inline url="letter_R.wrl"/>
        </Transform>
        <Transform
          translation="2.621 -.048 0">
          <Inline url="letter_m.wrl"/>
        </Transform>
        <Transform
          translation="4.042 -.048 0">
          <Inline url="letter_L.wrl"/>
        </Transform>
      </Transform>
```

```
    <!-- -->
    <!--*****     Define animated objects-->
    <!-- -->
<Transform DEF="Objects3D"
      translation=".30927 .22571 0">
<TouchSensor DEF="ShapeTouch"/>
<Transform DEF="Box">
  <Transform
    rotation=".809 -.588 0 .765"
    translation=".291 0 0">
    <Shape>
      <Appearance>
        <Material diffuseColor="1 0 0"/>
      </Appearance>
      <Box size=".6 .6 .6"/>
    </Shape>
  </Transform>
</Transform>
<Transform DEF="Sphere">
  <Transform translation="1.278 0 0">
    <Shape>
      <Appearance>
        <Material ambientIntensity=".4"
          diffuseColor=".16863 .57647 .17647"
          shininess=".9"
          specularColor=".32549 .8 .33725"/>
      </Appearance>
      <Sphere radius=".4"/>
    </Shape>
  </Transform>
</Transform>
```

Codifica XML

```
<Transform DEF="Cone">
        <Transform rotation=".772 -.636 0 1.349"
                translation="2.0701 .21047 0">
          <Shape>
            <Appearance>
              <Material ambientIntensity=".4"
                diffuseColor=".45882 .45882 1"
                shininess=".9"
                specularColor=".70196 .70196 1"/>
            </Appearance>
            <Cone bottomRadius=".4" height=".8"/>
          </Shape>
        </Transform>
      </Transform>
    </Transform>
  </Group>
  <TimeSensor DEF="LightTimer" cycleInterval="10" enabled="true"
    loop="false" startTime="1"/>
  <ScalarInterpolator DEF="Brightness" key="0 1" keyValue=".3 1"/>
  <ROUTE fromField="touchTime" fromNode="vrmlTouch"
    toField="startTime" toNode="LightTimer"/>
  <ROUTE fromField="fraction_changed" fromNode="LightTimer"
    toField="set_fraction" toNode="Brightness"/>
  <ROUTE fromField="value_changed" fromNode="Brightness"
    toField="intensity" toNode="SceneLight"/>
  <TimeSensor DEF="MoveTimer" cycleInterval="2" enabled="true"
    loop="true" startTime="0" stopTime="1"/>
```

Codifica XML

```
<!-- --><!--*******
      Create object animation--><!-- --><PositionInterpolator
      DEF="TossBox" key="0 .1 .2 .25 .3 .4 .5 .6 .7 .75 .8 .9 1
          keyValue="0 1 0, 0 1.59 0, 0 1.95 0, 0 2 0, 0 1.95 0,
                    0 1.59 0, 0 1 0, 0 .41 0, 0 .05 0,
                    0 0 0, 0 .05 0, 0 .41 0, 0 1 0"/>
    <PositionInterpolator DEF="TossSphere"
      key="0 .1 .2 .3 .4 .45 .5 .6 .7 .8 .9 .95 1
          keyValue="0 1.95 0, 0 1.59 0, 0 1 0, 0 .41 0, 0 .05 0, 0 0 0,
                    0 .05 0, 0 .41 0, 0 1 0, 0 1.59 0, 0 1.95 0, 0 2 0,
                    0 1.95 0"/>
    <PositionInterpolator DEF="TossCone"
      key="0 .05 .1 .2 .3 .4 .5 .55 .6 .7 .8 .9 1”
         keyValue="0 .05 0, 0 0 0, 0 .05 0, 0 .41 0, 0 1 0, 0 1.59 0,
0 1.95 0, 0 2 0, 0 1.95 0, 0 1.59 0, 0 1 0, 0 .41 0, 0 .05 0"/>
    <ROUTE fromField="touchTime" fromNode="ShapeTouch"
      toField="startTime" toNode="MoveTimer"/>
    <ROUTE fromField="fraction_changed" fromNode="MoveTimer"
      toField="set_fraction" toNode="TossBox"/>
    <ROUTE fromField="fraction_changed" fromNode="MoveTimer"
      toField="set_fraction" toNode="TossSphere"/>
    <ROUTE fromField="fraction_changed" fromNode="MoveTimer"
      toField="set_fraction" toNode="TossCone"/>
    <ROUTE fromField="value_changed" fromNode="TossBox"
      toField="translation" toNode="Box"/>
    <ROUTE fromField="value_changed" fromNode="TossSphere"
      toField="translation" toNode="Sphere"/>
    <ROUTE fromField="value_changed" fromNode="TossCone"
      toField="translation" toNode="Cone"/>
  </Scene>
</X3D>
```

Codifica VRML

```
#VRML V2.0 utf8
# X3D-to-VRML-97 XSL translation autogenerated by X3dToVrml97.xsl
# http://www.web3D.org/TaskGroups/x3d/translation/X3dToVrml97.xsl

# [X3D]  VRML V3.0 utf8

# [head]
# [meta] filename: VRML2X3D.x3d
# [meta] description: Visual animated history of Web3D.
# [meta] author: Leonard Daly
# [meta] translator: Leonard Daly
# [meta] created: 15 Feb 2002
# [meta] copyright: Copyright (c) 2002, Daly Realism.  All Rights Reserved.
# [meta] keywords: *enter keywords here*
# [meta] url: http://realism.com/Web3D/x3d/
# [meta] generator: X3D-Edit, http://www.web3D.org/TaskGroups/x3d/translation/README.X3D-Edit.html
# Additional authoring resources for meta-tags: http://www.w3.org/TR/html4/struct/global.html#h-7.4.4
#         http://dublincore.org/documents/dces http://vancouver-webpages.com/META
         http://vancouver-webpages.com/META/about-mk-metas2
#         html http://www.statelib.wa.gov:80/info_rscrs/dbs_tools/find-it/metadesc.htm
#         Additional authoring resources for language codes: ftp://ftp.isi.edu/in-notes/bcp/bcp47.txt
         [IETF RFC3066/BCP47]
#         http://www.loc.gov/standards/iso639-2/langhome.html http://www.iana.org/numbers.html#L
#         Additional authoring resources for country names: http://www.din.de/gremien/nas/nabd/iso3166ma

# [Scene]
```

Codifica VRML

```
NavigationInfo {
  headlight FALSE
  type [ "EXAMINE" "ANY" ]
}
Group {
  children [
    DEF SceneLight DirectionalLight {
      ambientIntensity .7
      direction 1 -1 -1
      intensity .3
    }
    DEF VRML: Transform {
      translation -5 0 0
      children [
        DEF vrmlTouch TouchSensor {
        }
        DEF char_V Transform {
          translation 1.416 -.291 0
          children [
            Inline {
              url [ "letter_V.wrl" ]
            }
          ]
        }
```

```
        DEF char_R Transform {
          translation 1.946 -.048 0
          children [
            Inline {
              url [ "letter_R.wrl" ]
            }
          ]
        }
        Transform {
          translation 2.621 -.048 0
          children [
            Inline {
              url [ "letter_m.wrl" ]
            }
          ]
        }
        Transform {
          translation 4.042 -.048 0
          children [
            Inline {
              url [ "letter_L.wrl" ]
            }
          ]
        }
      ]
    }
```

Codifica VRML

```
DEF Objects3D Transform {
      translation .30927 .22571 0
      children [
        DEF ShapeTouch TouchSensor {
        }
        DEF Box Transform {
          children [
            Transform {
              rotation .809 -.588 0 .765
              translation .291 0 0
              children [
                Shape {
                  appearance Appearance
{
                    material Material {
                      diffuseColor 1 0 0
                    }
                  }
                  geometry Box {
                    size .6 .6 .6
                  }
                }
              ]
            }
          ]
        }
```

```
DEF Sphere Transform {
          children [
            Transform {
              translation 1.278 0 0
              children [
                Shape {
                  appearance Appearance {
                    material Material {
                      ambientIntensity .4
                      diffuseColor .16863 .57647 .17647
                      shininess .9
                      specularColor .32549 .8 .33725
                    }
                  }
                  geometry Sphere {
                    radius .4
                  }
                }
              ]
            }
          ]
        }
```

Codifica VRML

```
DEF Cone Transform {
          children [
            Transform {
              rotation .772 -.636 0 1.349
              translation 2.0701 .21047 0
              children [
                Shape {
                  appearance Appearance {
                    material Material {
                      ambientIntensity .4
                      diffuseColor .45882 .45882 1
                      shininess .9
                      specularColor .70196 .70196 1
                    }
                  }
                  geometry Cone {
                    bottomRadius .4
                    height .8
                  }
                }
              ]
            }
          ]
        }
      ]
    }
  ]
}
```

Codifica VRML

```
DEF LightTimer TimeSensor {
  cycleInterval 10
  startTime 1
}
DEF Brightness ScalarInterpolator {
  key [ 0 1 ]
  keyValue [ .3 1 ]
}
ROUTE vrmlTouch.touchTime TO LightTimer.startTime
ROUTE LightTimer.fraction_changed
      TO Brightness.set_fraction
ROUTE Brightness.value_changed TO SceneLight.intensity
DEF MoveTimer TimeSensor {
  cycleInterval 2
  loop TRUE
  stopTime 1
}
#
# ******* Create object animation
#
DEF TossBox PositionInterpolator {
  key [ 0 .1 .2 .25 .3 .4 .5 .6 .7 .75 .8 .9 1 ]
  keyValue [ 0 1 0, 0 1.59 0, 0 1.95 0, 0 2 0, 0 1.95 0,
0 1.59 0, 0 1 0, 0 .41 0, 0 .05 0, 0 0 0, 0 .05 0, 0 .41 0, 0 1 0 ]
}
DEF TossSphere PositionInterpolator {
  key [ 0 .1 .2 .3 .4 .45 .5 .6 .7 .8 .9 .95 1 ]
  keyValue [ 0 1.95 0, 0 1.59 0, 0 1 0, 0 .41 0, 0 .05 0, 0 0 0,
0 .05 0, 0 .41 0, 0 1 0, 0 1.59 0, 0 1.95 0, 0 2 0, 0 1.95 0 ]
}
```

```
DEF TossCone PositionInterpolator {
  key [ 0 .05 .1 .2 .3 .4 .5 .55 .6 .7 .8 .9 1 ]
  keyValue [ 0 .05 0, 0 0 0, 0 .05 0, 0 .41 0,
             0 1 0, 0 1.59 0, 0 1.95 0,
           0 2 0, 0 1.95 0, 0 1.59 0, 0 1 0,
             0 .41 0, 0 .05 0 ]
}
ROUTE ShapeTouch.touchTime
                      TO MoveTimer.startTime
ROUTE MoveTimer.fraction_changed
                      TO TossBox.set_fraction
ROUTE MoveTimer.fraction_changed
                      TO TossSphere.set_fraction
ROUTE MoveTimer.fraction_changed
                      TO TossCone.set_fraction
ROUTE TossBox.value_changed
                      TO Box.translation
ROUTE TossSphere.value_changed
                      TO Sphere.translation
ROUTE TossCone.value_changed
                      TO Cone.translation
```

Tipi / codifica MIME

X3D encoding	File extension	MIME type
Classic VRML	`.x3dv`	model/x3d+vrml
XML	`.x3d`	model/x3d+xml
Binary	`.x3db`	model/x3d+binary

Aggiungere nel f le .htaccess del server Web le seguenti istruzioni:

```
AddType model/x3d+xml .x3d
AddType model/x3d+vrml .x3dv
AddType model/x3d+binary .x3db
AddEncoding gzip .x3dvz
AddEncoding gzip .x3dbz AddType model/x3d+xml .x3d
AddType model/x3d+vrml .x3dv
AddType model/x3d+binary .x3db
AddEncoding gzip .x3dvz
AddEncoding gzip .x3dbz
```

Principi XML per X3D

- Document Structure
- XML Tags
- X3D Elements
- Xeena

Struttura del documento

- I Tag sono Case SeNsItiVe
- I Tag devono essere chiusi
  - <Tag> … </Tag>
  - <Tag />
- Gli attributi sono contenuti entro apici (“ o ‘)
- Dichiarazioni XML
- Document Type Def nitions (DTD) Statement
- Root Tag

XML Tags

- XML Declaration
  - <?xml version="1.0" encoding="UTF-8"?>
- Document Type Def nition Statement
  - <!DOCTYPE X3D PUBLIC "http://www.web3D.org/TaskGroups/x3d/translation/x3d-draft.dtd" "f le://localhost/C:/www.web3D.org/TaskGroups/x3d/translation/x3d-draft.dtd" >
- Root Tag
  - <X3D>
- Tag aggiuntivi (3D Nodes)
  - <Tag attr1=“value1” attr2=“value2”…>content</Tag>

X3D Elements

- DTD
  - http://www.web3D.org/TaskGroups/x3d/translation/x3d-draft.dtd
    file://localhost/C:/www.web3D.org/TaskGroups/x3d/translation/x3d-draft.dtd
  - Definisce I nodi e campi permessi
- Non-Node Tags
  - <X3D>: Root Tag of X3D Content
  - <Header>: X3D Meta-data
  - <Meta>: Individual Meta-datum
  - <Scene>: Scene Graph Description
- Field References
  - Verifica del tipo di campi.

Scene Access Interface (SAI)

- Permette di interagire con il mondo X3D dall'esterno, modif cando il mondo stesso (funzione analoga all'EAI per VRML)
- Può essere utilizzata anche dall'interno del mondo. Una script SAI interna deve implementare l'interfaccia **X3DScriptionImplementation**
- Questa interfaccia implementa i seguenti metodi:

void **eventsProcessed**()
Notif ca che tutti gli eventi sono stati elaborati.

void **initialize**()
Notif ca che la script ha terminato il setup e procede alla propria inizializzazione.

void **setBrowser** (Browser browser)
Attiva l'interfaccia browser allo script.

void **setFields**(X3DScriptNode externalView, java.util.Map fields)
Def nisce la lista di campi attivati per questo nodo Script.

void **shutdown**()
Notif ca che lo Script non è più in uso, per cui rilascia tutte le risorse

Scene Access Interface (SAI) (ii)

- Questi metodi vengono chiamati al momento opportuno nel mondo X3D
- Nell'esempio viene definita l'interfaccia seguente al programma script:

```
DEF S Script {

inputOnly SFTime pulse

outputOnly SFVec3f location

outputOnly SFRotation orientation

url [ "MoveObjectScript.class" ] }
```

X3D Core Node Reference

Proprietà di base

- L’insieme dei nodi Core X3D è un sottoinsieme del VRML

Shape

```
<!ATTLIST Shape
     DEF  ID     #IMPLIED
     USE  IDREF  #IMPLIED>
```

Può contenere:

- Appearance, Box, Cone, Cylinder, Sphere, Text, IndexedFaceSet, IndexedLineSet, PointSet

XML Syntax (.x3d)

```
<Shape DEF="MyShapeNode"
bboxCenter="0 0 0"
bboxSize="-1 -1 -1">
<Box DEF="SingleGeometryNode"/>
<Appearance
DEF="SingleAppearanceNode"/>
</Shape>
```

Classic VRML Syntax (.x3dv)

```
DEF MyShapeNode Shape {
   geometry DEF SingleGeometryNode
                                  Box { }
   appearance DEF SingleAppearanceNode
                                  Appearance { }
bboxCenter 0 0 0
bboxSize -1 -1 -1
}
```

Appearance

```
<!ATTLIST Appearance
     DEF ID     #IMPLIED
     USE IDREF  #IMPLIED>
```

Può contenere:

Material, ImageTexture, FillProperties, LineProperties

XML Syntax (.x3d)

```
<Appearance DEF="MyAppearanceNode"
 <FillProperties filled="true"  hatched="true"
   hatchColor="1 1 1" hatchStyle="1"  />
 <LineProperties linetype="1"
                 linewidthScaleFactor="1.0"/>
 <Material DEF="MyMaterial"
   diffuseColor="0 0.6 0.6" shininess="0.2" />
 <ImageTexture DEF="EarthImage"
   url="earth-topo.png" />
 <TextureTransform rotation="0.78" />
</Appearance>
```

Classic VRML Syntax (.x3dv)

```
Appearance {
  fillProperties FillProperties {
      filled= TRUE  hatched TRUE
   hatchColor 1 1 1 hatchStyle 1 }
  lineProperties LineProperties {
     linetype 1  linewidthScaleFactor 1.0  }
  material DEF MyMaterial Material {
    diffuseColor 0 0.6 0.6 shininess 0.2}
  texture DEF EarthImage ImageTexture {
  url ["earth-topo.png"}  }
  textureTransform TextureTransform {
     rotation 0.78   }
}
```

Material

```
<!ATTLIST Material
    diffuseColor     %SFColor;    "0.8 0.8 0.8"
    emissiveColor    %SFColor;    "0 0 0"
    specularColor    #SFColor;    "0 0 0"
    shininess        %SFFloat;    "0.2"
    ambientintensity #SFFloat;    "0.2"
    transparency     %SFFloat;    "0"
    DEF  ID     #IMPLIED
    USE  IDREF  #IMPLIED>
```

Non è un nodo contenitore

XML Syntax (.x3d)

```
<Material DEF="MyMaterial"
  diffuseColor="0.8 0.8 0.8" shininess="0.2"
  emissiveColor="0 0 0" specularColor="0 0 0"
  transparency="0" ambientIntensity="0.2"
  containerField="material"   />
```

Classic VRML Syntax (.x3dv)

```
    DEF MyMaterial Material {
    diffuseColor 0.8 0.8 0.8 shininess 0.2
    emissiveColor 0 0 0 specularColor 0 0 0
    transparency 0  ambientIntensity 0.2
}
```

Pellucid material editor:
http://www.acm.org/tog/resources/applets/vrml/pellucid.html

Group

```
<!ATTLIST Group
    bboxCenter    %SFVec3f; "0 0 0"
    bboxSize      %SFVec3f; "-1 -1 -1"
    DEF ID     #IMPLIED
    USE IDREF #IMPLIED>
```

- Può contenere:
  - CoordinateInterpolator, OrientationInterpolator , PositionInterpolator, ScalarInterpolator, TimeSensor, TouchSensor; Background, NavigationInfo, Viewpoint; Anchor, Group, Inline, Transform; DirectionalLight, Shape, WorldInfo

Group

XML Syntax (.x3d)

```
<Group DEF="MyGroupNode"
  bboxSize="-1 -1 -1"
  bboxCenter="0 0 0"
  <Shape />
</Group>
```

Classic VRML Syntax (.x3dv)

```
DEF MyGroupNode Group {
   bboxSize -1 -1 -1
   bboxCenter 0 0 0
   children{Shape{}]
}
```

Transform

```
<!ATTLIST Transform
    center           %SFVec3f;     "0 0 0"
    rotation         %SFRotation;  "0 0 1 0"
    scale            %SFVec3f;     "1 1 1"
    scaleOrientation %SFRotation;  "0 0 1 0"
    translation      %SFVec3f;     "0 0 0"
    bboxCenter       %SFVec3f;     "0 0 0"
    bboxSize         %SFVec3f;     "-1 -1 -1"
    DEF ID     #IMPLIED
    USE IDREF  #IMPLIED >
```

Può contenere:

CoordinateInterpolator, OrientationInterpolator , PositionInterpolator, ScalarInterpolator, TimeSensor, TouchSensor; Background, NavigationInfo, Viewpoint; Anchor, Group, Inline, Transform; DirectionalLight, Shape, WorldInfo

Transform

XML Syntax (.x3d)

```
<Transform DEF="MyTransformNode"
  translation="0 0 0 "
  rotation="0 0 1 0"
  center="0 0 0" scale="1 1 1"
  scaleOrientation="0 0 1 0"
  bboxCenter="0 0 0"
  bboxSize="-1 -1 -1">
    <Group/>
</Transform>
```

Classic VRML Syntax (.x3dv)

```
  DEF MyTransformNode Transform {
  translation 0 0 0
  rotation 0 0 1 0
  center 0 0 0  scale 1 1 1
  scaleOrientation 0 0 1 0
  bboxCenter 0 0 0
  bboxSize -1 -1 -1
    children [ Group { } ]
}
```

Inline

```
<!ATTLIST Inline
    url           %MFString;  NULL      #IMPLIED

    load          %SFBool     TRUE
    bboxCenter    %SFVec3f;   "0 0 0"
    bboxSize      %SFVec3f;   "-1 -1 -1"
    DEF  ID     #IMPLIED
    USE  IDREF  #IMPLIED>
```

Può contenere:

CoordinateInterpolator, OrientationInterpolator , PositionInterpolator, ScalarInterpolator, TimeSensor, TouchSensor; Background, NavigationInfo, Viewpoint; Anchor, Group, Inline, Transform; DirectionalLight; WorldInfo; ROUTE

Inline

XML Syntax (.x3d)

```
<Inline DEF="MyInlineNode"
  url=' "HelloWorld.x3d"
        "http://my.site.com/HelloWorld.x3d" '
  load="true"
  rotation="0 0 1 0"
  bboxCenter="0 0 0"
  bboxSize="-1 -1 -1">
```

Classic VRML Syntax (.x3dv)

```
  DEF MyInlineNode Inline {
  url [ "HelloWorld.x3d"
       "http://my.site.com/HelloWorld.x3d"]
  load TRUE
  rotation 0 0 1 0
  bboxCenter 0 0 0
  bboxSize -1 -1 -1
}
```

Anchor

```
<!ATTLIST Anchor
      url           %MFString;   #IMPLIED
      bboxCenter    %SFVec3f;    "0 0 0”
      bboxSize      %SFVec3f;    "-1 -1 -1”
      DEF           ID           #IMPLIED
      USE           IDREF        #IMPLIED>
```

Può contenere:

CoordinateInterpolator, OrientationInterpolator, PositionInterpolator, ScalarInterpolator, TimeSensor, TouchSensor; Background, NavigationInfo, Viewpoint; Anchor, Group, Inline, Transform; DirectionalLight, Shape, WorldInfo

XML Syntax (.x3d)

```
 <Anchor DEF='AnchorExample'
description='Aquarium Exhibit Web Site'
parameter='"target=_blank"'
Url=' "http://www.mbayaq.org/efc/kelp.asp" '>
<Shape>
….
</Anchor>
```

Classic VRML Syntax (.x3dv)

```
  DEF AnchorExample Anchor {
        description "Aquarium Exhibit Web Site"
        parameter [ "target=_blank" ]
        url
[ "http://www.mbayaq.org/efc/kelp.asp" ]
        children [
            Shape { ..
}
```

Background

```
<!ATTLIST Background
          bottomUrl  %MFString;   #IMPLIED
          skyAngle   %MFFloat;    #IMPLIED
          skyColor   %SFColor;    "0 0 0"
          set_bind   %SFBool;     "false"
          bindTime   %SFTime;     "-1"
          isBound    %SFBool;     "false"
          DEF     ID     #IMPLIED
          USE     IDREF  #IMPLIED >
```

TextureBackground

```
<!ATTLIST Background
          bottomUrl  %MFString;  #IMPLIED
          skyAngle   %MFFloat;   #IMPLIED    inputOutput
          skyColor   %SFColor;   "0 0 0"     inputOutput
          groundAngle %MFFloat; #IMPLIED    inputOutput
          groundColor %SFColor; "0 0 0"     inputOutput
                        transparency %MFFloat; "0"
  inputOutput                    set_bind  %SFBool;    "false"
    inputOnly
          bindTime   %SFTime;    "-1"         outputOnly
          isBound    %SFBool;    "false"      outputOnly
          DEF     ID     #IMPLIED
          USE     IDREF  #IMPLIED >
```

- Non è un nodo contenitore

Color

```
<!ATTLIST Color
    color   %MFColor;    #IMPLIED
    DEF ID          #IMPLIED
    USE IDREF       #IMPLIED>
```

- Non è un nodo contenitore

Coordinate

- ```
  <!ATTLIST Coordinate
    point      %MFVec3f;    #IMPLIED
    DEF  ID    #IMPLIED
    USE  IDREF #IMPLIED>
  ```
- Non è un nodo contenitore
  ```

CoordinateInterpolator

```
<!ATTLIST CoordinateInterpolator
    set_fraction %SFFloat;   "0"
    key          %MFFloat;   #IMPLIED
    keyValue     %MFVec3f;   #IMPLIED
    value_changed    %MFVec3f;   "0 0 0"
    DEF  ID          #IMPLIED
    USE  IDREF       #IMPLIED>
```

- Non è un nodo contenitore

DirectionalLight

```
<!ATTLIST DirectionalLight
    color      %SFColor;   "1 1 1"
    direction  %SFVec3f;   "0 0 -1"
    intensity  %SFFloat;   "1"
    on         %SFBool; "true"
    DEF  ID       #IMPLIED
    USE  IDREF    #IMPLIED>
```

- Non è un nodo contenitore

ImageTexture

```
<!ATTLIST ImageTexture
    url         %MFString;  #IMPLIED
    repeatS     %SFBool; "true”
    repeatT     %SFBool; "true”
    DEF ID      #IMPLIED
    USE IDREF #IMPLIED>
```

- Non è un nodo contenitore

NavigationInfo

```
<!ATTLIST NavigationInfo
    headlight     %SFBool; "true”
    set_bind      %SFBool; "false”
    bindTime      %SFTime; “-1”
    isBound       %SFBool; "false”
    DEF  ID     #IMPLIED
    USE  IDREF  #IMPLIED>
```

Non è un nodo contenitore

OrientationInterpolator

```
<!ATTLIST OrientationInterpolator
    set_fraction %SFFloat;   "0"
    key          %MFFloat;   #IMPLIED
    keyValue     %MFRotation;   #IMPLIED
    value_changed %SFRotation;  "0 0 1 0"
    DEF  ID      #IMPLIED
    USE  IDREF   #IMPLIED>
```

- Genera valori interpolati di assi di rotazione

PointSet

```
<!ATTLIST PointSet
    pointSize    %SFFloat;   "1.0"
    DEF  ID      #IMPLIED
    USE  IDREF   #IMPLIED>
```

- Può contenere:
  - Color, Coordinate

PositionInterpolator

```
<!ATTLIST PositionInterpolator
    set_fraction %SFFloat;    "0”
    key          %MFFloat;    #IMPLIED
    keyValue     %MFVec3f;    #IMPLIED
    value_changed %SFVec3f;   "0 0 0”
    DEF  ID      #IMPLIED
    USE  IDREF   #IMPLIED>
```

- Genera valori interpolati di vettori 3D

PositionInterpolator2D

```
<!ATTLIST PositionInterpolator2D
    set_fraction    %SFFloat;   "0”
    key             %MFFloat;   #IMPLIED
    keyValue        %MFVec2f;   #IMPLIED
    value_changed  %SFVec2f;  "0 0”
    DEF  ID     #IMPLIED
    USE  IDREF  #IMPLIED>
```

- Genera valori interpolati di vettori 2D

ScalarInterpolator

```
<!ATTLIST ScalarInterpolator
    set_fraction %SFFloat;   "0”
    key          %MFFloat;   #IMPLIED
    keyValue     %MFFloat;   #IMPLIED
    value_changed %SFFloat;  "0”
    DEF  ID      #IMPLIED
    USE  IDREF   #IMPLIED>
```

- Genera valori interpolati di numeri reali

StringSensor

```
<!ATTLIST StringSensor
    deletionAllowed %SFBool;    “true”   inputOutput
    enabled         %SFBool;    "true”   inputOutput
    enteredText     %SFString;  ""       outputOnly
    finalText       %SFSTring;  ""       outputOnly
    isActive        %SFBool;    "false”  outputOnly
    DEF  ID     #IMPLIED
    USE  IDREF  #IMPLIED>
```

- Genera eventi quando l’utente digita un tasto

TimeSensor

```
<!ATTLIST TimeSensor
    cycleInterval    %SFTime;  "1.0”
    enabled          %SFBool;  "true”
    loop             %SFBool;  "false”
    startTime        %SFTime;  "0”
    stopTime         %SFTime;  "0”
    cycleTime        %SFTime;  "0”
    fraction_changed %SFFloat;  "0”
    isActive         %SFBool;  "false”
    time             %SFTime;  "0”
    DEF  ID     #IMPLIED
    USE  IDREF  #IMPLIED>
```

- Non è un nodo contenitore

TouchSensor

```
<!ATTLIST TouchSensor
    enabled       %SFBool;  "true"
    hitNormal     %SFVec3f; "0 0 1"
    hitPoint      %SFVec3f; "0 0 0"
    hitTexCoord   %SFVec2f; "0 0"
    isActive      %SFBool;  "false"
    isOver        %SFBool;  "false"
    touchTime     %SFTime;  "0"
    DEF  ID     #IMPLIED
    USE  IDREF  #IMPLIED>
```

- Non è un nodo contenitore

Viewpoint

```
<!ATTLIST Viewpoint
    fieldOfView      %SFFloat;     "0.785398"
     jump            %SFBool;      "true"
     orientation     %SFRotation;  "0 0 1 0"
     position        %SFVec3f;     "0 0 10"
     description     %SFString;    #IMPLIED
     set_bind        %SFBool;      "false"
     bindTime        %SFTime;      "-1"
     isBound         %SFBool;      "false"
     examine         %SFVec3f;     "0 0 0"
     DEFID     #IMPLIED
     USEIDREF  #IMPLIED>
```

- Non è un nodo contenitore

WorldInfo

```
<!ATTLIST WorldInfo
    info       %MFString;   #IMPLIED
     title     %SFString;   #IMPLIED
     DEF ID    #IMPLIED
     USE IDREF #IMPLIED>
```

- Non è un nodo contenitore

IndexedFaceSet

```
<!ATTLIST IndexedFaceSet
     ccw                %SFBool;   "true"
     colorIndex         %MFInt32; #IMPLIED
     colorPerVertex %SFBool;   "true"
     convex             %SFBool;   #FIXED    "true"
     coordIndex         %MFInt32; #IMPLIED
     creaseAngle    %SFFloat; "0"
     normalPerVertex    %SFBool;   "true"
     solid              %SFBool;   "true"
     texCoordIndex  %MFInt32; #IMPLIED
     DEF   ID      #IMPLIED
     USE   IDREF   #IMPLIED>
```

Es: (codifica XML (.x3d)

```
<Shape>

    <Appearance>
       <Material/>
       <PixelTexture image='2 2 3 0xFF0000 0xFFFF00 0xFFFF00 0xFF0000'/>
    </Appearance>
    <IndexedFaceSet colorPerVertex='false' creaseAngle='0.5'
        coordIndex='0 1 3 2 -1 4 5 7 6 -1 6 7 1 0 -1 2 3 5 4 -1 6 0 2 4 -1 1 7 5 3 -1'>
    <Color color='1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0'/>
     <Coordinate
        point='-2 1.5 1 -2 -1.5 1 2 1.5 1 2 -1.5 1 2 1.5 -1 2 -1.5 -1 -2 1.5 -1 -2 -1.5 -1'/>
    </IndexedFaceSet>
</Shape>
```

IndexedFaceSet

Es: (codifica classicVRML (.x3dv)

```
Shape {

   appearance Appearance {
        texture PixelTexture {
             image 2 2 3 0xFF0000 0xFFFF00 0xFFFF00 0xFF0000 }

              }

   geometry IndexedFaceSet {
         colorPerVertex FALSE
        creaseAngle 0.5
        coordIndex [ 0 1 3 2 -1 4 5 7 6 -1 6 7 1 0 -1 2 3 5 4 -1 6 0 2 4 -1 1 7 5 3 -1 ]
        color Color {
              color [ 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 ]  }
         coord Coordinate {
         point [-2 1.5 1  -2 -1.5 1  2 1.5 1  2 -1.5 1  2 1.5 -1  2 -1.5 -1  -2 1.5 -1  -2 -1.5 -1' ] }
         }
}
```

IndexedLineSet

```
<!ATTLIST IndexedLineSet
    colorIndex       %MFInt32;   #IMPLIED
    colorPerVertex   %SFBool; "true"
    coordIndex       %MFInt32;   #IMPLIED
    lineWidth        %SFFloat;   "1.0"
    DEF  ID     #IMPLIED
    USE  IDREF  #IMPLIED>
```

- Può contenere:
  - Color, Coordinate
  - CoordinateInterpolator, OrientationInterpolator , PositionInterpolator, ScalarInterpolator, TimeSensor, TouchSensor; Background, NavigationInfo, Viewpoint; Anchor, Group, Inline, Transform; DirectionalLight; WorldInfo; ROUTE

IndexedLineSet

Es:

```
<Appearance>
  <Material emissiveColor='1 0 0'/>
</Appearance>

<IndexedLineSet coordIndex='0 1 2 -1 2 1 3 -1 2 3 4 -1 4 3 5 -1 4 5 6 -1 6 5 7 -1 6 7 8 -1 8 7 9 -1 8 9 10 -1 1 11 3 -1 3 11 12 -1 3 12 5
     -1 5 12 13 -1 5 13 7 -1 7 13 14 -1 7 14 9 -1 11 15 12 -1 12 15 16 -1 12 16 13 -1 13 16 17 -1 13 17 14 -1 15 18 16 -1 16 18 19 -1 16
     19 17 -1 19 18 20 -1 10 9 21 -1 21 9 22 -1 21 22 23 -1 23 22 24 -1 23 24 25 -1 25 24 26 -1 25 26 27 -1 27 26 28 -1 27 28 29 -1 9 14
     22 -1 22 14 30 -1 22 30 24 -1 24 30 31 -1 24 31 26 -1 26 31 32 -1 26 32 28 -1 14 17 30 -1 30 17 33 -1 30 33 31 -1 31 33 34 -1 31 34
     32 -1 17 19 33 -1 33 19 35 -1 33 35 34 -1 35 19 20 -1 10 36 8 -1 8 36 37 -1 8 37 6 -1 6 37 38 -1 6 38 4 -1 4 38 39 -1 4 39 2 -1 2 39
     40 -1 2 40 0 -1 36 41 37 -1 37 41 42 -1 37 42 38 -1 38 42 43 -1 38 43 39 -1 39 43 44 -1 39 44 40 -1 41 45 42 -1 42 45 46 -1 42 46
     43 -1 43 46 47 -1 43 47 44 -1 45 48 46 -1 46 48 49 -1 46 49 47 -1 49 48 50 -1 29 51 27 -1 27 51 52 -1 27 52 25 -1 25 52 53 -1 25 53
     23 -1 23 53 54 -1 23 54 21 -1 21 54 36 -1 21 36 10 -1 51 55 52 -1 52 55 56 -1 52 56 53 -1 53 56 57 -1 53 57 54 -1 54 57 41 -1 54 41
     36 -1 55 58 56 -1 56 58 59 -1 56 59 57 -1 57 59 45 -1 57 45 41 -1 58 60 59 -1 59 60 48 -1 59 48 45 -1 48 60 50 -1 61 62 63 -1 63 62
     64 -1 63 64 65 -1 65 64 66 -1 65 66 67 -1 67 66 68 -1 67 68 69 -1 69 68 1 -1 69 1 0 -1 62 70 64 -1 64 70 71 -1 64 71 66 -1 66 71 72
     -1 66 72 68 -1 68 72 11 -1 68 11 1 -1 70 73 71 -1 71 73 74 -1 71 74 72 -1 72 74 15 -1 72 15 11 -1 73 75 74 -1 74 75 18 -1 74 18 15
     -1 18 75 20 -1 29 28 76 -1 76 28 77 -1 76 77 78 -1 78 77 79 -1 78 79 80 -1 80 79 81 -1 80 81 82 -1 82 81 62 -1 82 62 61 -1 28 32 77
     -1 77 32 83 -1 77 83 79 -1 79 83 84 -1 79 84 81 -1 81 84 70 -1 81 70 62 -1 32 34 83 -1 83 34 85 -1 83 85 84 -1 84 85 73 -1 84 73 70
     -1 34 35 85 -1 85 35 75 -1 85 75 73 -1 75 35 20 -1 0 40 69 -1 69 40 86 -1 69 86 67 -1 67 86 87 -1 67 87 65 -1 65 87 88 -1 65 88 63
     -1 63 88 89 -1 63 89 61 -1 40 44 86 -1 86 44 90 -1 86 90 87 -1 87 90 91 -1 87 91 88 -1 88 91 92 -1 88 92 89 -1 44 47 90 -1 90 47 93
     -1 90 93 91 -1 91 93 94 -1 91 94 92 -1 47 49 93 -1 93 49 95 -1 93 95 94 -1 95 49 50 -1 61 89 82 -1 82 89 96 -1 82 96 80 -1 80 96 97
     -1 80 97 78 -1 78 97 98 -1 78 98 76 -1 76 98 51 -1 76 51 29 -1 89 92 96 -1 96 92 99 -1 96 99 97 -1 97 99 100 -1 97 100 98 -1 98
     100 55 -1 98 55 51 -1 92 94 99 -1 99 94 101 -1 99 101 100 -1 100 101 58 -1 100 58 55 -1 94 95 101 -1 101 95 60 -1 101 60 58 -1 60
     95 50 -1'>
<Coordinate point='1 0 0 0.970142 0.242536 0 0.970142 0 0.242536 0.904534 0.301511 0.301511 0.83205 0 0.5547 0.666667 0.333333
     0.666667 0.5547 0 0.83205 0.301511 0.301511 0.904534 0.242536 0 0.970142 0 0 0.242536 0.970142 0 0 1 0.83205 0.5547 0 0.666667
     0.666667 0.333333 0.333333 0.666667 0.666667 0 0.5547 0.83205 0.5547 0.83205 0 0.301511 0.904534 0.301511 0 0.83205 0.5547
     0.242536 0.970142 0 0 0.970142 0.242536 0 1 0 -0.242536 0 0.970142 -0.301511 0.301511 0.904534 -0.5547 0 0.83205 -0.666667
     0.333333 0.666667 -0.83205 0 0.5547 -0.904534 0.301511 0.301511 -0.970142 0 0.242536 -0.970142 0.242536 0 -1 0 0 -0.333333
     0.666667 0.666667 -0.666667 0.666667 0.333333 -0.83205 0.5547 0 -0.301511 0.904534 0.301511 -0.5547 0.83205 0 -0.242536
     0.970142 0 0 -0.242536 0.970142 0.301511 -0.301511 0.904534 0.666667 -0.333333 0.666667 0.904534 -0.301511 0.301511 0.970142
     -0.242536 0 0 -0.5547 0.83205 0.333333 -0.666667 0.666667 0.666667 -0.666667 0.333333 0.83205 -0.5547 0 0 -0.83205 0.5547
     0.301511 -0.904534 0.301511 0.5547 -0.83205 0 0 -0.970142 0.242536 0.242536 -0.970142 0 0 -1 0 -0.970142 -0.242536 0 -0.904534
     -0.301511 0.301511 -0.666667 -0.333333 0.666667 -0.301511 -0.301511 0.904534 -0.83205 -0.5547 0 -0.666667 -0.666667 0.333333
     -0.333333 -0.666667 0.666667 -0.5547 -0.83205 0 -0.301511 -0.904534 0.301511 -0.242536 -0.970142 0 0 0 -1 0 0.242536 -0.970142
     0.242536 0 -0.970142 0.301511 0.301511 -0.904534 0.5547 0 -0.83205 0.666667 0.333333 -0.666667 0.83205 0 -0.5547 0.904534
     0.301511 -0.301511 0.970142 0 -0.242536 0 0.5547 -0.83205 0.333333 0.666667 -0.666667 0.666667 0.666667 -0.333333 0 0.83205
     -0.5547 0.301511 0.904534 -0.301511 0 0.970142 -0.242536 -0.970142 0 -0.242536 -0.904534 0.301511 -0.301511 -0.83205 0 -0.5547
     -0.666667 0.333333 -0.666667 -0.5547 0 -0.83205 -0.301511 0.301511 -0.904534 -0.242536 0 -0.970142 -0.666667 0.666667
     -0.333333 -0.333333 0.666667 -0.666667 -0.301511 0.904534 -0.301511 0.904534 -0.301511 -0.301511 0.666667 -0.333333 -0.666667
     0.301511 -0.301511 -0.904534 0 -0.242536 -0.970142 0.666667 -0.666667 -0.333333 0.333333 -0.666667 -0.666667 0 -0.5547
     -0.83205 0.301511 -0.904534 -0.301511 0 -0.83205 -0.5547 0 -0.970142 -0.242536 -0.301511 -0.301511 -0.904534 -0.666667
     -0.333333 -0.666667 -0.904534 -0.301511 -0.301511 -0.333333 -0.666667 -0.666667 -0.666667 -0.666667 -0.333333 -0.301511
     -0.904534 -0.301511'/>
</IndexedLineSet>
```

IndexedLineSet

Es: codif ca ClassicVRML (.x3dv)

```
Shape {
appearance Appearance {
  material Material {emissiveColor 1 0 0 }
        }
geometry IndexedLineSet {
   coordIndex [ 0 1 2 -1 2 1 3 -1 2 3 4 -1 4 3 5 -1 4 5 6 -1 6 5 7 -1 6 7 8 -1 8 7 9 -1 8 9 10 -1 1 11 3 -1 3 11 12 -1 3 12 5 -1 5 12 13 -1
      5 13 7 -1 7 13 14 -1 7 14 9 -1 11 15 12 -1 12 15 16 -1 12 16 13 -1 13 16 17 -1 13 17 14 -1 15 18 16 -1 16 18 19 -1 16 19 17 -1 19
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      0.333333 0.333333 0.666667 0.666667 0 0.5547 0.83205 0.5547 0.83205 0 0.301511 0.904534 0.301511 0 0.83205 0.5547 0.242536
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