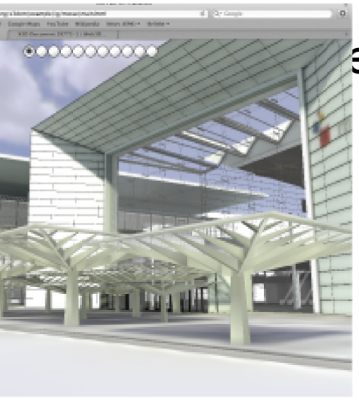
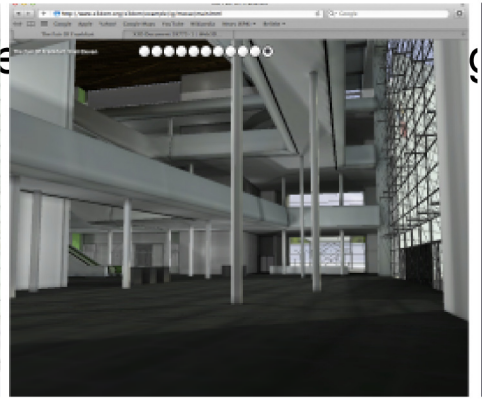
# Efficient Binary Meshes in X3DOM refined: Not just images anymore!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Fraunhofer IGD

W3C web|3D

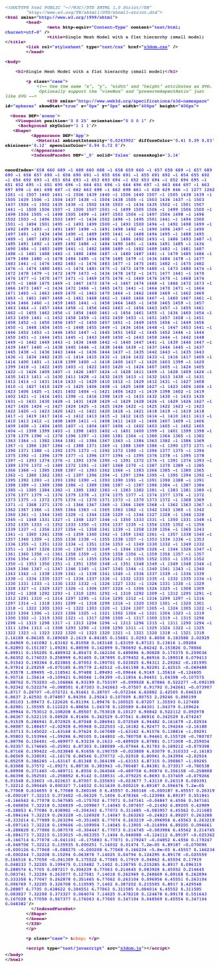
# Declarative (X)3D in HTML

## Embed a live scenegraph in the DOM

```
<!DOCTYPE html >
<html >
    <body>
      <h1>Hello X3DOM World</
       <x3d xmlns='...' profile='I
         <scene>
           <shape>
          <box></box>
           </shape>
         </scene>
       </x3d>
```

# Declarative (X)3D in HTML

## Large Datasets: Issue of the current approach



- Real 3D applications tend to be huge HTML-files
  - **Unpleasant** non-interactive **user experience**
    - Browser are not build to hold GByte of DOM attribute data (e.g. multiple data copies)
- Reference external sub-trees
  - X3D “Inline” node
  - black/white-box interface?
  - xml/json parser architecture
- Binary XML decompression

# DOM holds structure and data

```
<!DOCTYPE html>
<html>
  <head>
    <link rel='stylesheet' type='text/css' href='http://www.x3dom.org/x3dom/release/x3dom.css'></link>
    <script type='text/javascript' src='http://www.x3dom.org/x3dom/release/x3dom.js'></script>
  </head>
  <body>
    <x3d id='3dstuff' width='400px' height='400px'>
      <scene DEF='scene'>
        <shape>
          <appearance>
            <material diffuseColor='#FF0000'></material>
          </appearance>
          <indexedTriangleSet solid='false' index='0 1 2 1 3 2 1 4 3 5 4 1 0 5 1 0 6 5 6 7 5 5 7 4 7 8 4 7 9 8 7 6 9 6 10 9 10 11
9 10 2 11 10 0 2 6 0 10 11 2 3 8 11 3 4 8 3 11 8 9'>
            <coordinate point='0.447214 0 -0.894427 0.447214 0.850651 -0.276393 1 0 -0 0.447214 0.525731 0.723607 -0.447214
0.850651 0.276393 -0.447214 0.525731 -0.723607 -0.447214 -0.525731 -0.723607 -1 0 0 -0.447214 0 0.894427 -0.447214 -0.850651
0.276393 0.447214 -0.850651 -0.276393 0.447214 -0.525731 0.723607'></coordinate>
            <normal vector='0.447214 0 -0.894427 0.447214 0.850651 -0.276393 1 0 -0 0.447214 0.525731 0.723607 -0.447214 0.850651
0.276393 -0.447214 0.525731 -0.723607 -0.447214 -0.525731 -0.723607 -1 0 0 -0.447214 0 0.894427 -0.447214 -0.850651 0.276393
0.447214 -0.850651 -0.276393 0.447214 -0.525731 0.723607'></normal>
          </indexedTriangleSet>
        </shape>
      </scene>
    </x3d>
  </body>
</html>
```

# DOM holds structure and data

## More than 95% are usually unstructured data

```
<!DOCTYPE html>
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  <head>
    <link rel='stylesheet' type='text/css' href='http://www.x3dom.org/x3dom/release/x3dom.css'></link>
    <script type='text/javascript' src='http://www.x3dom.org/x3dom/release/x3dom.js'></script>
  </head>
  <body>
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          <appearance>
            <material diffuseColor='#FF0000'></material>
          </appearance>
          <indexedTriangleSet solid='false' index='0 1 2 1 3 2 1 4 3 5 4 1 0 5 1 0 6 5 6 7 5 5 7 4 7 8 4 7 9 8 7 6 9 6 10 9 10 11
9 10 2 11 10 0 2 6 0 10 11 2 3 8 11 3 4 8 3 11 8 9'>
            <coordinate point='0.447214 0 -0.894427 0.447214 0.850651 -0.276393 1 0 -0 0.447214 0.525731 0.723607 -0.447214
0.850651 0.276393 -0.447214 0.525731 -0.723607 -0.447214 -0.525731 -0.723607 -1 0 0 -0.447214 0 0.894427 -0.447214 -0.850651
0.276393 0.447214 -0.850651 -0.276393 0.447214 -0.525731 0.723607'></coordinate>
            <normal vector='0.447214 0 -0.894427 0.447214 0.850651 -0.276393 1 0 -0 0.447214 0.525731 0.723607 -0.447214 0.850651
0.276393 -0.447214 0.525731 -0.723607 -0.447214 -0.525731 -0.723607 -1 0 0 -0.447214 0 0.894427 -0.447214 -0.850651 0.276393
0.447214 -0.850651 -0.276393 0.447214 -0.525731 0.723607'></normal>
          </indexedTriangleSet>
        </shape>
      </scene>
    </x3d>
  </body>
</html>
```

# Mesh Container in X3DOM

Follow the generic X3DOM approach:

Evaluate the general "**Declarative 3D**" **use cases and requirements** while providing a prototype system which works on **todays W3C/JavaScript/WebGL layer**

**General Question**: What Container are useful in todays W3C technology stack to support the "Generic Requirements"

- binary
- regular structure
- fast transmission, decoding
- must map to GPU container/buffer

# “General Goals”

## Increased User experience

User does not have to wait until the document is loaded

## Increased Polygon count

From 0.3 Million to 10 Million Polygon

More data can be delivered in acceptable time

## Increased Communication speed

Incremental Updates (similar to jpeg decompression)

# Separate structure and data

## HTML element reference external binary data element

DOM / HTML Document

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN"
        "http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
        <head>
                <meta http-equiv="Content-Type" content="text/html;
charset=utf-8" />
                <title>Single Mesh Model with a flat hierarchy (small model)
</title>
        <link rel="stylesheet" type="text/css" href="x3dom.css" />
        </head>

<body>

    <h1>Single Mesh Model with a flat hierarchy (small model)</h1>

        <p class="case">
            <!-- Use the same "x", "y", "width" and "height" attributes as SVG.
             Optionally support the "viewBox" and "preserveAspectRatio" just
like SVG -->
                <X3D xmlns="http://www.web3d.org/specifications/x3d-namespace"
id="spheres" showStat="true" x="0px" y="0px" width="400px" height="400px">

  <Scene DEF='scene'>
    <Viewpoint position='0 0 25' orientation="0 0 0 1" />
    <Background skyColor='1 1 1'/>
   <Shape>
          <Appearance DEF='App'>
            <Material ambientIntensity='0.0243902' diffuseColor='0.41 0.39 0.03'
shininess='0.12' specularColor='0.94 0.72 0'/>
          </Appearance>
          <IndexedFaceSet DEF="_0" solid="true" creaseAngle="3.14
0.048382'/>
          </IndexedFaceSet>
        </Shape>
        </Scene>
        </X3D>
        </p>

        <p class="case">   </p>

        <script type="text/javascript" src="x3dom.js"></script>
</body>
</html>
```

Binary asset resources

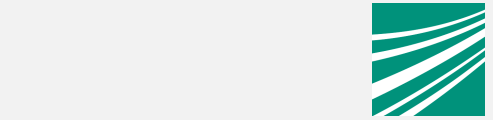
Images and Videos

- Encodes int/float arrays (e.g. coordinate, normal, texCoords, generic-attributes) in RGBA-images
- Multiple images per array
- Multiple images per scene

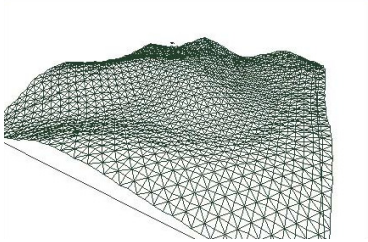
Explicit Binary Container

- Directly loaded to TypedArrays
- Data assignment in JS
- Multiple arrays per file
- Multiple files per scene

# 3D Geometry in Images

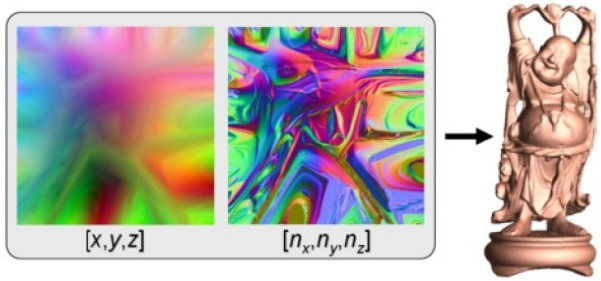


**HeightMap**



2D (semi)regular grid with 1D Height-Data

**Geometry Images** (Hoppe, Siggraph 2002)

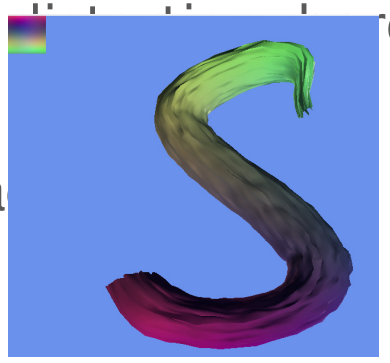



Surface usually irregular triangle mesh

=> Remeshing to (semi)regular grid

pro: up/down sampling operation

con: genus-zero surface, parametrization distortions, border-handling



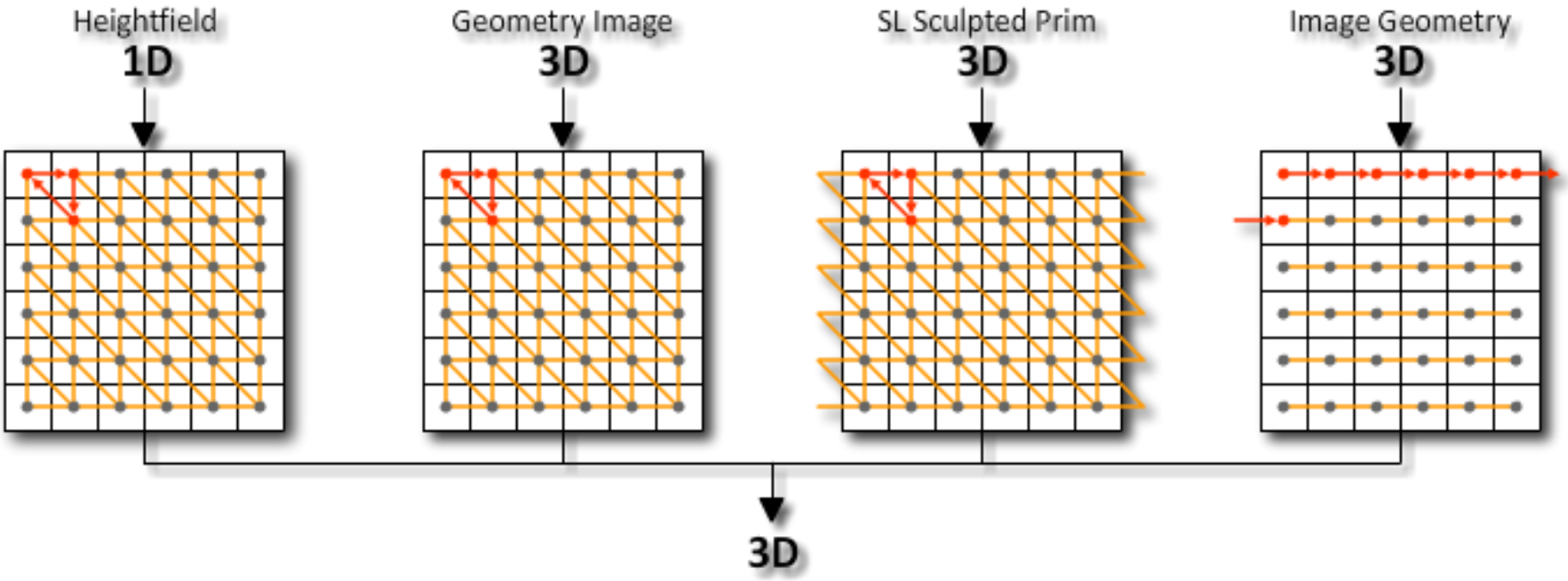
Latest development focus on multi-patch approaches, irregular structures

(see “Adaptive Quad patches” paper )

# Idea: Sequential Image Geometry



Implicit mesh does not correlate with the mesh topology



# <img>/<video> as generic binary container

Normalization and **linear Quantization** to 2^n Bytes: n is error/user controlled

Uses **multiple images** to distribute precision
( e.g. 1 Image -> 8bit, 2 images -> 16bit, ...)

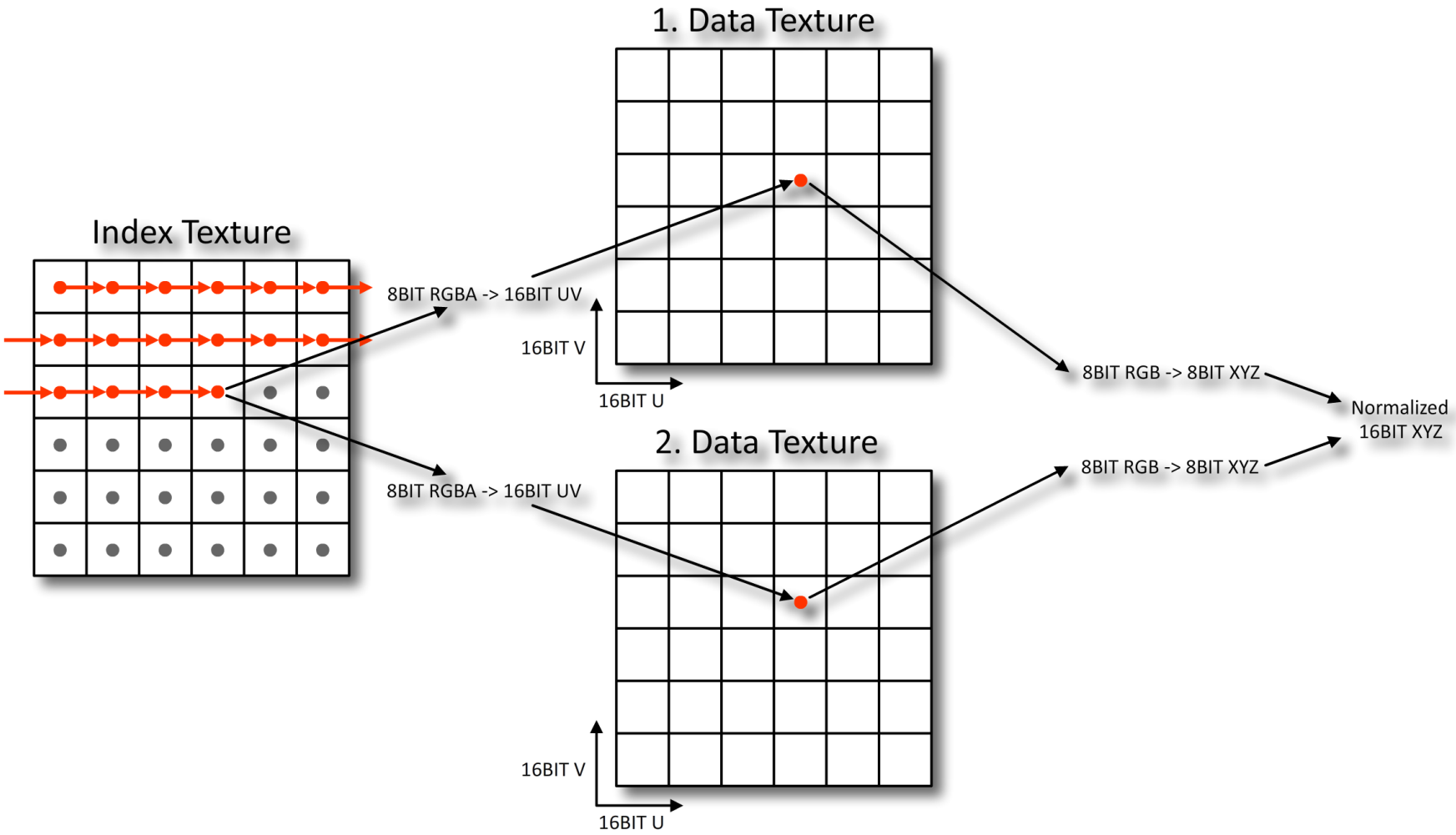
**LOD** and streaming of precision (e.g. closer objects use higher precision)

**Decompression** for free (only lossless png is useful right now )

**Streaming** updates for free: WebGL/X3DOM support <video>

Browser/Server well optimized to handle **large number of images and parallel downloads** of image => Great user experience

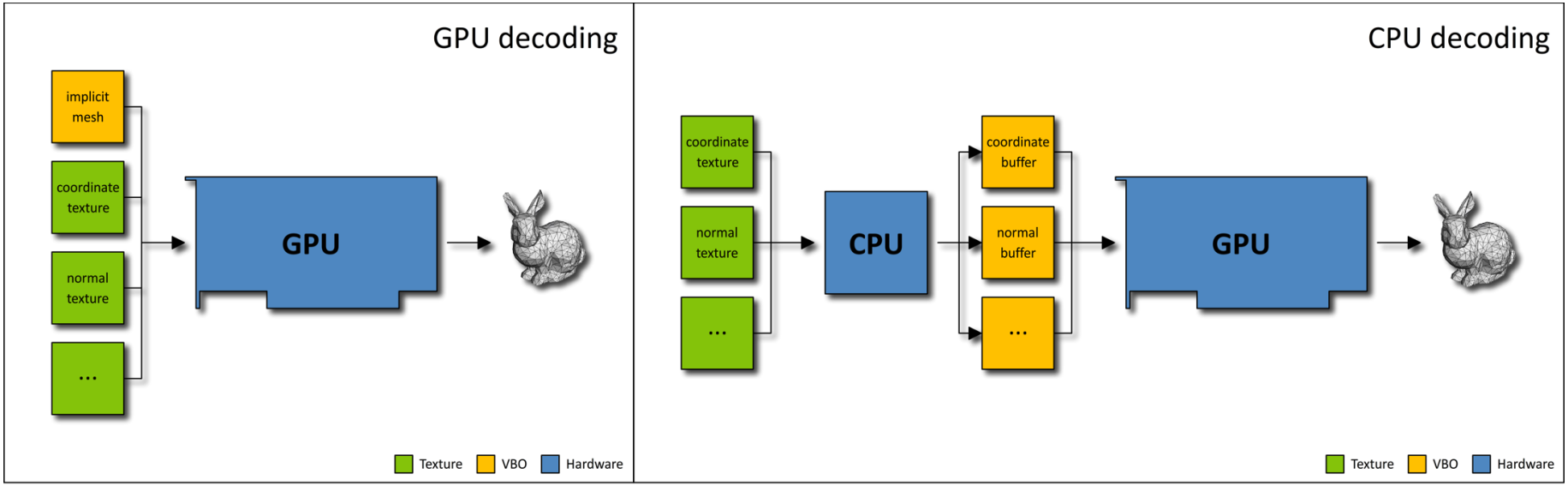
# Multi image vertex property encoding



# Data decoding and rendering

**GPU**: Single VBO, Extremely fast visualization with Vertex Textures Units, precision grows until vertex texture limit is reached

**CPU/GPU**: WebGL without Vertex Texture Unit support/ Flash 11



# Binary Container

Powerful abstraction for efficient data encoding for Web-apps

- Uses new **XHR ability to load binary ArrayBuffer**
- Maps to **TypedArray/GPU buffer**
- No **JS-Interaction for decoding**
- Could be used for RESTful mesh attribute access
  - e.g. http://meshLand.com/mesh/32/coordinate.bin
- Support **quantization with GPU based decoder**
  - (WebGL can handle 8 and 16 bit TypedArrays)
- **Standard rendering** and shader handling
  - ( Does not need support for Vertex Textures for GPU decoding as SIG)
- Support also **incremental updates** through bit distribution over multiple files

# Priority Controlled Rendering

Priority controlled **download manager and renderer**

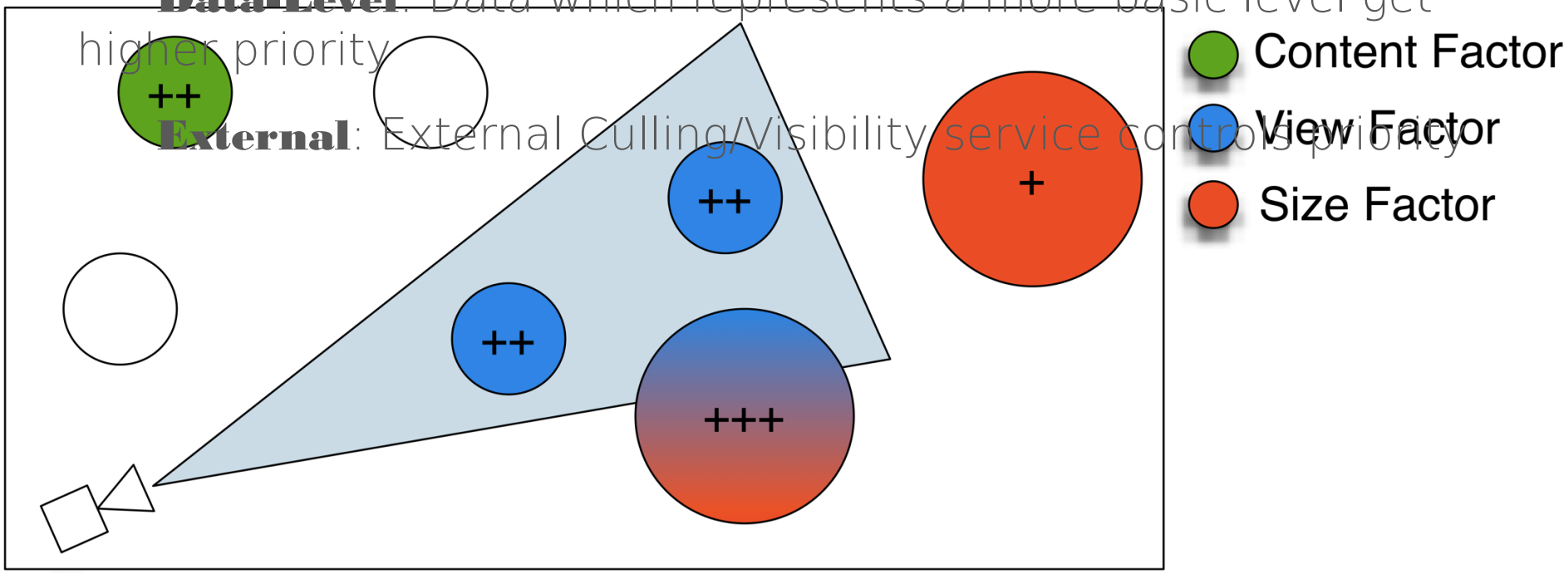
**Content**: Use/Application given to focus on specific objects

**View**: Objects which are in the view frustum

**Size**: Objects which are bigger in world space

**Data-Level**: Data which represents a more basic level get higher priority

**External**: External Culling/Visibility service controls priority



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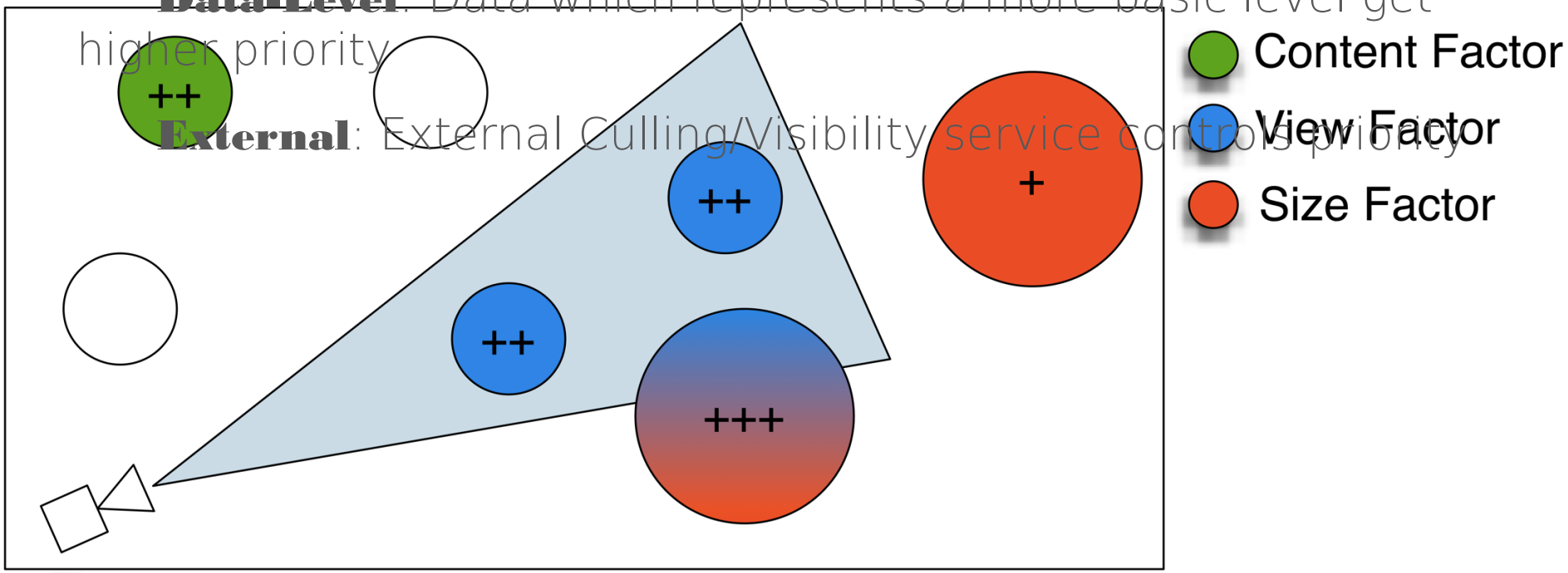
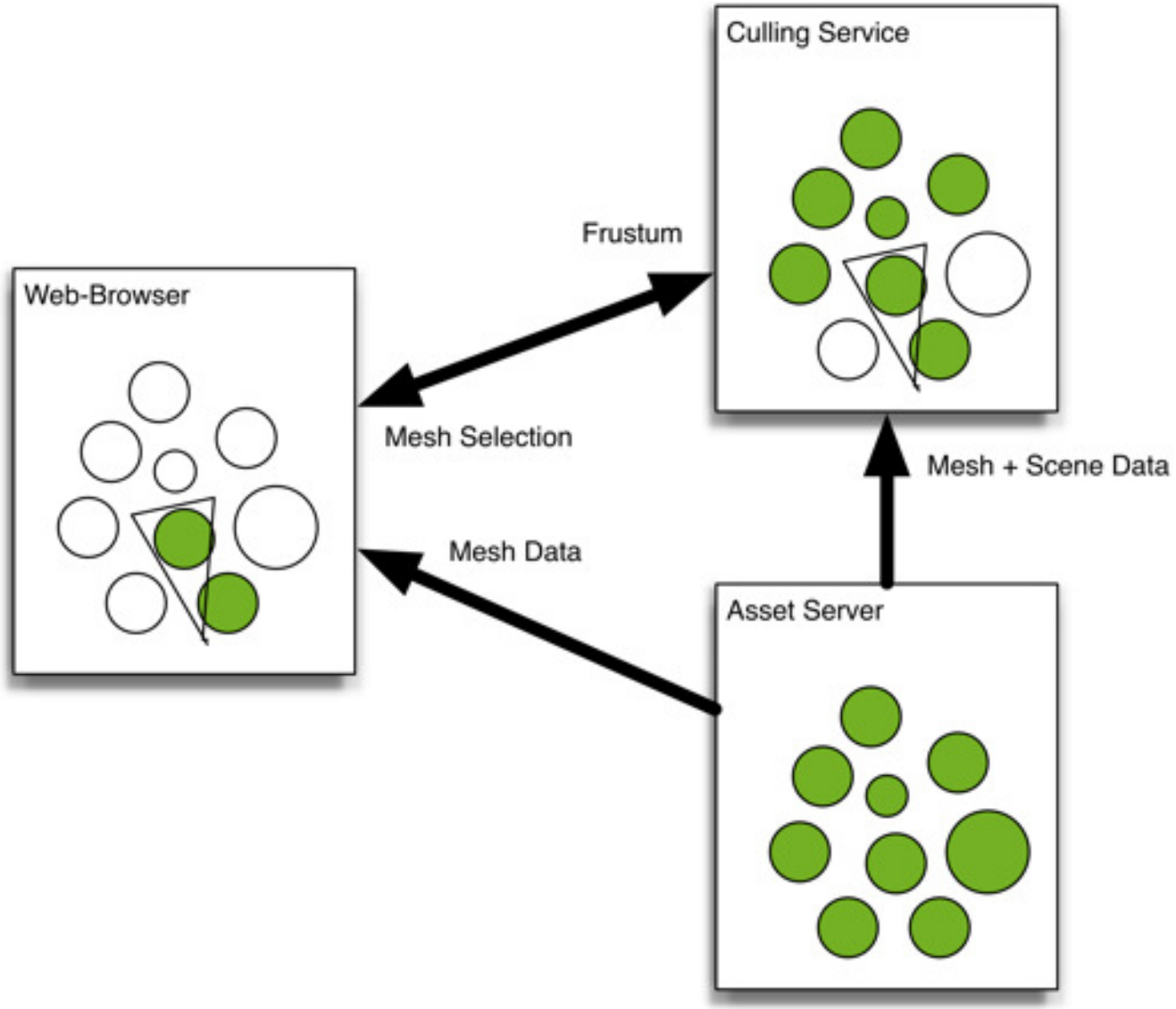
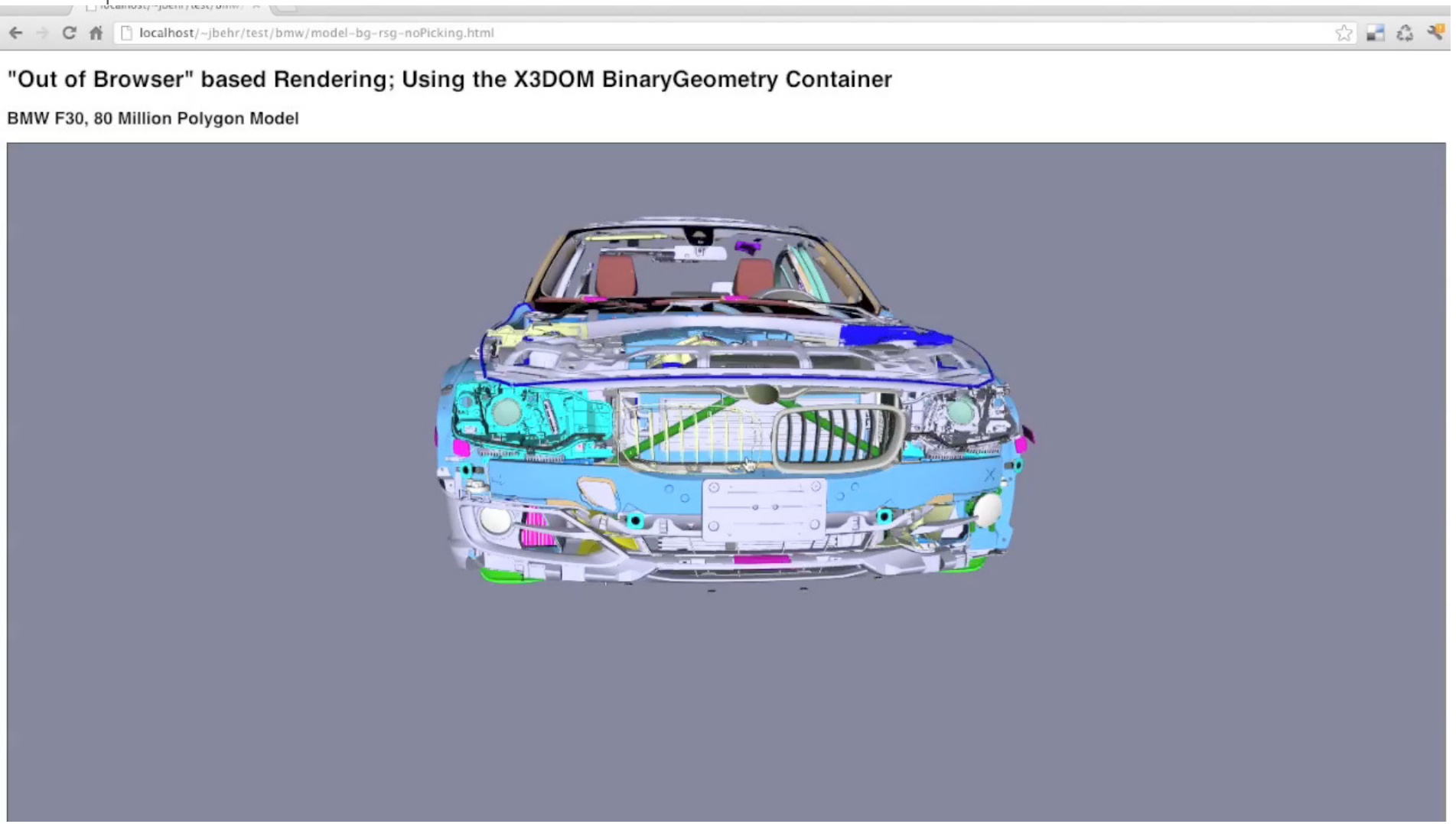


# “Out of Core” Rendering with PCR

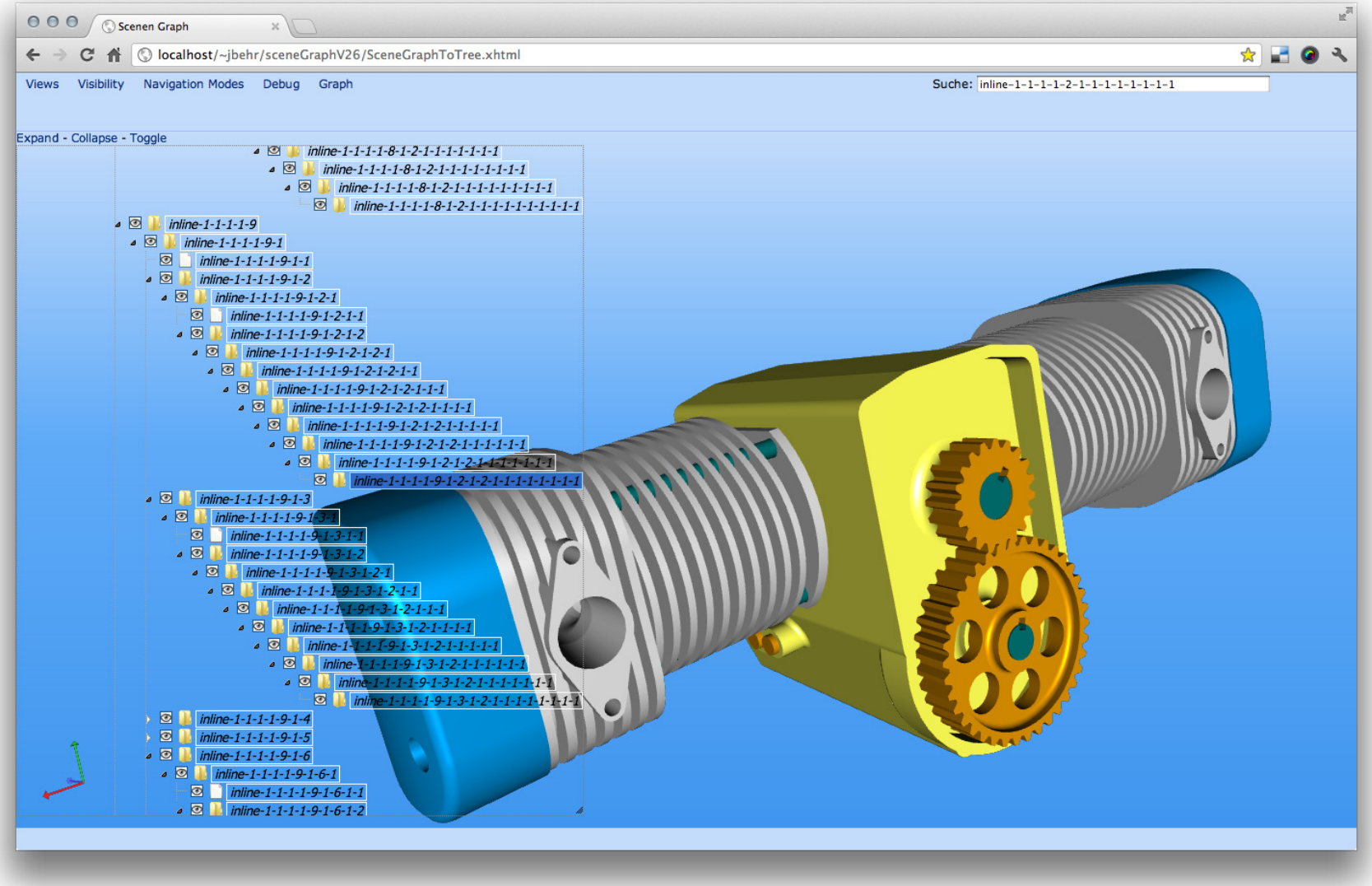


# Service Controlled PCR

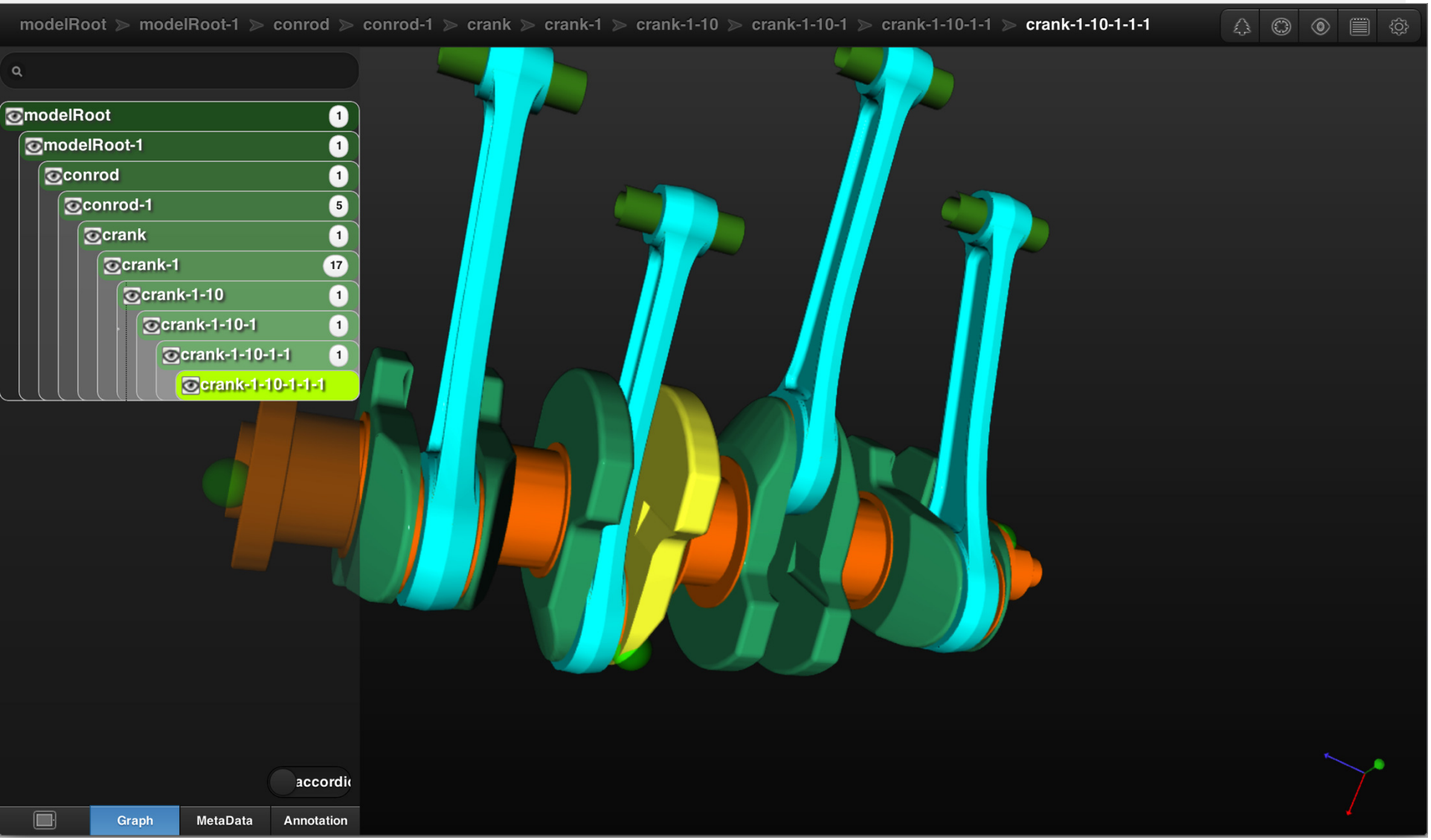
Uses bidirectional WebSocket connection to distribute computation



# Application Example – Desktop

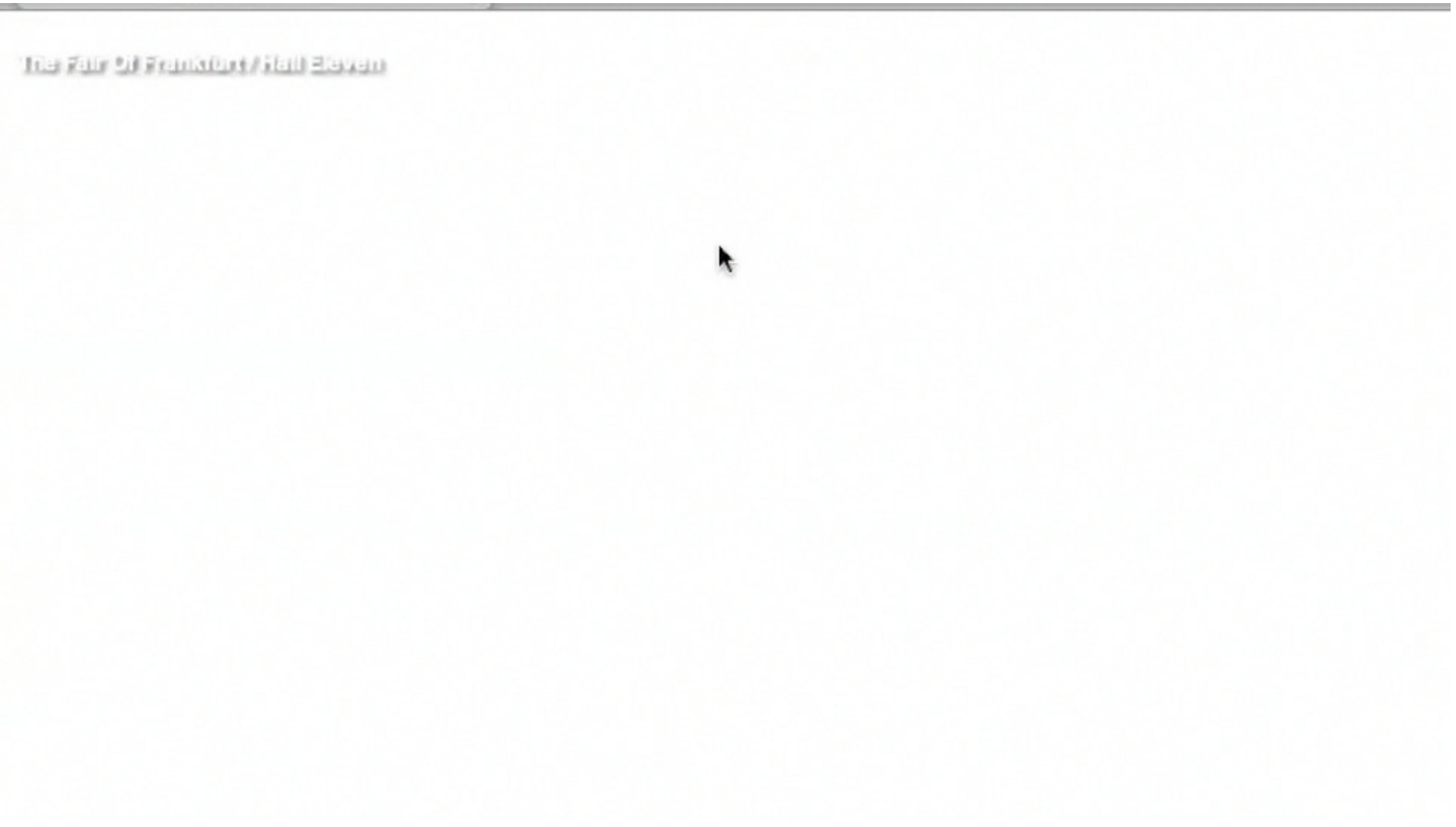


# Application Example – Mobile



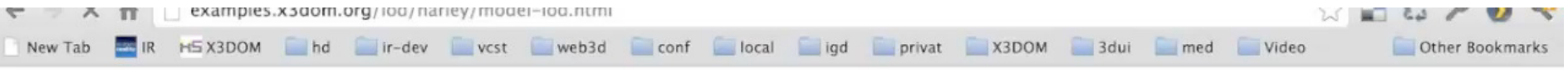
# Combination with textures

Single container type can minimize Donwload-Management



# Low Bandwidth / Mobile device

## Online BG-LOD Examples over 3G



# Implementation

**Decoding & Rendering**:

Open source and Part of X3DOM, available on github

http://www. x3dom.org

**Patch creation and encoding**:

Closed source aopt/instantReality 2.2 (release 3. August 2012)

Windows, Mac & Linux

http://www.instantreality.org

New “Large Datasets” tutorial on x3dom.org page

Free for “non commercial use”

# Patch creation and encoding
# Using the instantReality/aopt tool

Scene/Mesh statistics

aopt –I foo.x3d –p

aopt –I foo.x3d –J

Patch creation:

aopt –I foo.x3d –u –F subtree:”maxtris(20000)” –N foo-opt.x3d

subtree: Single Node (DEF/id), Node-Type or “Scene”

BinaryGeometry from PrimitiveSet

mkdir binGeo

aopt –I foo-opt.x3d –G binGeo/:sal –x foo-bg.x3d –N foo-

# Thanks

## Demos: http://examples.x3dom.org