Information-Rich Virtual Environments:

Applications, Guidelines, and Architectures

Bibliotheca Alexandrina Visit

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Schedule

Morning:

- Part 1 : Standards & Applications
- Part 2 : Design for Perception

Afternoon :

- Part 3 : Architectures & Implementations

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Why International Standards?

- **Durability**
  - Applications written in ‘98 still run and faster than ever!
- **Portability**
  - File formats and abstract behaviors are specified
  - Multiple authoring and viewing environments
- **Evolution**
  - VRML -> X3D

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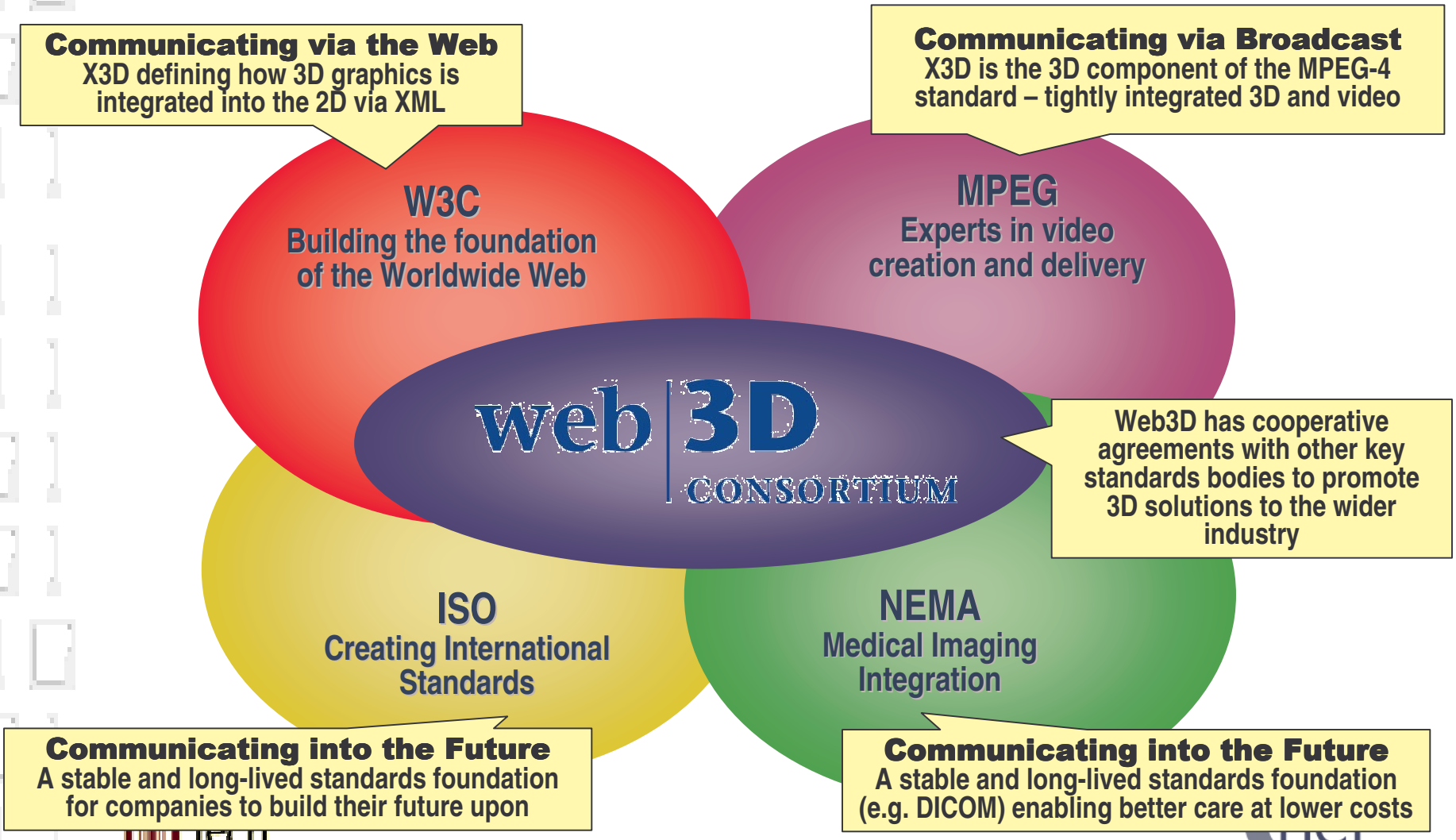
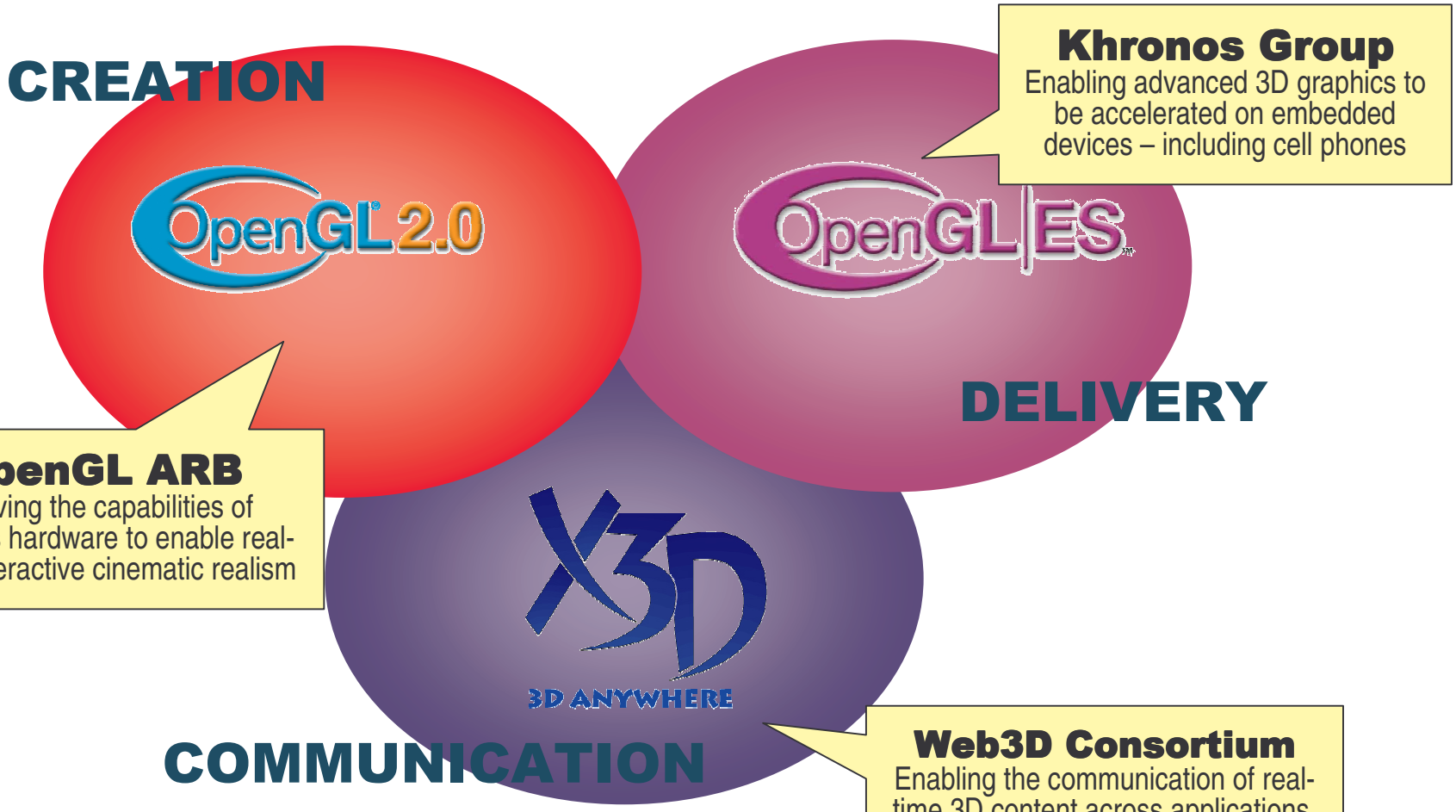
Web3D Consortium – The Macro View



The Universe of 3D Standards



Khronos Group
Enabling advanced 3D graphics to be accelerated on embedded devices – including cell phones

OpenGL ARB
Evolving the capabilities of graphics hardware to enable real-time, interactive cinematic realism

Web3D Consortium
Enabling the communication of real-time 3D content across applications, networks and the web

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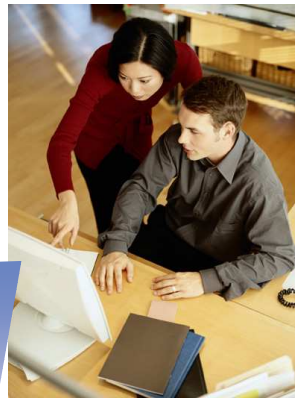
X3D Enables Real-time 3D Communication

Between applications



"X3D is an open standard to enable the communication of real-time 3D across networks and XML-based web services"

Between systems

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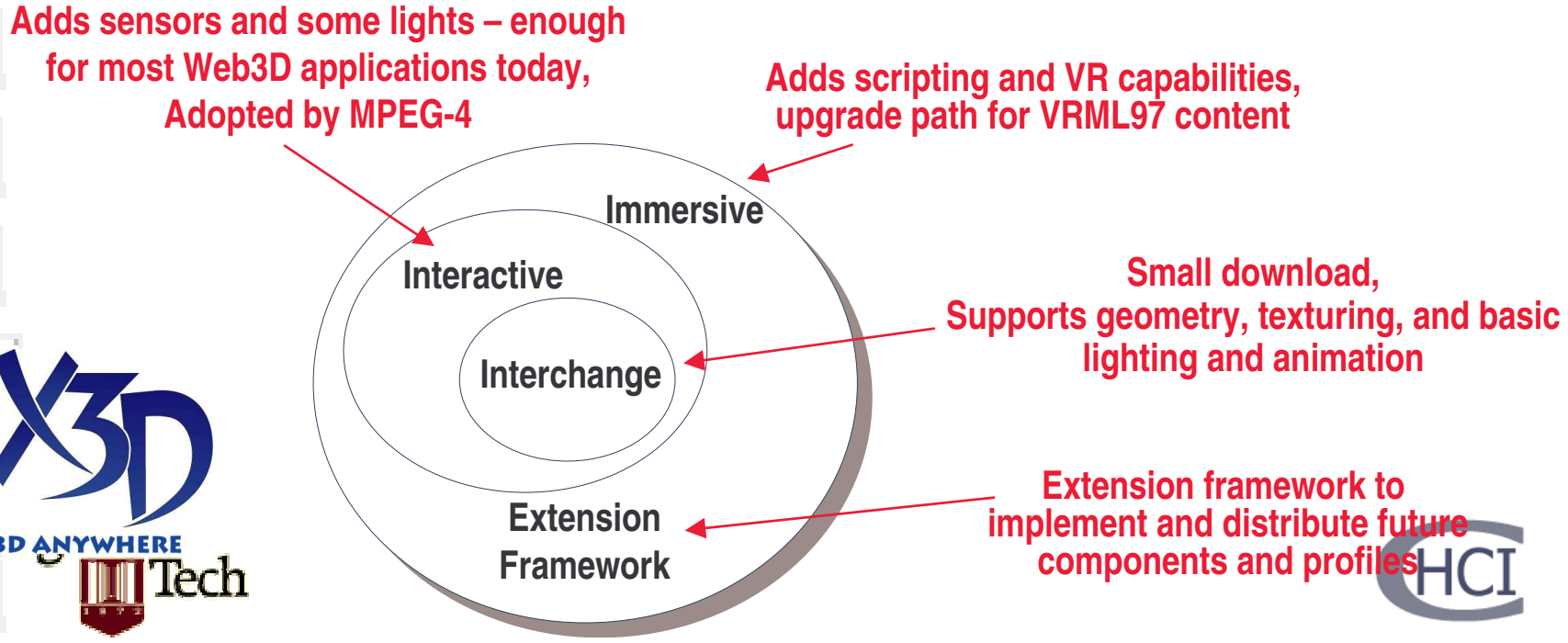
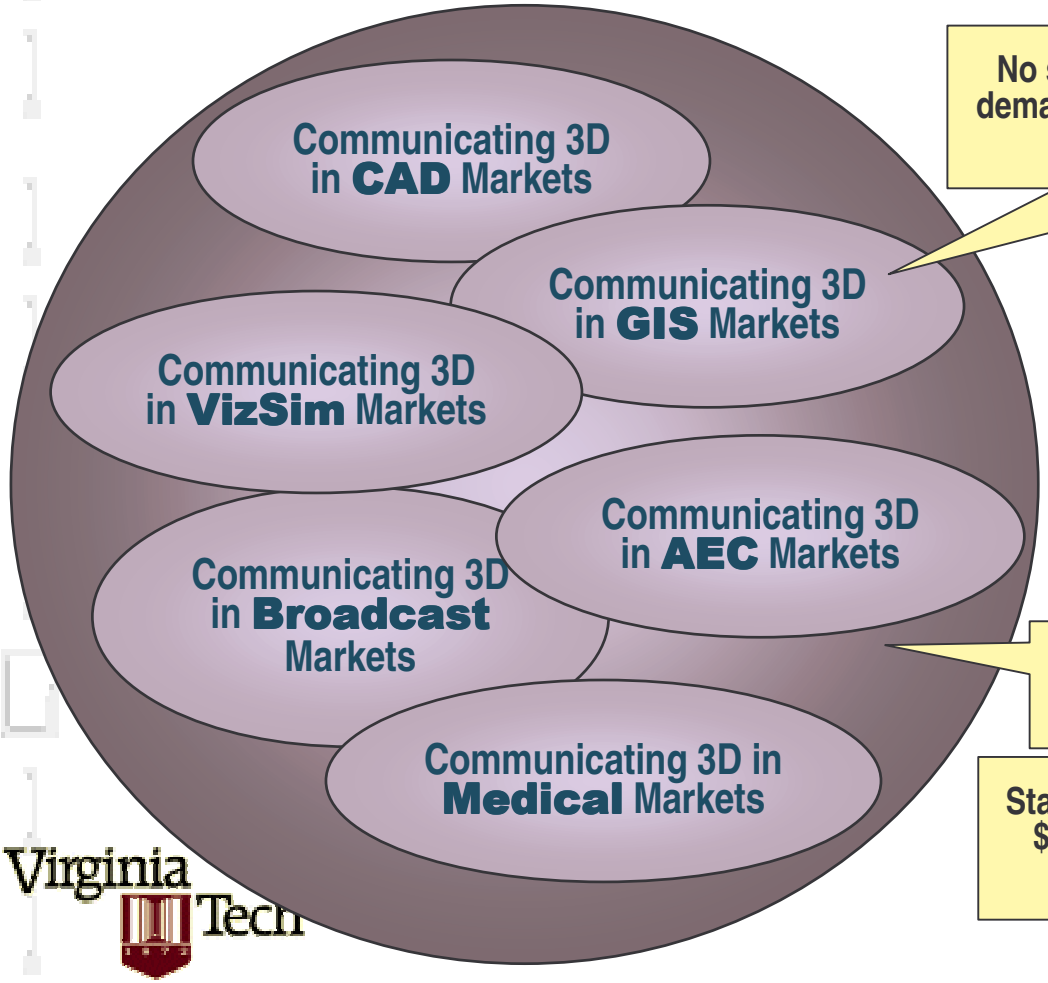
X3D – Third Gen Web3D Standard

- E**x**tensible – profiles are adaptable in size and functionality
- Tightly integrated with XML – text and binary encodings



Communicable 3D:

The next-generation common denominator



No single market segment has enough demand for 3D communications to create commercial critical mass

Proprietary 3D web solutions typically fail as they address only one segment– and don't find enough customers

Need TRANS-SEGMENT STANDARDS to amortize the cost of developing 3D communication solutions across ALL segments

Collectively all the segments together form a commercial critical mass

Standard games are not the killer app – although a $30Bn industry – most games are 3D apps that communicate – they don't communicate 3D

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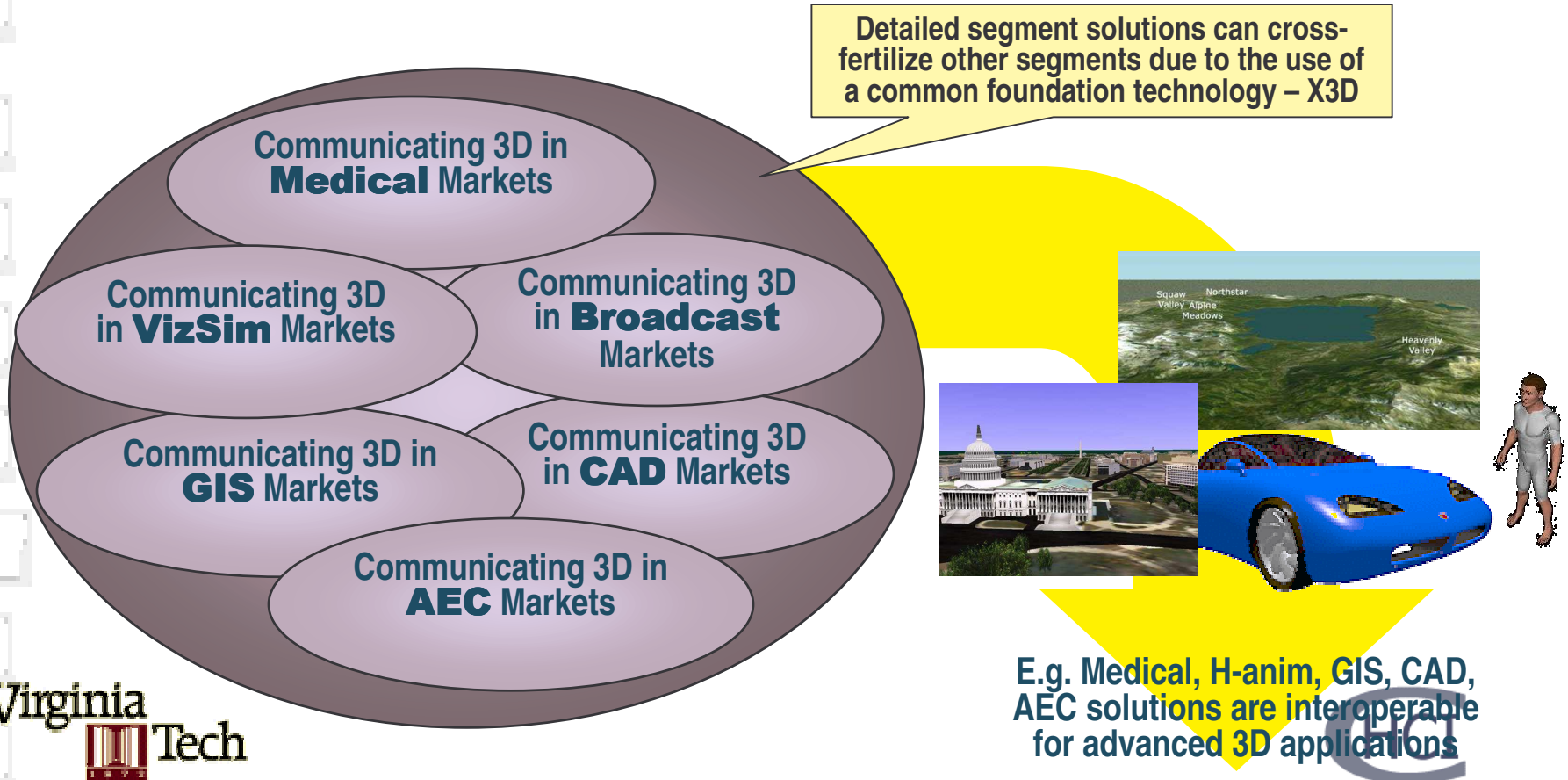
Cross Segment Synergy

Vertical focus is key to enabling market segments

- A cross-segment ecosystem will begin to form to the benefit of all



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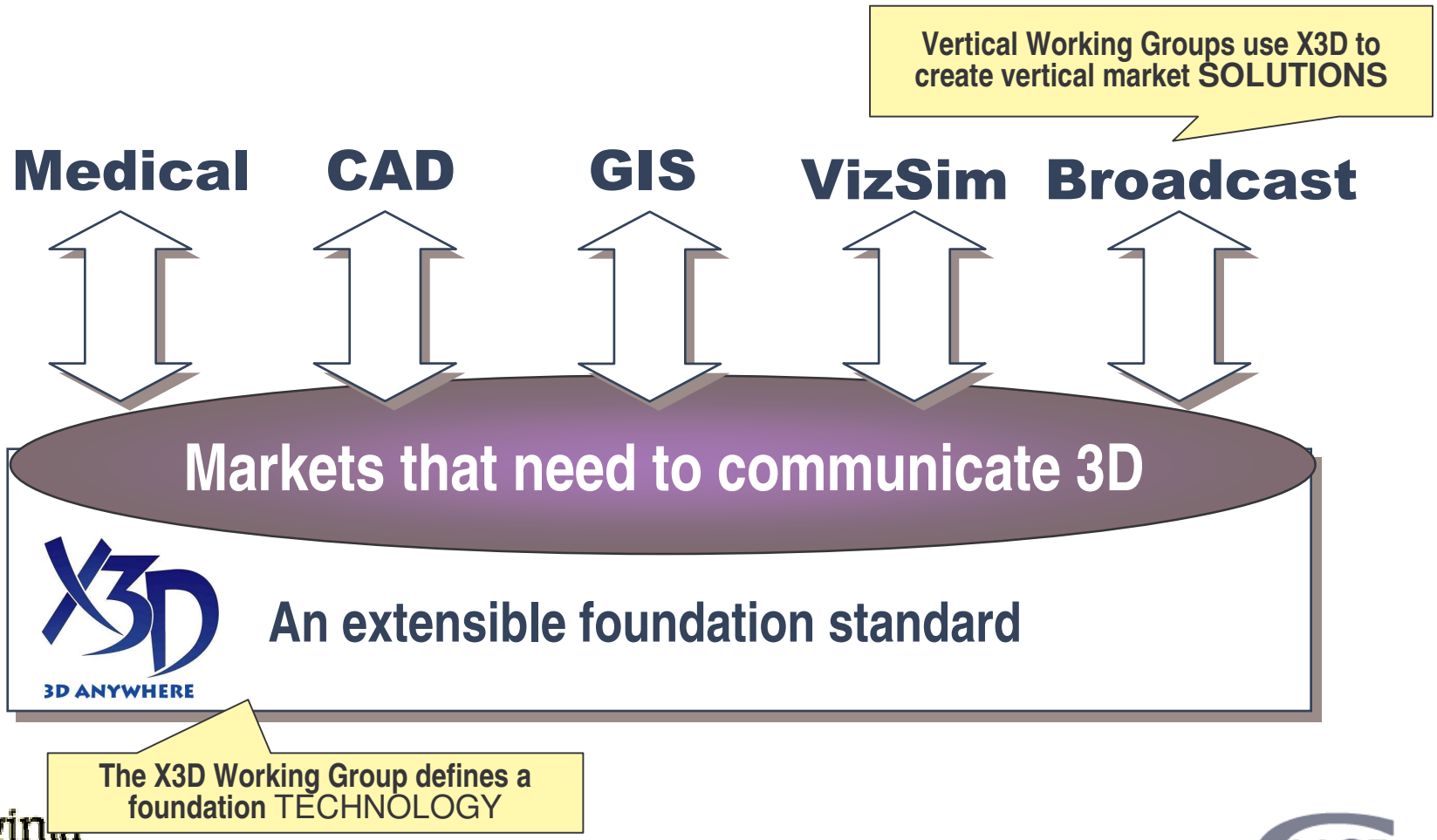
X3D – a Trans-Segment Standard



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What is X3D?

- Open, Free Standard : ISO Ratified
  - 3rd iteration (VRML 1.0, VRML97 prior versions)
  - No IP-encumbered technologies
- Interchange format
- Scenegraph Runtime system
  - Components
  - Profiles
    - Subsets of spec for different markets
  - Event model

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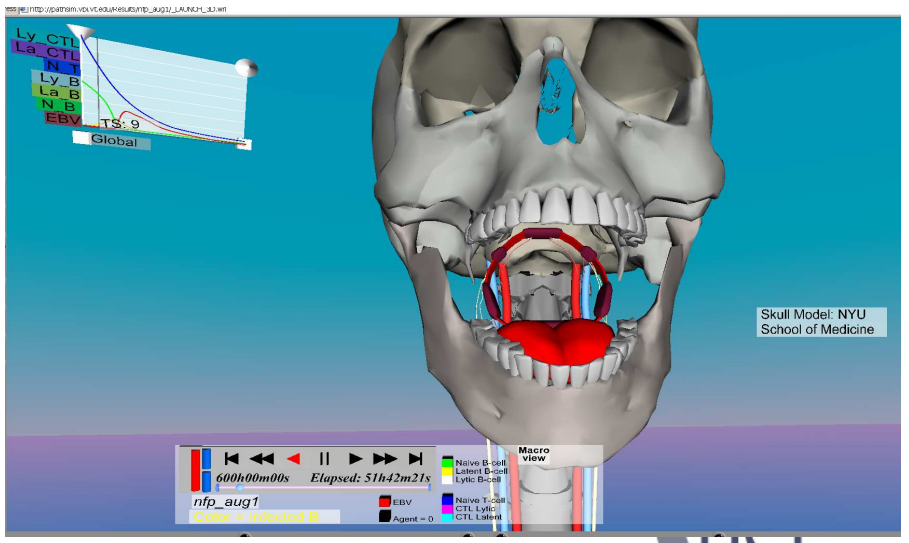
What is Extensible 3D (X3D)?

Successor to VRML for the next-generation ISO standard…

reflecting industry trends and innovations in:

- Graphics
- Data interchange
- Interoperability
- Programmability
- Delivery



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What is X3D? - Graphics

- **3D graphics** - Polygonal geometry, parametric geometry, hierarchical transformations, lighting, materials, and multi-pass/multi-stage texture mapping
- **2D graphics** - Spatialized text; 2D vector graphics; 2D/3D compositing
- **Programmable shaders** – Support for programmable shading languages so that authors can take maximum advantage of modern 3D hardware as well as create the effects needed for their purposes
- **3D and Cube Map Textures** – Includes the ability to use volumetric and environment textures
- **LOD node**

- **Animation** - Timers and interpolators to drive continuous animations; humanoid animation and morphing
- **Spatialized audio and video** – Audio-visual sources mapped onto geometry in the scene

- **User interaction** - Mouse-based picking and dragging; keyboard input
- **Navigation** - Cameras; user movement within the 3D scene; collision, proximity and visibility detection

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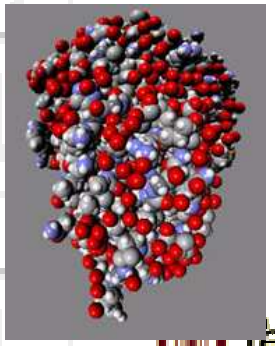
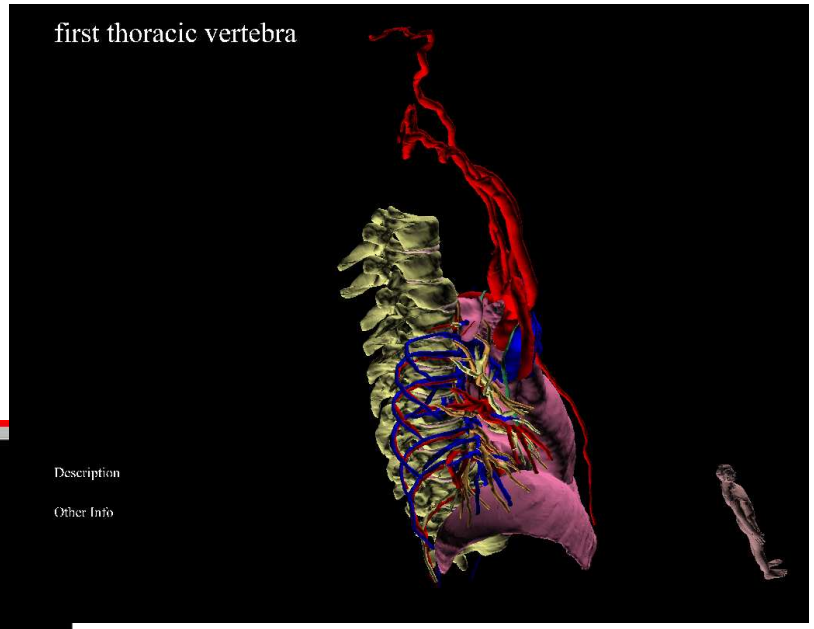
What is the strength of X3D?

Archival 3D standard

- 3D Data which requires significant resources to obtain and are needed for reference purposes
  - Anatomy
  - Molecular structure
  - Terrain
    - GIS layers
  - Astronomical data





New Features - Graphics

- Multitexture
  - –Layered Textures, ex: Light maps, Bump maps
- NURBS
  - –Higher Order Surface description
- 4 Component Color
  - –Support alpha component for color calculations
- 2D Nodes: Shapes and Text
  - –2D Primitives and Text layouts in 3D space
- Background
  - –Better support for transparency and layering
- TriangleSet, Fan, Strip
  - –Hardware aligned primitives

What is X3D? - Interoperability

- Encodings supported
  - XML
  - VRML Classic
  - Binary compressed
- File formats supported
  - jpg, png, gif, cgm
  - mpeg-1
  - wav, midi
  - GeoSpatial reference frames GD, GC, UTM
- Protocols
  - http
  - Distributed Interactive Simulation (DIS)

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What is the strength of X3D?

XML encoded

- Semantics & Metadata
- Web Services
- Distributed Networks
- Cross-platform, inter-application file and data transfer
- Enables end users and applications to add meta-data to virtually every aspect of scenegraph model
  - Facilitates integration with more sophisticated analytic programs.
    - » Information about blood flow (e.g. viscosity, velocity) can be encoded right where the geometry is stored
    - » Diagnostic information about a tumor (e.g. tissue type, receptors, metastases) can be encoded where the geometry for the tumor is located
  - May be DEF'd and accessed by SAI services
    - » Common SFStrings: `standard`, `name`
    - » *MF* Nodes: *Double, Float, Integer, String, DataSet*

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XML Integration

- XML Encoding: 4D informatics
  - Self-describing data for portability and durability
  - Leveraging the XML ecology:
    - Semantic Web Ontologies
    - XML authentication and encryption
    - Interoperability with Patient Reports data
    - Other XML data sources (I.e. Chemical Markup Language (CML))
- Media Interoperability
  - DOM Scripting
  - XHTML – HTML Encoding in XML
  - SVG – 2D Graphics
  - SMIL – Synchronization and Timing
- Composable Content

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What is X3D? - Programability

- **Scripting** - Ability to dynamically change the scene via programming and scripting languages

  SAI – Scene Authoring Interface
  - Unified API for internal and external scripting
  - Multiple Views of a shared Scene
  - Detailed Access to Scene Information

- **Languages**
  - ECMAScript (required)
  - Java (optional)
  - Preliminary work on C/C++ bindings

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What is X3D? - Delivery

- **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
- **Authentication and Encryption** - Binary format compatible with W3C standards

X3D Binary

- X3D Canonical form for regular formating
- Type specific binary compression of field data
- Node specific compression like Geometric Compression
  - –Java3D compression patents licensed for X3D implementations
  - –Method registrey
- Lossless and Lossy compression available
- 2-5X Parsing Speed improvements
- Up to 20:1 compression with no visual loss
- XML Encryption and Authentication
- Implementation released with Xj3D 1.0
- Draft undergoing final review

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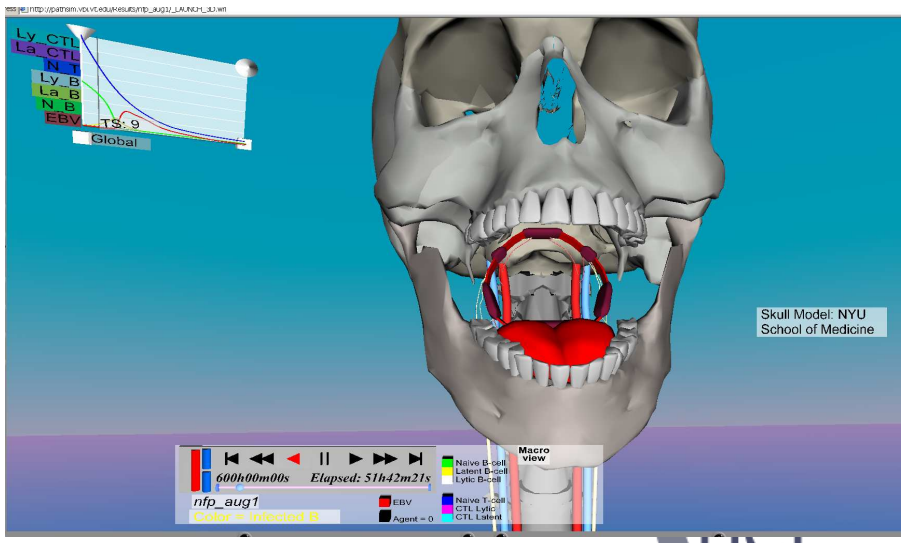

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10 Reasons to migrate

- VRML Compatible
- XML Encoding for integration
- X3D scenes operate predictably between players
- X3D is componentized
- X3D authoring for any player is consistent and simpler
- X3D is more feature rich
- X3D is continually enchanced and updated
- X3D applications can be certified as reliable
- An X3D open source conformant application is available
- X3D binary format offers encryption and compression

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New Features – VRML to X3D

- Import / Export
  - –Inlines can export Nodes for routing
- Metadata
- Block Comments
- StaticGroup
  - –Define X3D content which will not change so it can be optimized
- KeySensor & LoadSensor
- Query the browser for capabilities and properties
- Event Utilities
- Humanoid Animation(H-Anim)
- GeoSpatial(GeoVRML)
- DIS – Distributed Interactive Simulation

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Recent Consortium Progress

- Combined base and Amendment 1 document
- Annual Updates
  - –213 spec comments processed
- ISO Process Approvals
  - –ISO 19775
  - –ISO 19776
  - –ISO 19777
- Empowered community: X3D Wiki, WG listerves, B-boards
- X3D officially approved for Navy use

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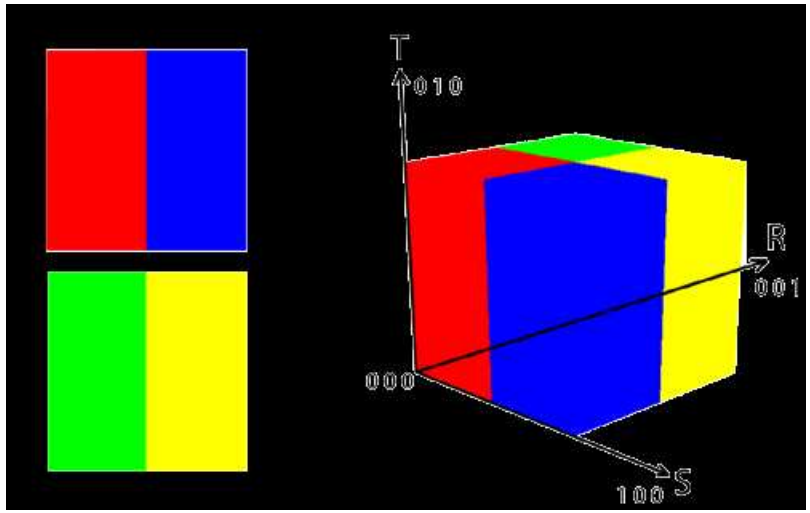
Amendment 1 - 2005

- Programmable Shaders
- Texturing 3D
- Binary Encoding
- CubeMap
- CAD Profile
- Local Fog
- Minor tweaks
  - –Global Lights
  - –Text bounds
  - –LOD Level Changed and Force Transitions
  - –Viewpoint Transition Time



X3D Amendment 2 – June 1, 2006

- Layering
- Volume Rendering
- Non Linear Interpolators, Linear Filtering
- Rigid-Body Physics
- Picking Sensors
- Viewpoint Management
- DisEntityManager (to discover new entities)
- Clip Planes
- Geospatial Extensions: GeoTransform, GeoProxSensor
- Ortho Camera
- Two-Sided Material/Appearance
- Image Formats: JPEG2000, MNG, MP3, DDS?
- TextureProperties

X3D Future - Conformance

- Interoperability
  - Use of open standards provides the best potential for interoperable systems
- Standard ≠ Interoperability
  - Conformance testing
  - Encouraging multiple implementations
    - 6 Open source implementations available
      - CyberX3D, FreeWRL, H3D, Open ActiveWRL, X3D Toolkit, Xj3D
    - 6 Commercial implementations
      - Avalon, Contact, Flux, JINX, Octaga, Venues
- Royalty Free Standard
  - IP Polices in place

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Applications

Publishing Paradigms

- Identity
- Pipeline
- Hybrid (Pipeline + Composition)

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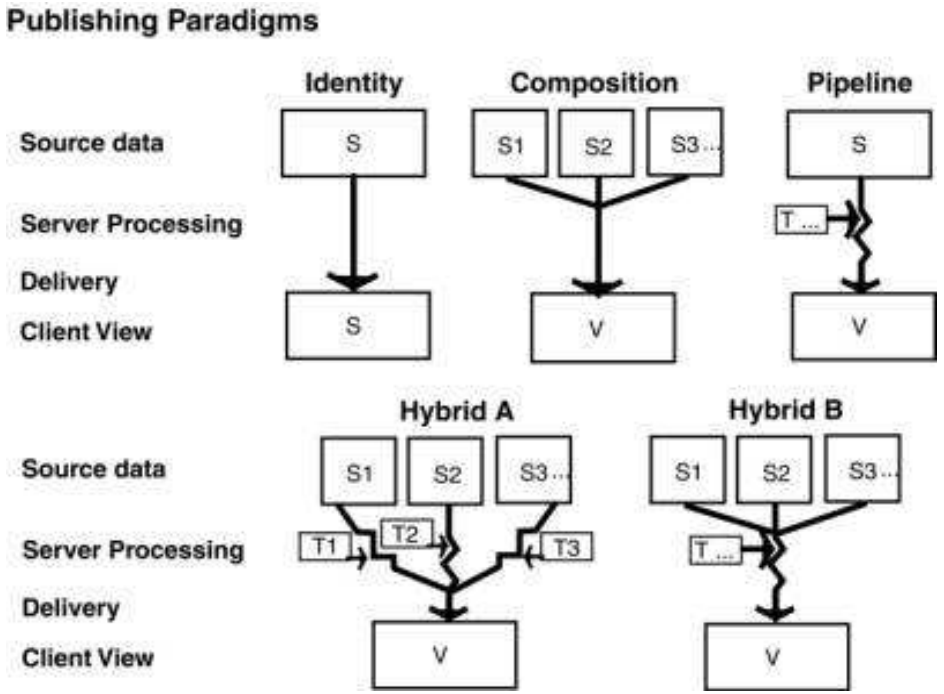
Publishing Systems: Content vs. Representation



Polys, Nicholas F. "Publishing Paradigms with X3D" In: *Information Visualization with SVG and X3D*, (eds.) Chanomei Chen and Vladimir Geroimenko, Springer-Verlag, 2005.

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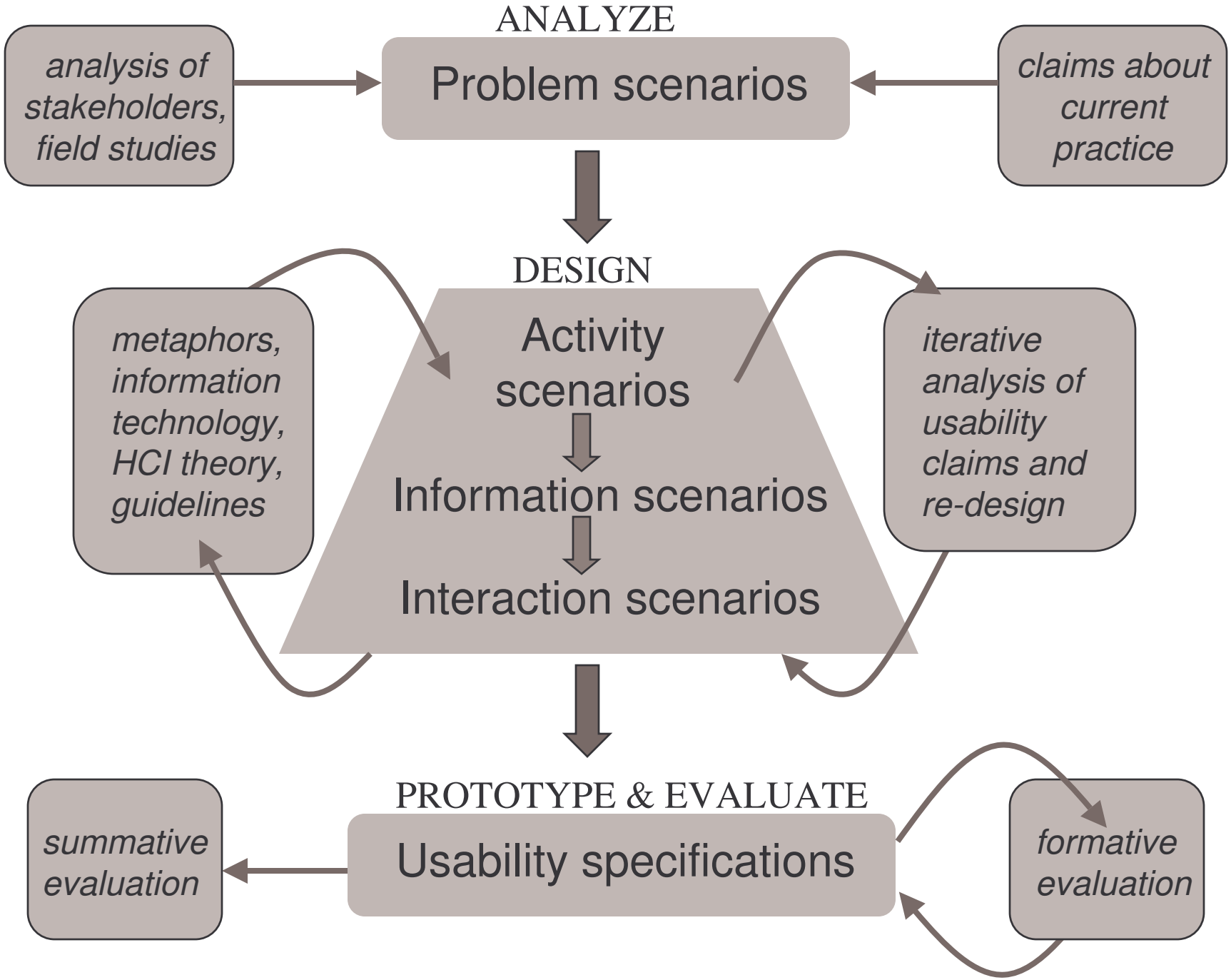
Usability Engineering

- Where the rubber meets the road!
  - Design Process / Method
  - User Models
  - Performance Metrics


ANALYZE
analysis of stakeholders, field studies
Problem scenarios
claims about current practice
DESIGN
metaphors, information technology, HCI theory, guidelines
Activity scenarios
Information scenarios
Interaction scenarios
iterative analysis of usability claims and re-design
PROTOTYPE & EVALUATE
summative evaluation
Usability specifications
formative evaluation

Identity Publishing

- Collaboration with Gerontology
- VRML files are source and deliverable

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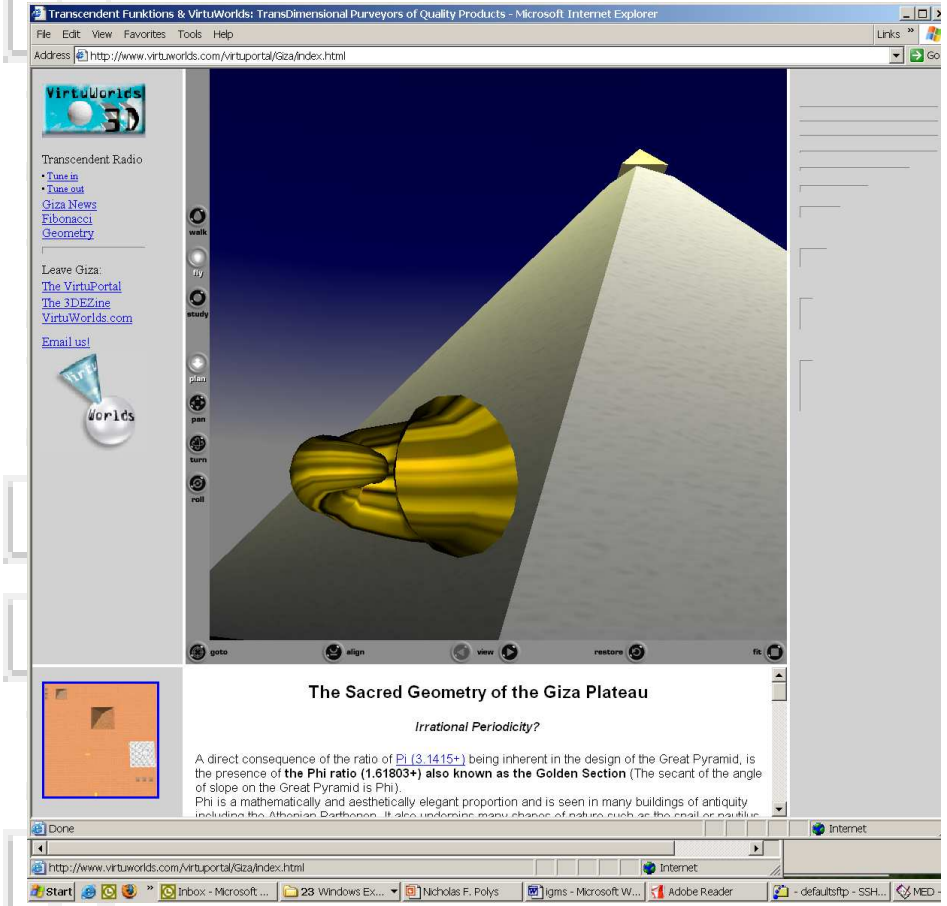
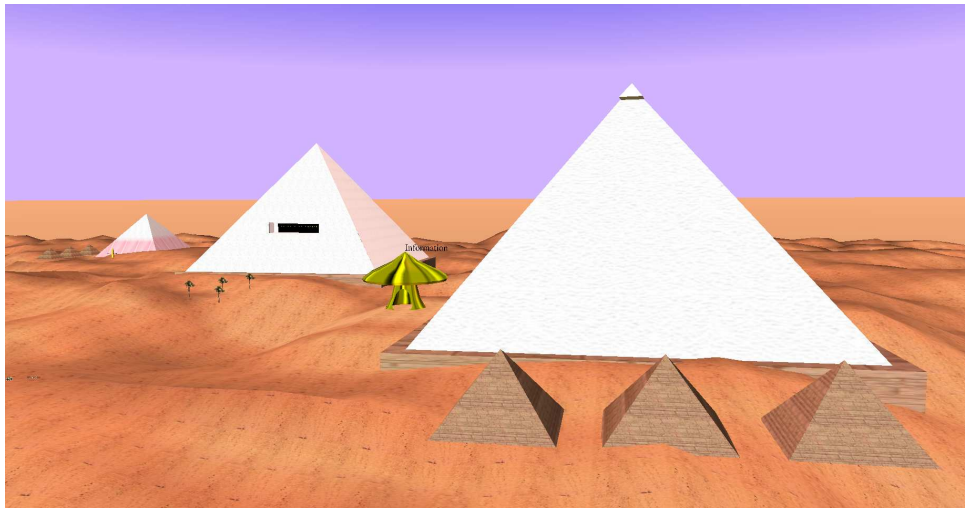
Edu-tainment & Online Destinations: Giza Plateau





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Independent Living Testbeds:
Street crossing, Wayfinding (CAVE)

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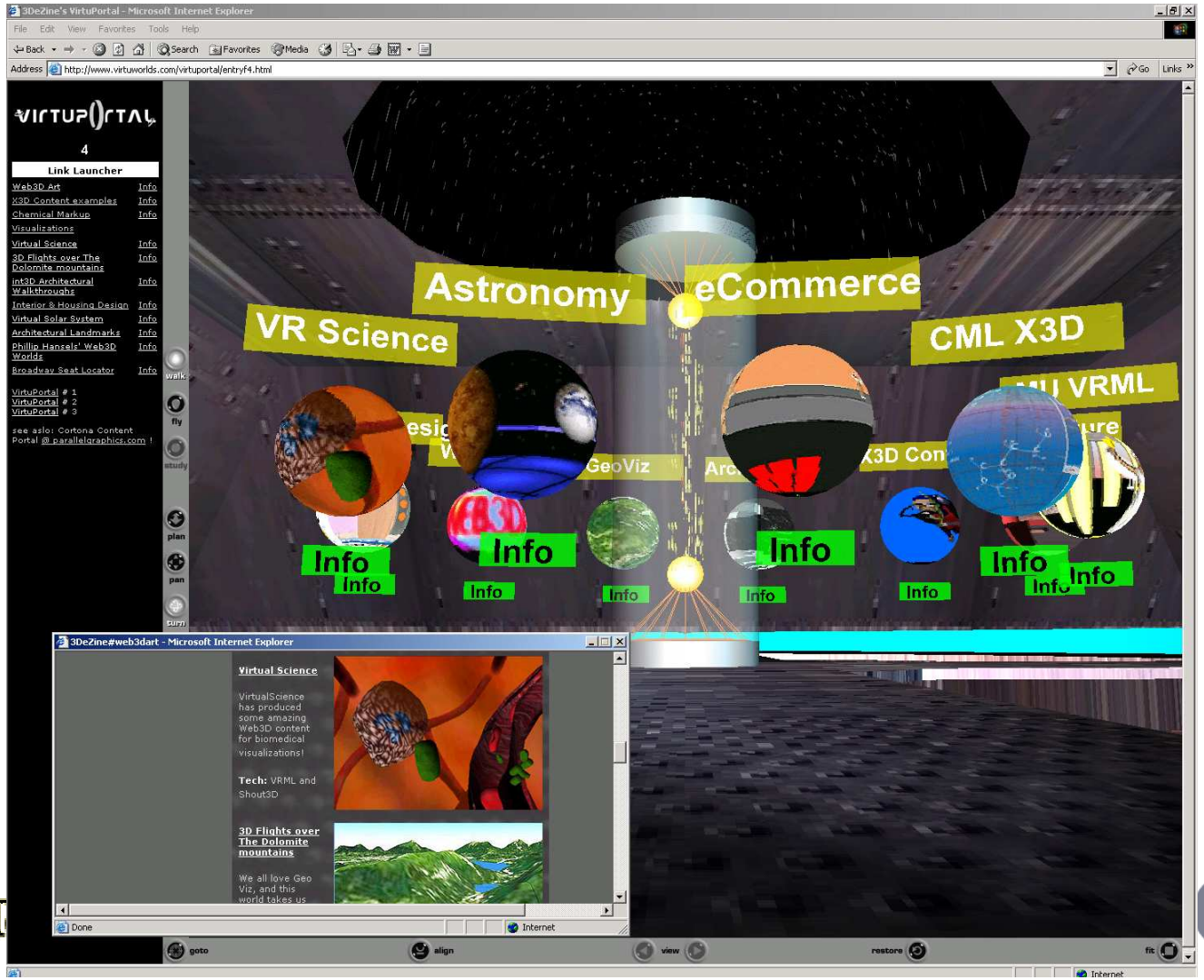
Composition Paradigm

- Server-side production of X3D VRML

(I.e. data driven)

Edu-tainment & Online Destinations: VirtuPortal



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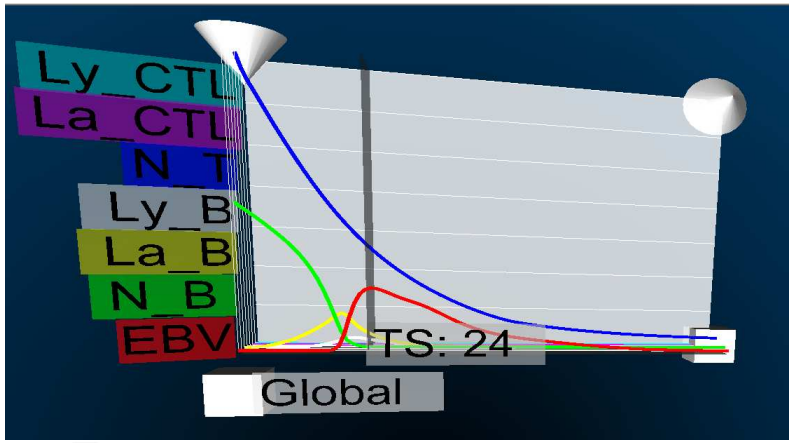
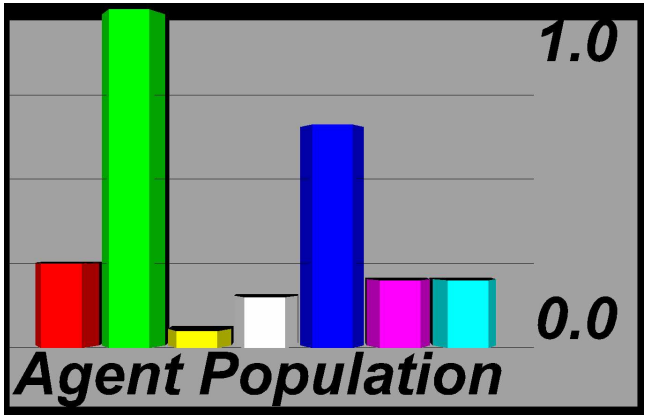
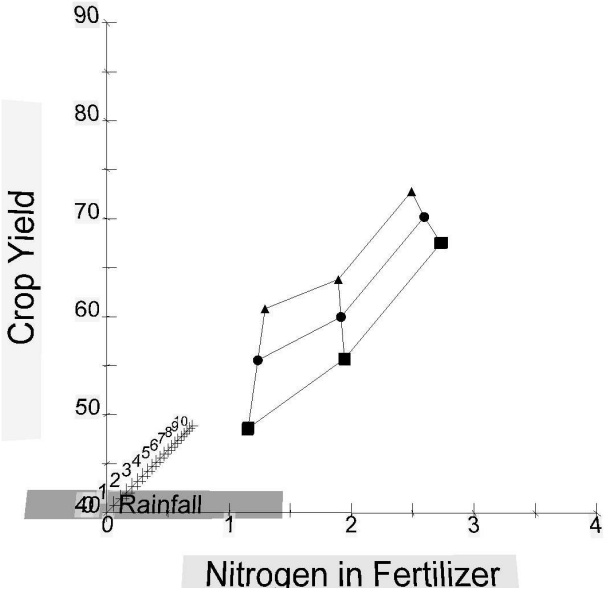
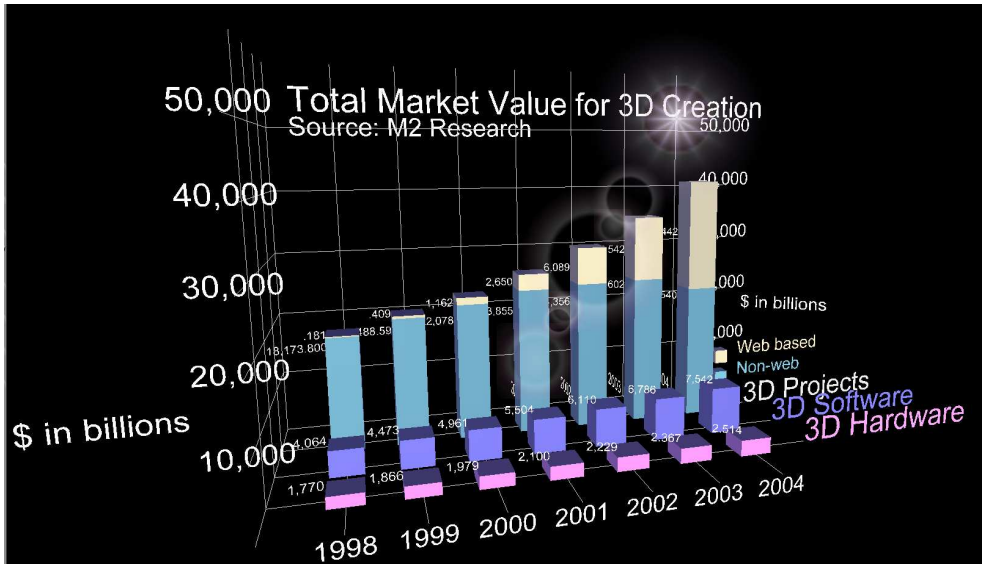
Visualization:
Timeseries & Data Graphs







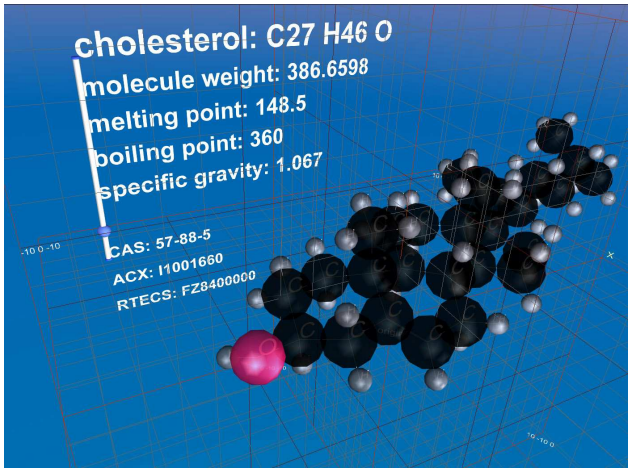


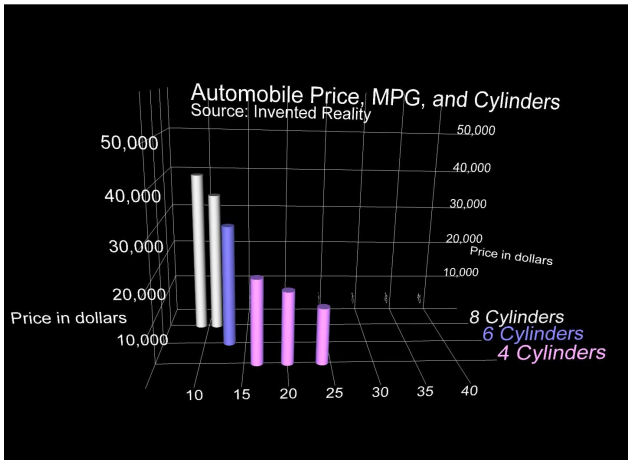
Pipeline Paradigm

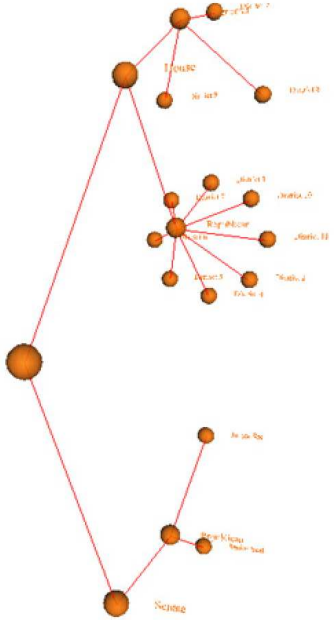
- Data transformations from XML to X3D and VRML

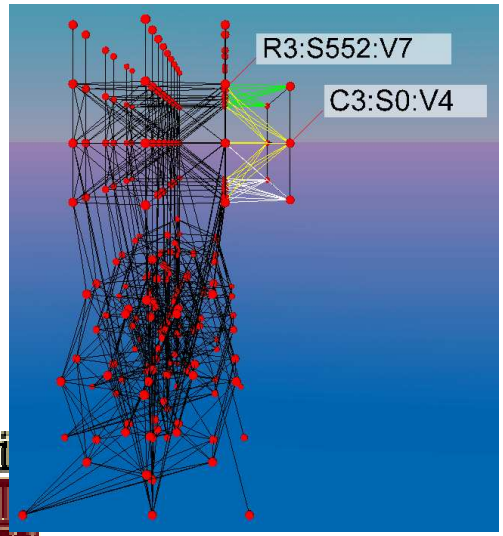
XML Data Transformations

- Chemical Markup Language
- Auto data
- VoteSmart
- PathSim



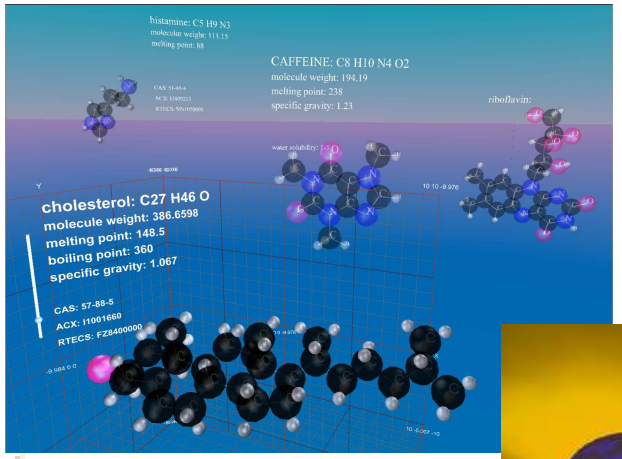


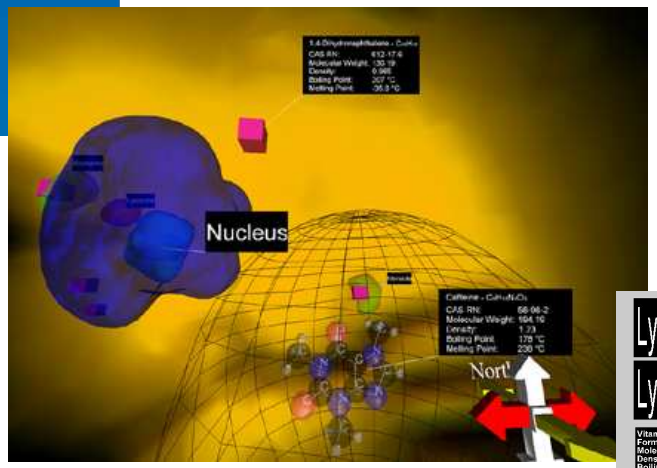


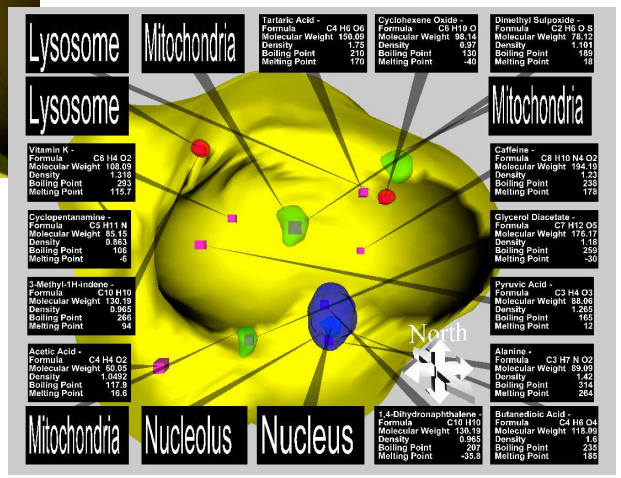


Polys, Nicholas F. "Stylesheet Transformations for Interactive Visualization: Towards a Web3D Chemistry Curricula". *Proceedings of the Web3D 2003 Symposium*, ACM SIGGRAPH. 2003.

Application Example: Chemical Markup Language







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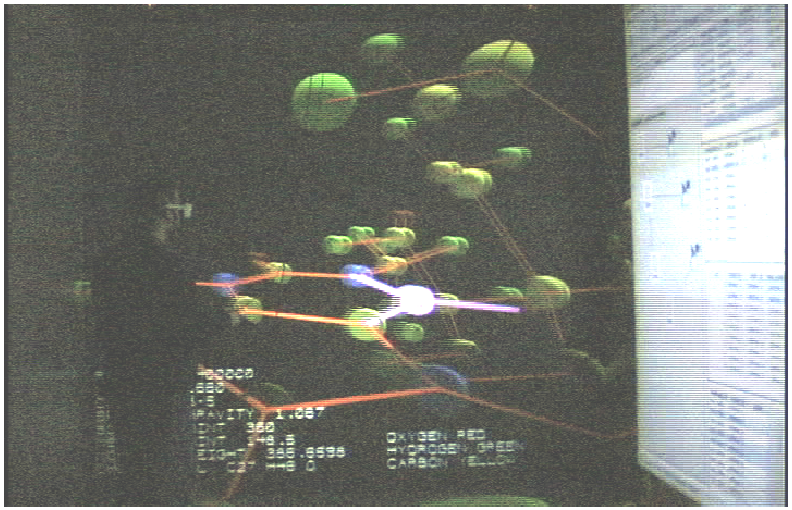
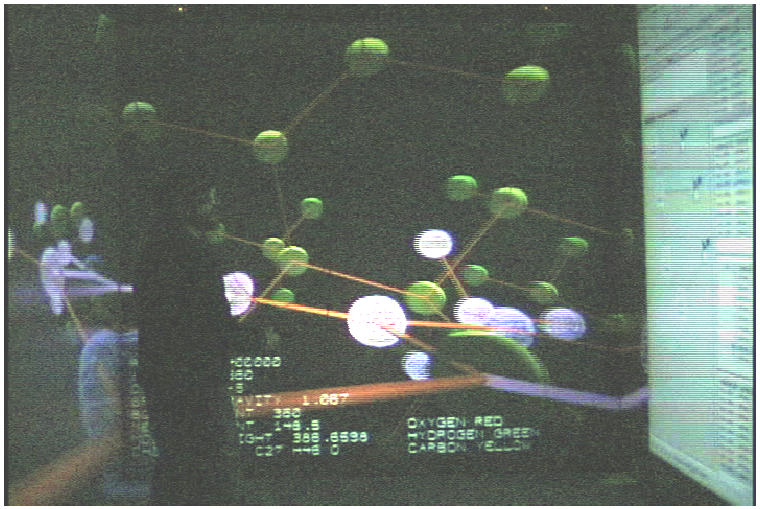
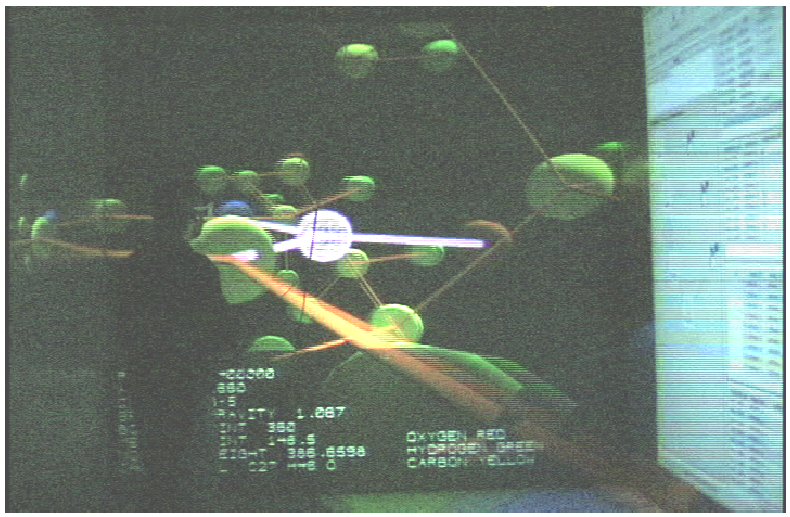
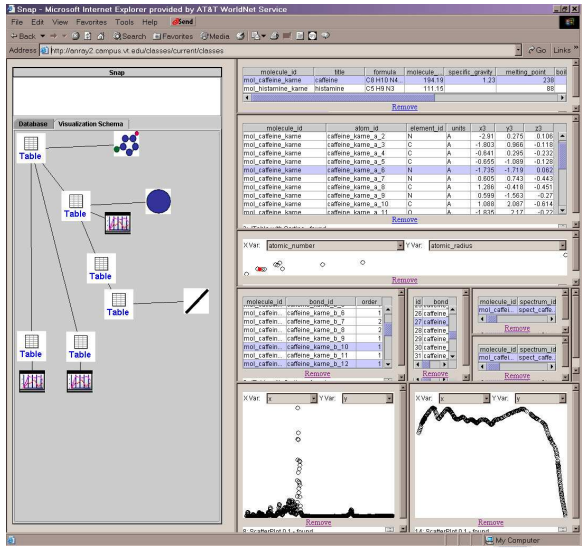
Display Space:
CML InfoVis + CAVE

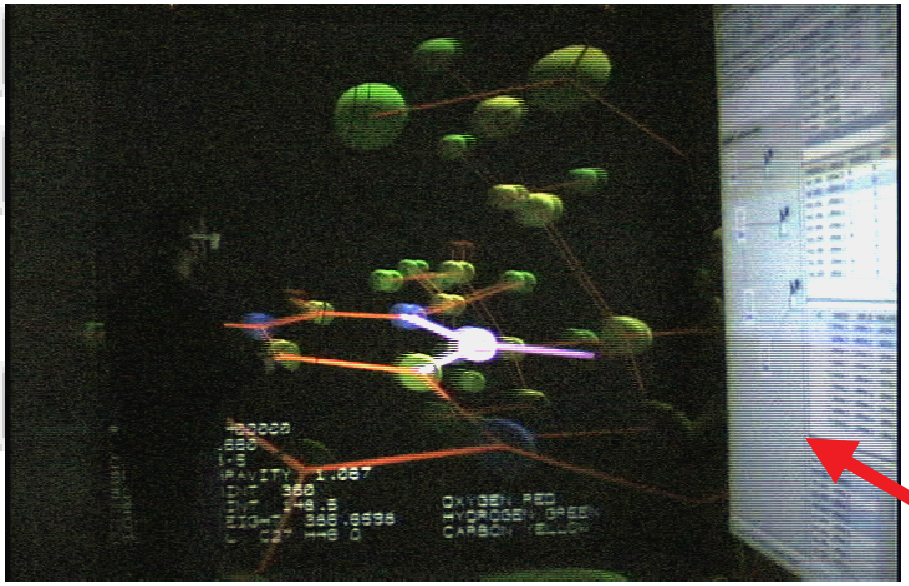


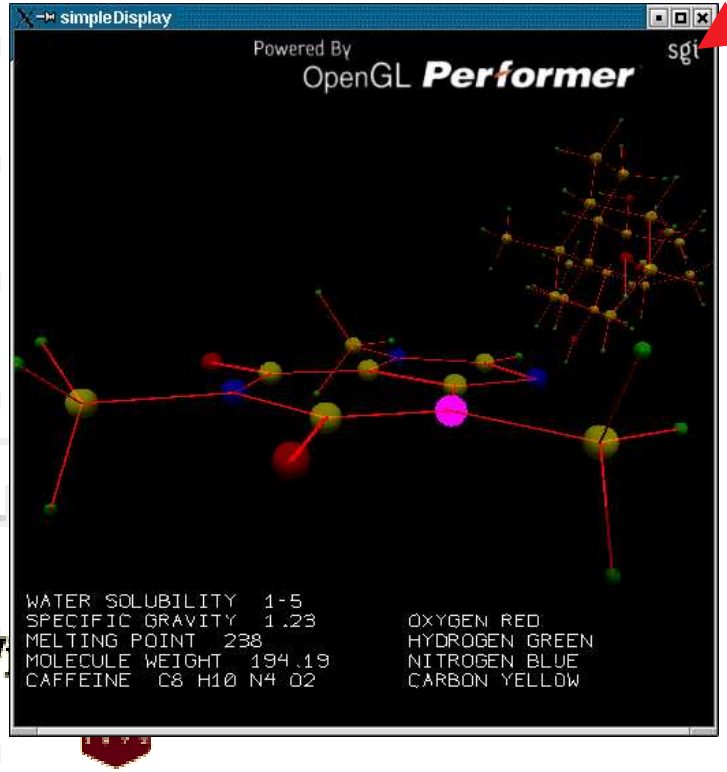


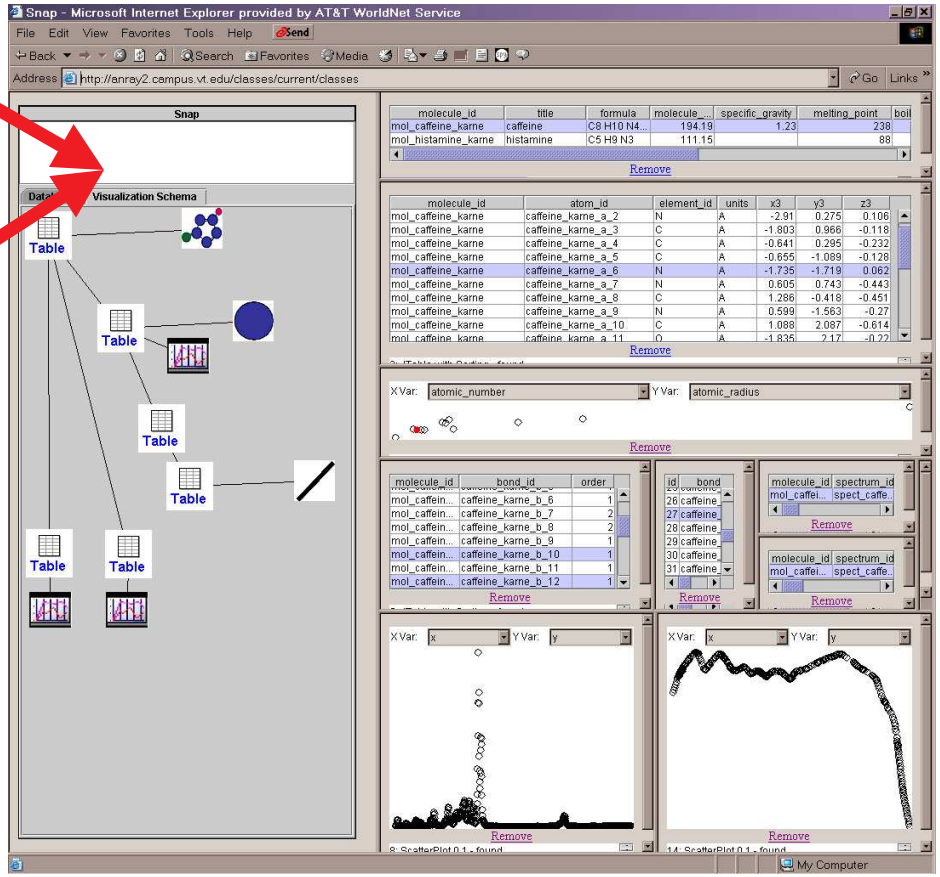




Snap2Diverse: linked views







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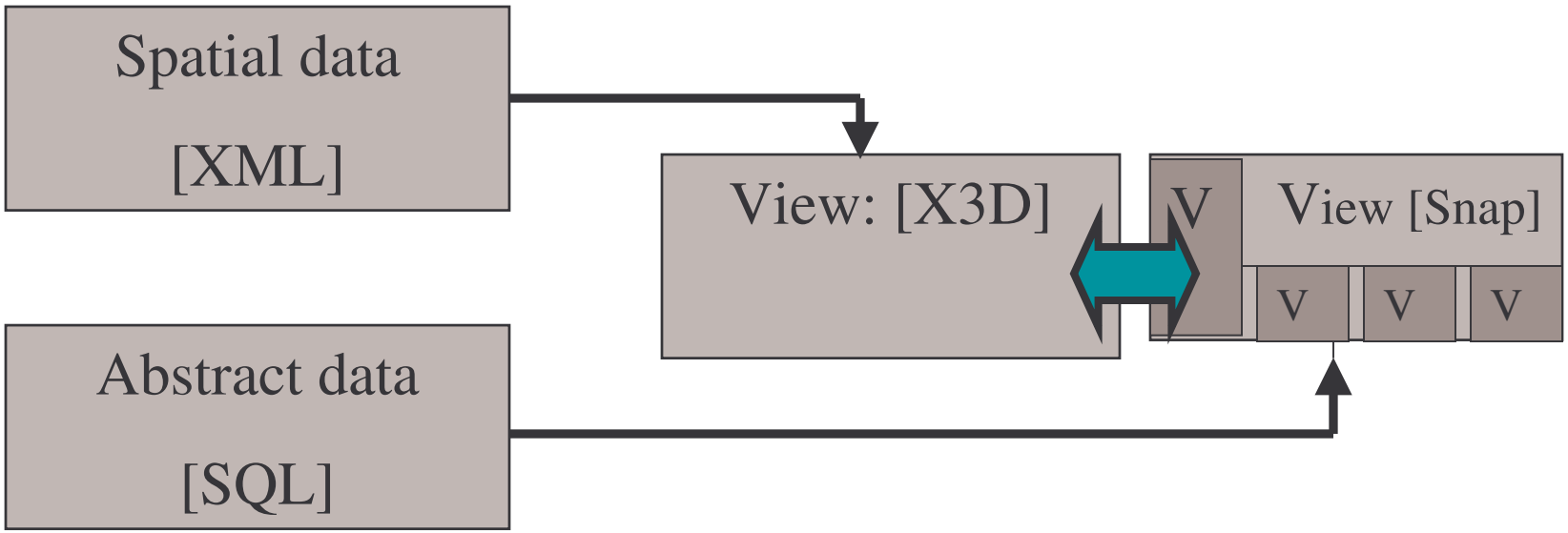
Snap2Diverse: Data & Viz Architecture



Polys, Nicholas F., North, C., Bowman, D., Ray, A., Moldenhauer, M., Dandekar, C. (2004). Snap2Diverse: Coordinating Information Visualizations and Virtual Environments. SPIE Conference on Visualization and Data Analysis (VDA), San Jose, CA.

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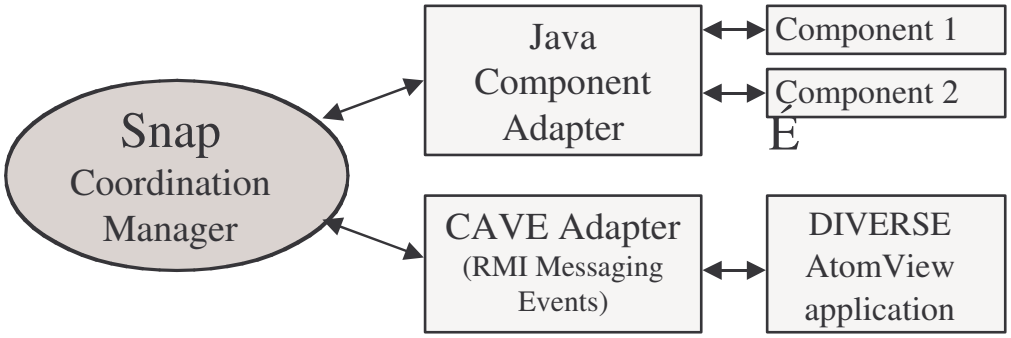
Multiple, Coordinated Views for IRVEs

Users can index to and from perceptual and abstract information through ‘brushing and linking’

- Diverse as a Snap-able component
- Linking XML and SQL data sources by unique IDs
- Event communication (e.g. select, load IDSet)



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Lessons Learned

Simple events provide ‘glue’ to support complex functionality btwn apps & data:

- Benefits of exposing VE scenegraphs to external events; enabling technology must be extended
- Benefits of composable and integrated information spaces
- Designers must consider tasks and the knowledge required for completion (i.e. Sutcliffe and Faraday, 1994; Shneiderman, 1996)

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Hybrid Paradigm

- Data is both transformed from multiple sources and composed to X3D or VRML

PathSim

- PathSim is a computer model and simulation engine designed for Systems Biology investigators and Virologists to study the dynamics of an immune system under various infection conditions ***in silico***

- Agent-based Simulations on anatomical geometry with biological agent interactions, set from initial physiological conditions

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Polys, Nicholas F., Bowman, D., North, C., Laubenbacher, R., Duca, K., (2004). PathSim Visualizer: An Information-Rich Virtual Environment for Systems Biology. Web3D Symposium, Monterey, CA, ACM Press.

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PathSim Application

- Managing and Visualizing large, multi-scale agent-based simulation results through the web
- Extensive use of annotation concept for views on: data, metadata, networked multimedia
- Scaling user-space controls across scales
- Generating insight into system dynamics for diagnosis, and ‘what if?’ to model interventions

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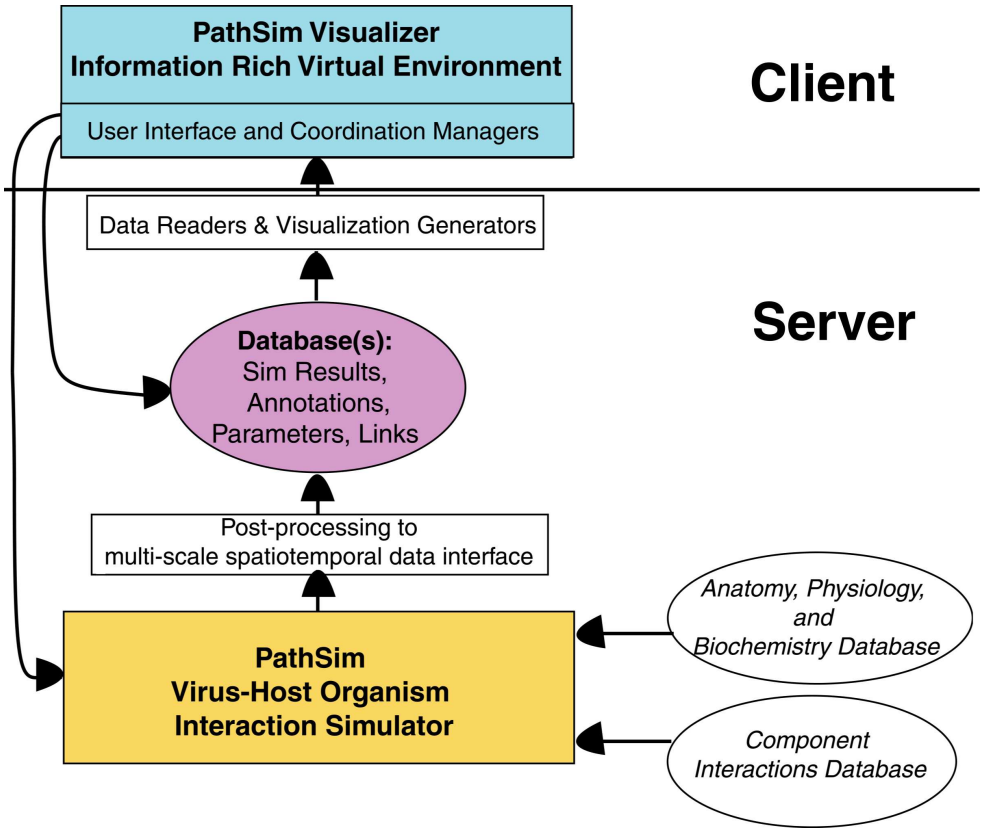
PathSim Data



- Massive: upwards of 7 million agents whose state and location can be measured every 6 simulation minutes!

Agents x	Anatomical Locations x	Timesteps	= Total
7	2309 (x 27 vertices)	100 (+)	1,616,300 datapoints

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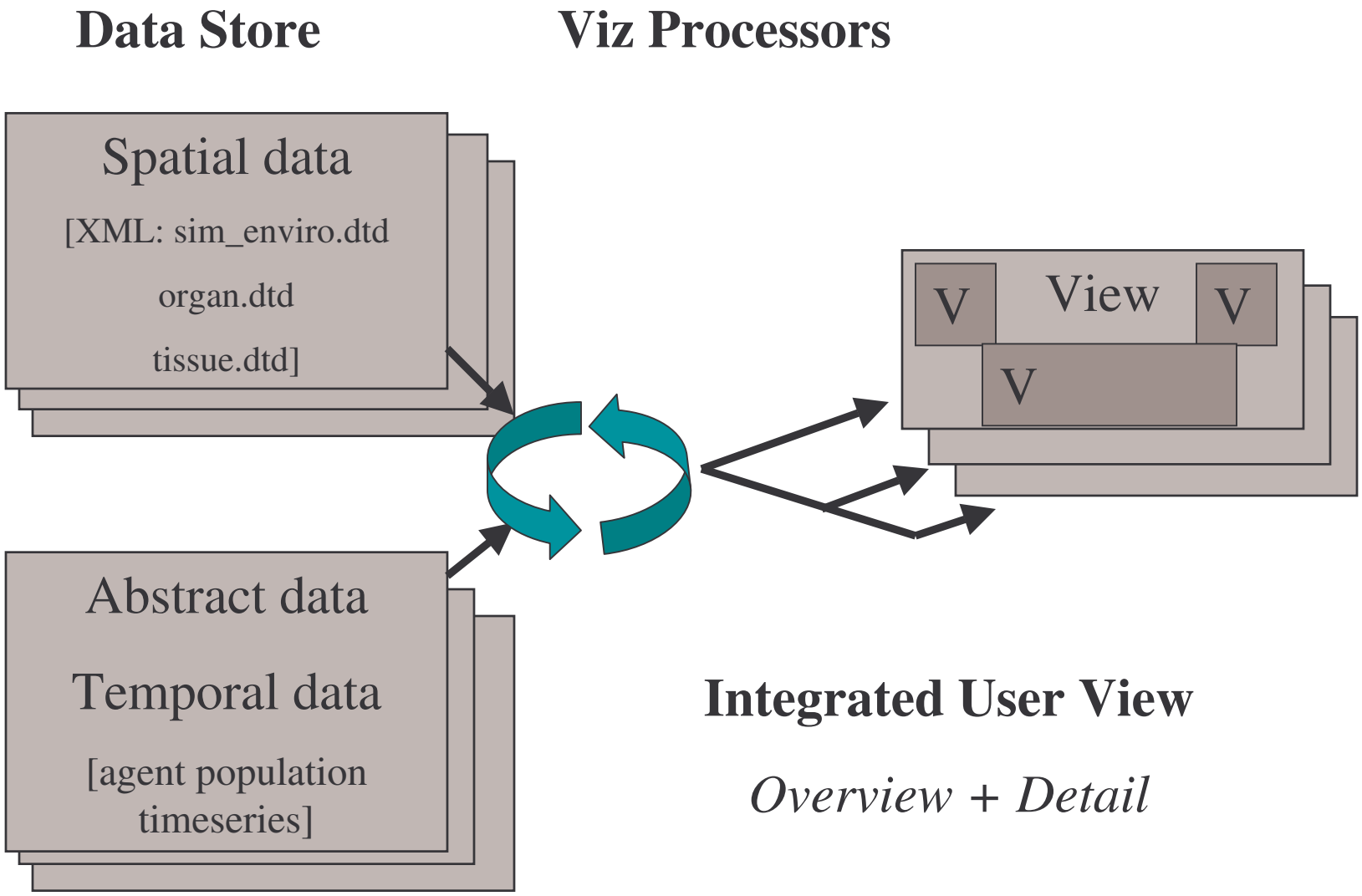
PathSim Visualizer



Integrated User View

Overview + Detail

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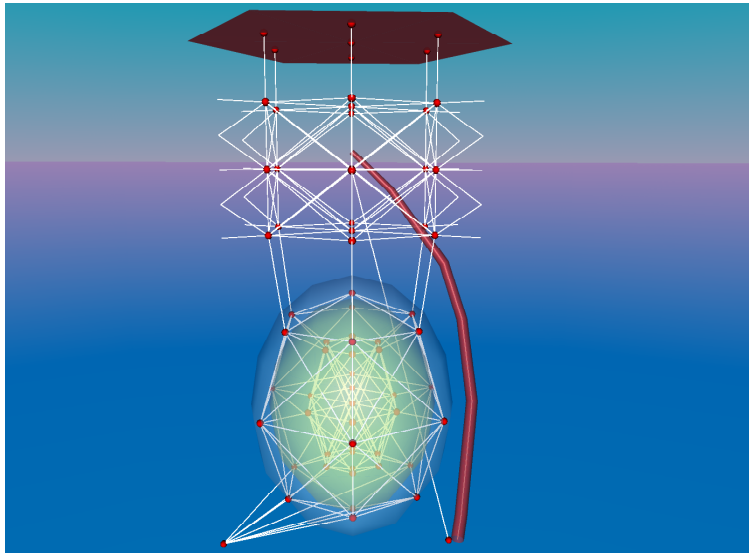
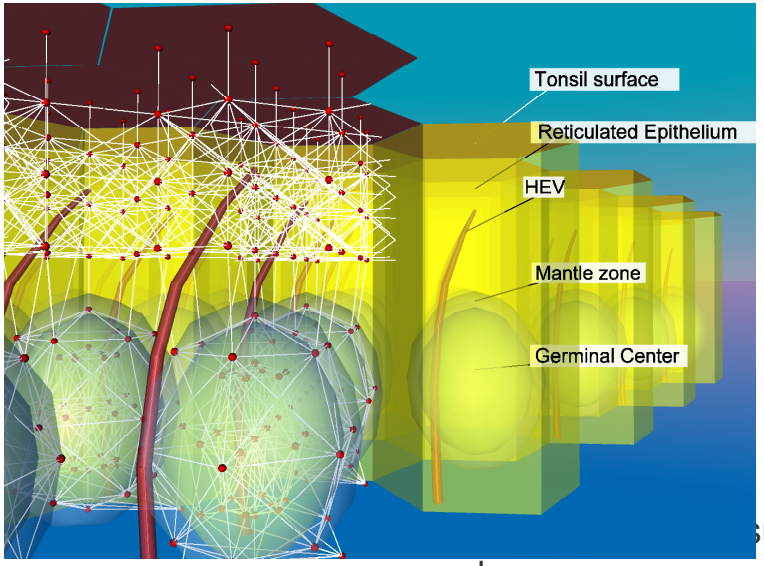
Application Example: PathSim Anatomy

Tissue



A micro-scale VRML view of the unit section tissue mesh translated from XML

Organ Part, Organ



sue mesh

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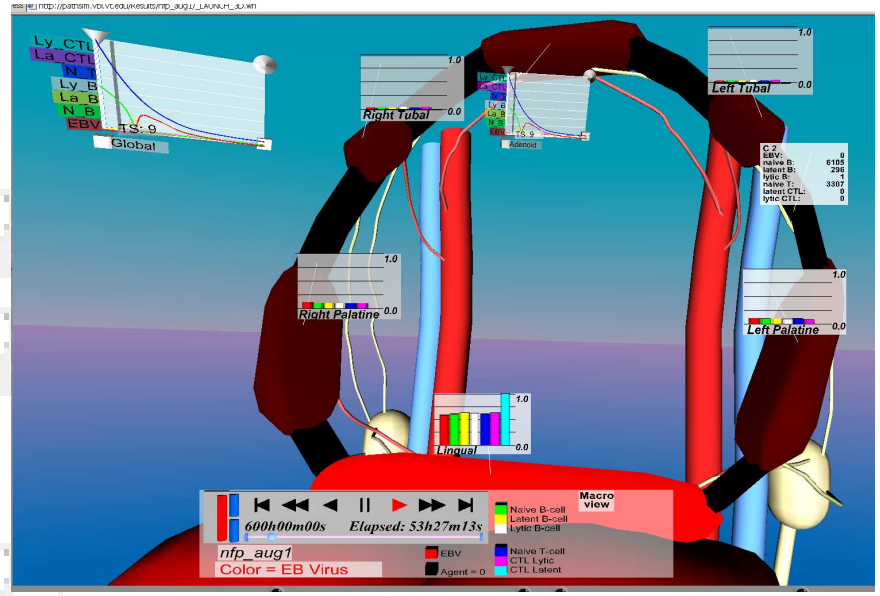
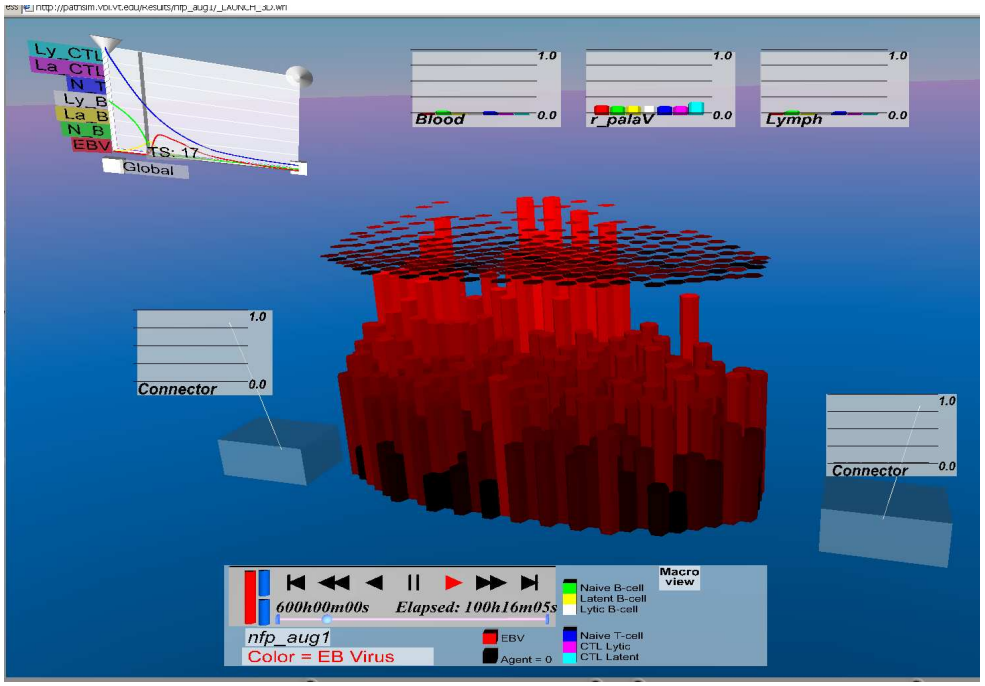
Application Example: Metadata and Annotation Layout

PathSim

Macro & Micro views of Agent-based simulation results





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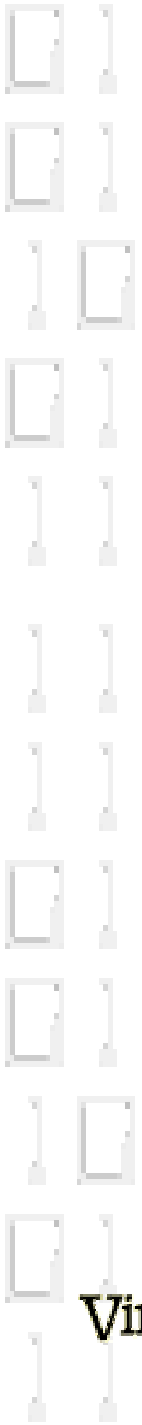

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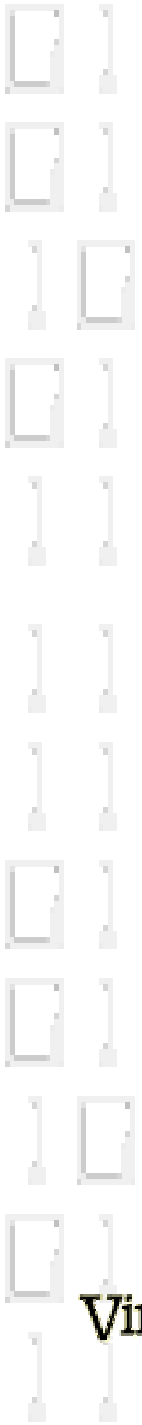

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