Engineering Virtual Environments with X3D

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Session Outline

- Polys: Overview, Case study: Bioinformatics
- Hetherington: Case study: Architecture
  - *Break -*
- Brutzman: Tactical Simulation, X3D content examples
- Gracanin: Traffic Visualization

Session Topics

- *Usability Engineering:* requirements to design
- *Content Engineering:* design and management
- *Application Architectures:* server, client-server, publish-subscribe
- *Delivery / Quality of Service:* accessibility, framerate, real-time interaction

Techniques

- Design of custom scene graph objects
- Composing content, behaviors, and interfaces
- Publishing interactive 3D content
- Connecting and integrating supplemental information with 3D worlds

Human-Computer Interaction

- Engineer software interfaces to support the user community
- Address issues of workflow, perception, cognition, action
- Understand how to provide appropriate spatial context
- Iterative development and evaluation
- Increase satisfaction and productivity

Requirements Analysis

Connecting

- User Activities
- User Workflow
- Implications of metaphors and technology
- System Requirements

Usability Engineering

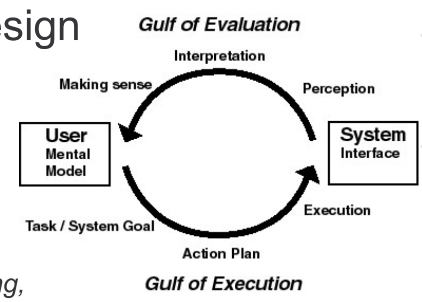
Where the rubber meets the road…

- Iterate design process to a pre-defined goal of performance / satfisfaction
- Scenario-Based Design:
  - Activities
  - Information
  - Interaction
  - Feature & Claims analysis

See:
ROSSON, M.B. AND CARROLL, J. 2002

Content Engineering

- Activities and Scenarios
- Information design
- Interaction design



Donald Norman,
Cognitive Engineering, 1986

Task-Knowledge Structure

- What information is required for the user to fulfill the various activities?
- Entity-Relationship diagrams for tasks and media

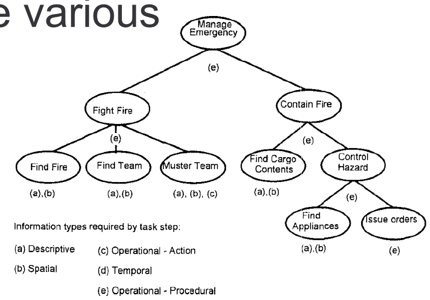


Figure 1 Task Model for Case Study Example

- SUTCLIFFE, A. AND FARADAY, P. 1994.

Designing Features

Armed with Scenarios and TKS, a typical scene production process will follow these steps:

1. Define environment & locations
2. Define user interface & viewpoints
3. Define interactions
4. Organize declarative scenegraph
5. Model objects
6. Build Prototypes
7. Transform data and compose visual markers
8. Deliver to user

Designing Objects

Protos :

- Abstraction
- Information hiding
- Encapsulation – transformation and behavior graphs
- Inheritance – not really; but
  first node of proto
  determines type
  (in X3DProtoDeclare)

X3Dnode <- is a--- X3DProtoInstance

OO
OO Analysis •Determine what the product is to do •Extract objects
OO Design Detailed design
OO programming •Implement appropriate OO programming language

Scenegraph Structure

- *Served Content type*
  - Header: Profile, Components, IMPORT/EXPORT
  - Scenegraph root
  - Custom node declarations: PROTO definitions and/or EXTERNPROTO references
  - Universe set (Backgrounds, global ProximitySensors)
  - User Interface / HUD
  - Scripts
  - World & Inhabitants set (lighting, geometry & objects)
  - ROUTEs

Target Scenegraphs

- Benefits of scene structures:
  - Modularity for composition / translation
  - Hooks for Scene Access Interface (eg DEF'ed Groups)
  - Improved readability & maintainability

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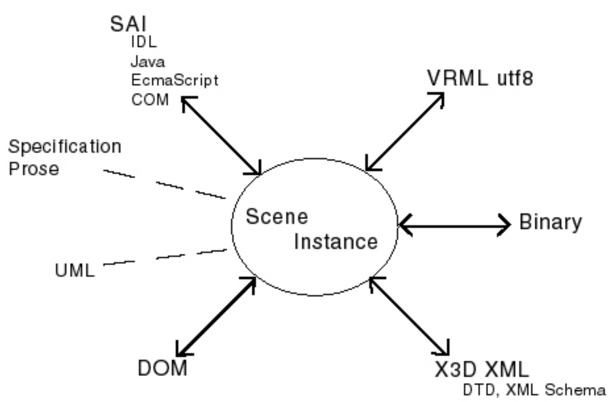
Target Scenegraphs



The abstract model of the scene graph is exactly the same for all of these representations.

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X3D Internet

- Multiple Encodings
- Leverage XML tool ecology to provide single content source in multiple representations / forms
  - Well-formedness & validity (.dtd, .xsd)
- XSLT Stylesheets via Spec group
  - .x3d -> .x3dv
  - .x3d -> .wrl
  - .x3d -> .xhtml
  - .x3d -> .html

Authoring Tips

•Use IndexedFaceSet; avoid Sphere

•Avoid deeply nested transforms

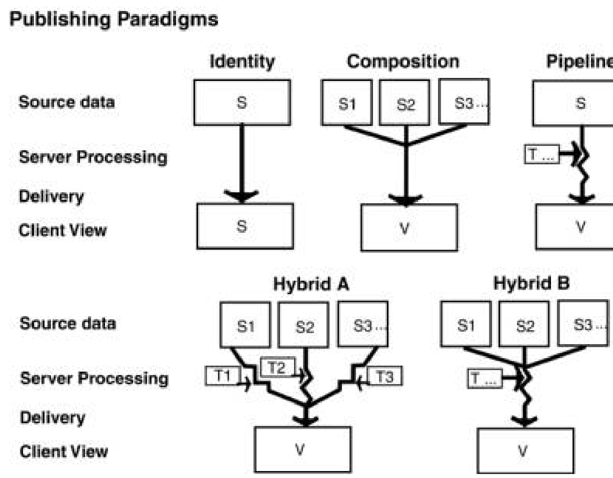
•As often as possible, do not scale or transform objects into position

•Divide large worlds according to desired user experience

(with LODs, VisibilitySensors and Switches)

- Self-sufficient scene blocks may be instantiated as Inlines

Publishing Paradigms



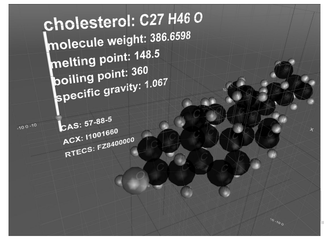
Application Logic

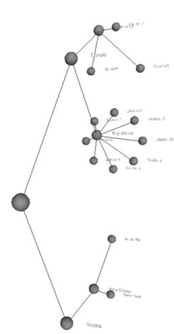
Client or server delivery:

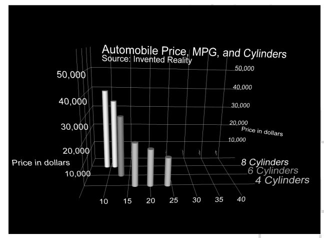
- Declarative: Files
- Programmatic: Scene Access Interface

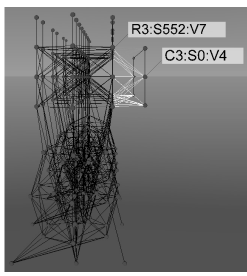
XSLT Examples

- Chemical Markup Language
- Auto data
- VoteSmart
- PathSim









General Problem: Integrated Information Spaces

- Complex systems typically span multiple scales and involve heterogeneous data
- Engineers, researchers, and analysts need to access and manage a wide variety of information types and their inter-relationships

Fundamental Data Types

- Spatial / perceptual data:
  geometry, colors, textures, lighting
- Abstract data / world & object attributes:
  nominal, ordinal, quantitative
- Temporal data / behaviors:
  state dynamics

Information-Rich Virtual Environments =

Virtual Environments
+ Information Visualization

Delivering:
- Temporal information
- Spatial / Perceptual information
- Abstract information

Rendering abstract information

- Text: Autosized & padded, background panel with specifiable Appearance; Unstructured and simple table flavors
- X3D AMD 1 provides better sizing control for text
- Other interaction objects:
  - graphs (2D/3D),
  - images,
  - audio/video clips,
  - hyperlinks

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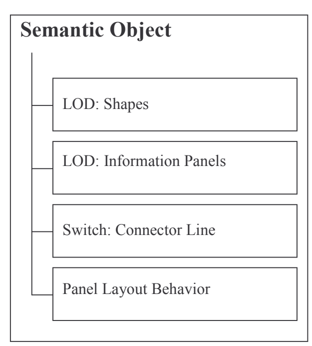
Registering abstract information to spatial objects

- Encapsulated layout behaviors:
  - LODs
  - Connector
  - Layout behaviors:
    - Annotation scale
    - Annotation location (object, world, user, viewport, display)
- Abstraction may extend to immersive displays



Encapsulating information display behaviors in the PathSim IRVE

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Guaranteed LOD

- Current LOD is designed for proximity-based filtering of geometric models and is subject to engine resources
- Underspecified for scenegraph management:
  - Guarantee child switching at range
  - Expose active child for SAI access
- X3D AMD 1 added `level_changed`

MFSequencers

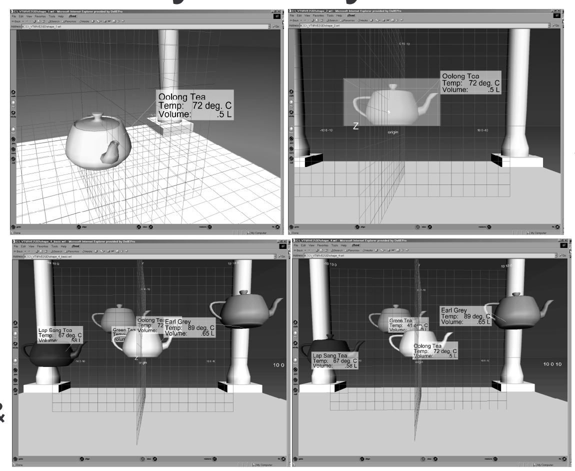
- Interpolators do not accurately represent simulation validity
- A given simulation uses the same `Timesensor { key []}`
- Current Spec requires `Script {}` overhead
- Float and String types with batch, cover other data types: e.g. SAVAGE work

Object-fixed Annotation Layout styles

Layout rules:

User-object transformation

Relative orthogonal



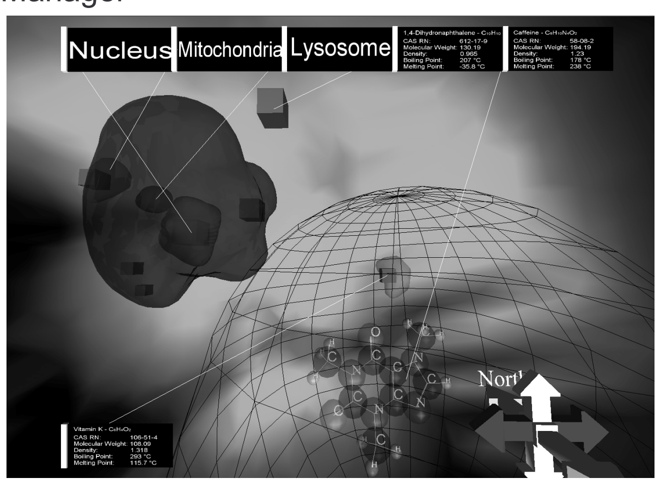
Bounds

Requires Scene level Access for UI & Layout

Flocking to Bounds

Viewport space layouts

BorderLayoutManager

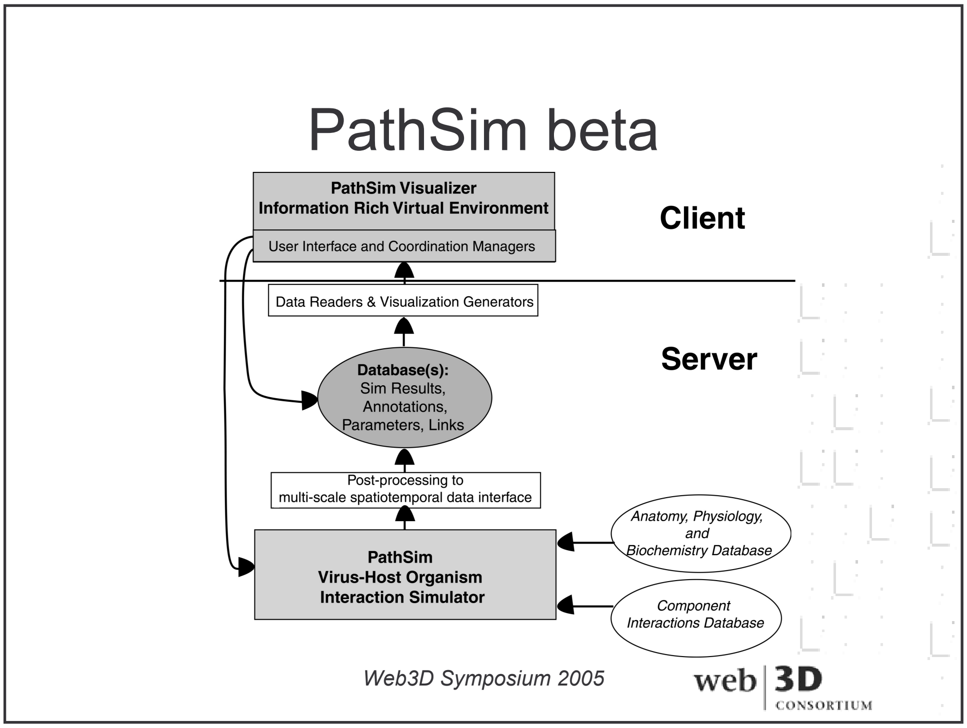


PathSim

- 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

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


PathSim beta
PathSim Visualizer
Information Rich Virtual Environment
User Interface and Coordination Managers
Client
Data Readers & Visualization Generators
Server
Database(s):
Sim Results,
Annotations,
Parameters, Links
Post-processing to
multi-scale spatiotemporal data interface
Anatomy, Physiology,
and
Biochemistry Database
PathSim
Virus-Host Organism
Interaction Simulator
Component
Interactions Database
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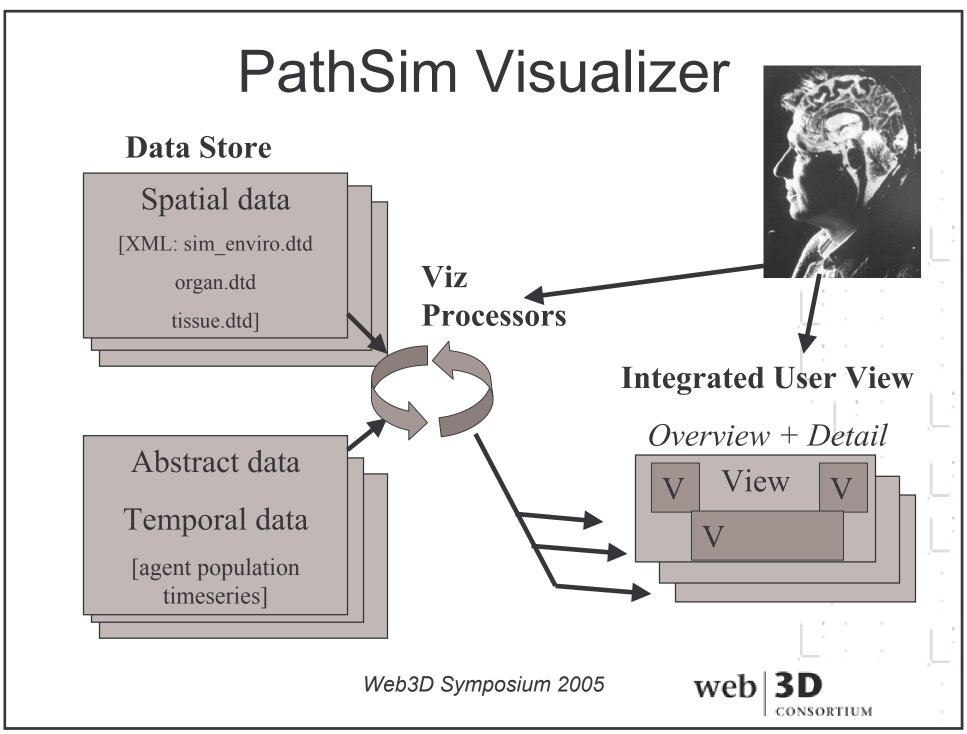
PathSim Visualizer
Data Store
Spatial data
[XML: sim_enviro.dtd
organ.dtd
tissue.dtd]
Viz
Processors
Integrated User View
Overview + Detail
Abstract data
Temporal data
[agent population
timeseries]
V
View
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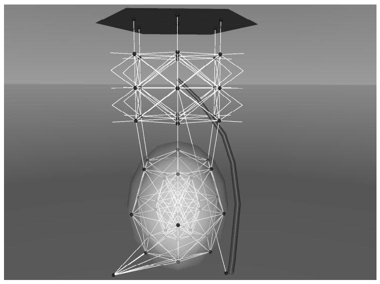
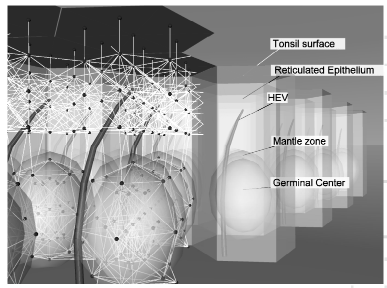
PathSim Anatomy

Tissue



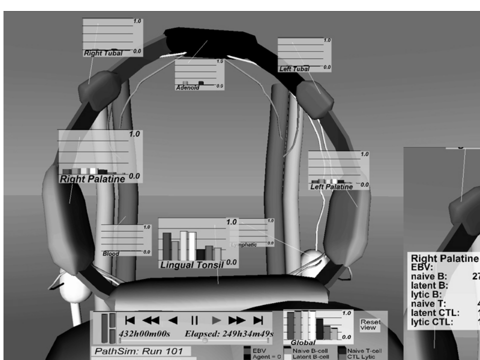
A micro-scale VRML view of the unit section tissue mesh translated from XML

Organ Part, Organ



A micro-scale, labeled view of a tonsil tissue mesh

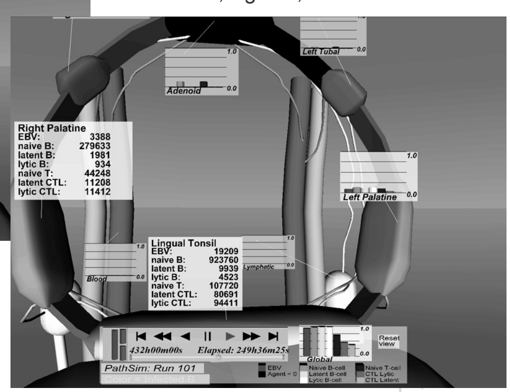
PathSim Simulation Results



Sim enviro: multiple organs and systems

Gross anatomy

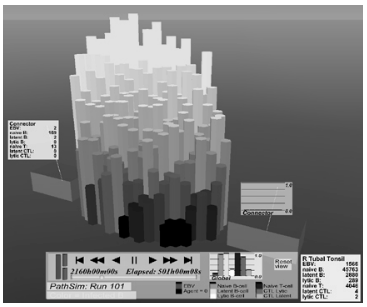
Parameters, Agents, Timeseries

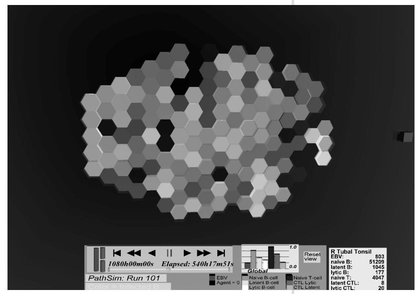


Unified with Annotation Panels: zoom, toggle view

PathSim Results

- Redundantly encoding population values for sensitivity (color, height)
- Using transparency mappings and color blending





Future PathSim Usability Engineering

- What are the features that will help PathSim be a usable tool and fit into the biomedical research workflow?
- How much spatial context is required for effective search and comparison?
- What are the most effective 2D visualizations for spatially referenced agent populations for finding patterns and trends?
- What is hard and easy about 3D navigation ?

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