Building Large-scale Interactive Systems with OSC, Siren, CSL, and CRAM

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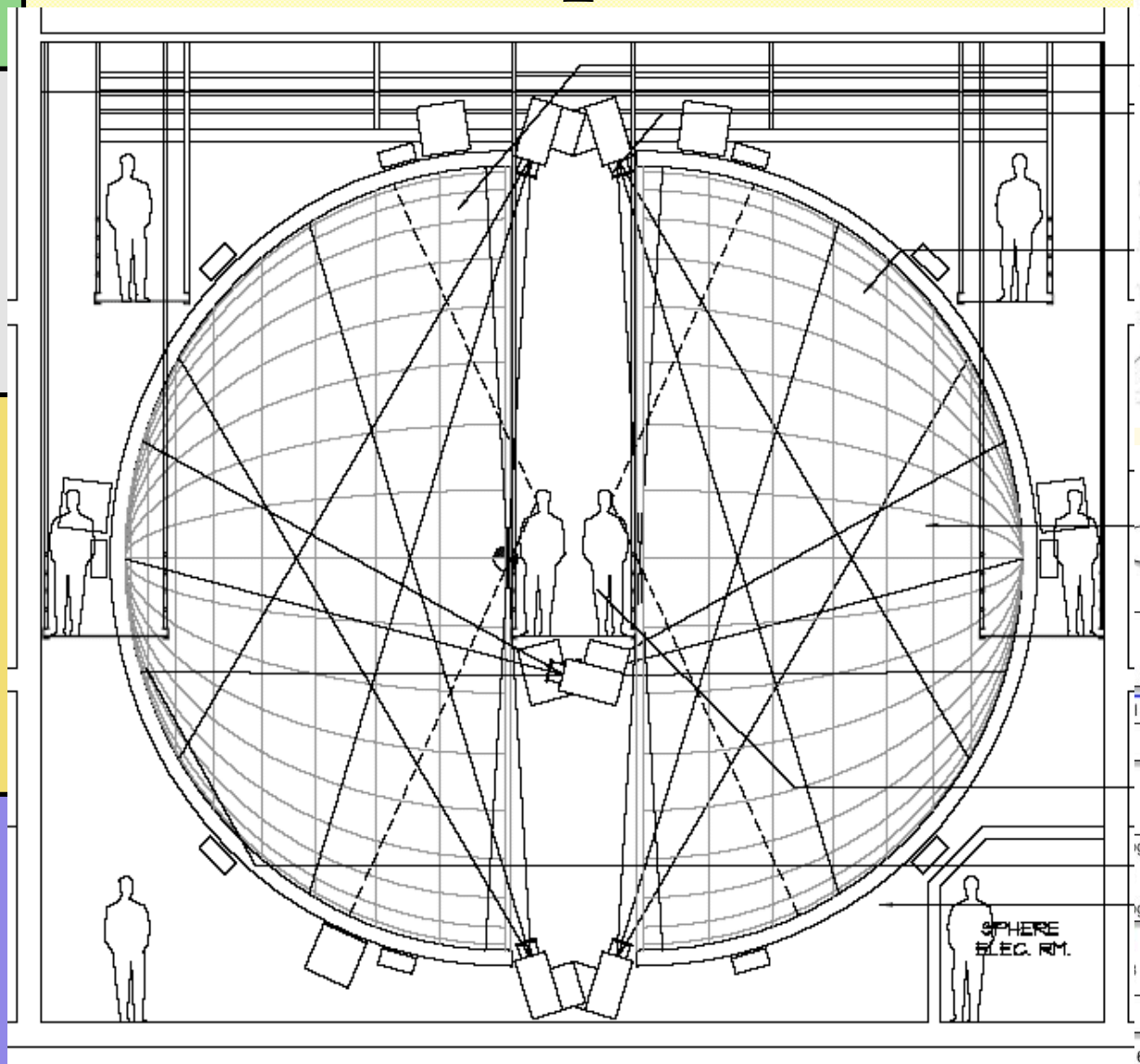
HW/SW Components

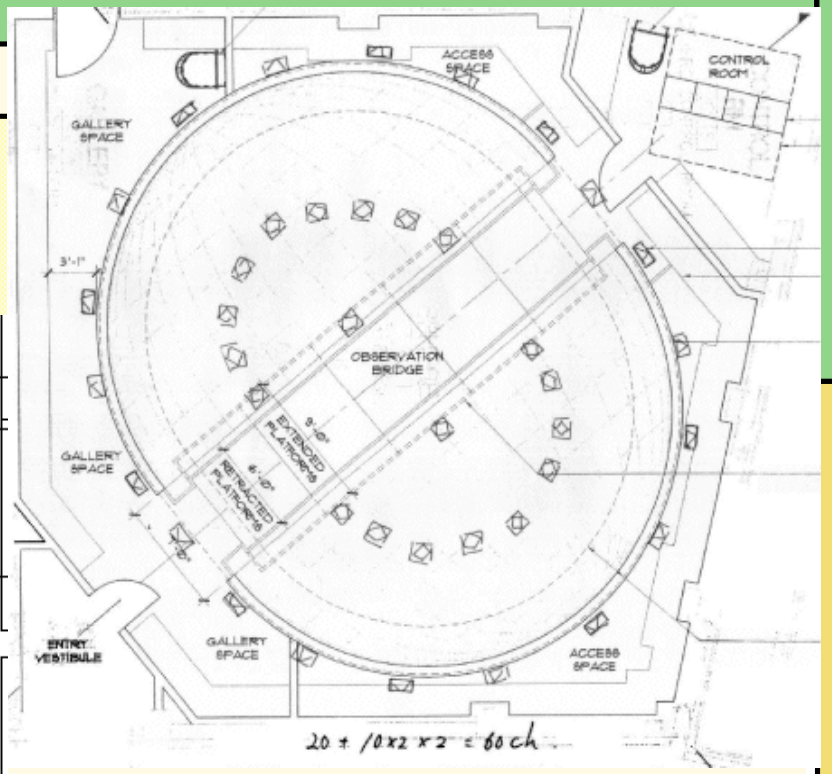
- **Siren**: Hierarchical/procedural representation for composers (OSC out)
- **CSL**: Scalable DSP framework (OSC srv)
- **CRAM**: Cluster management for distributed RT OO software (Mgr)
- **CNSI Sphere**: A really cool loud/bright/sensing space to play in!

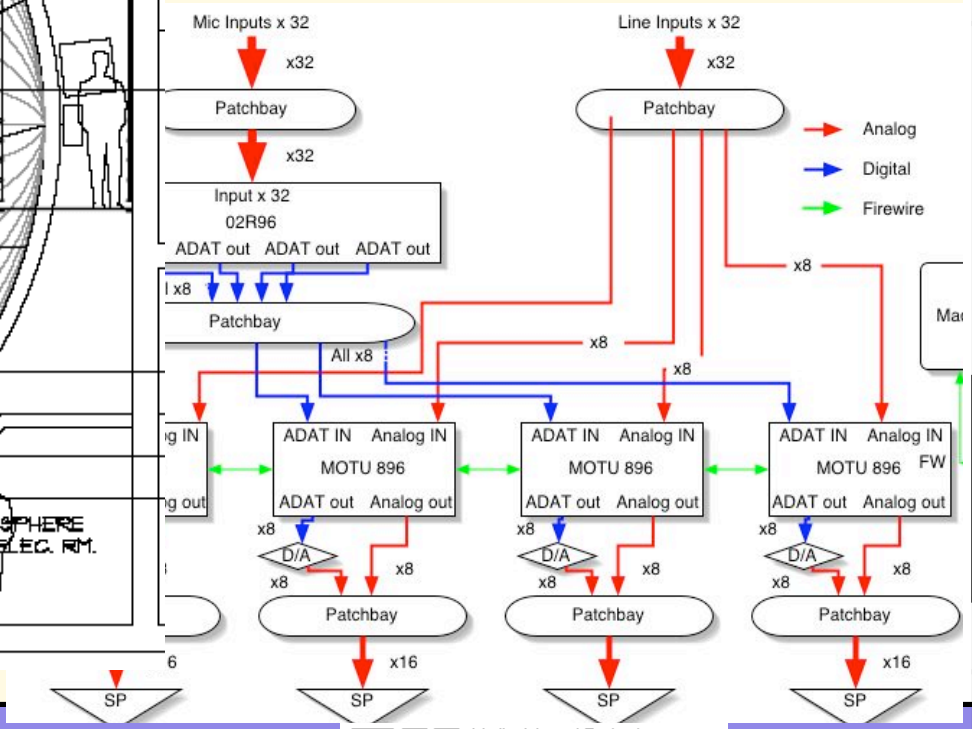
Cal. NanoSystems Inst. @ UCSB

- MAT in CNSI: labs, studios, workshops, sphere
- CNSI compute infrastructure
  - Traditional vector supercomputer
  - 1024-node Linux cluster
  - Multimedia processing cluster (TBD)
- Sphere: 3-story I/O space
  - 12-channel overlapping video output
  - 128-channel sound output
  - Camera/microphone/sensor multi-modal input

CNSI Sphere







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How? DSCP!

Distributed Sensing, Computation, and Projection = MVC on steroids

Back-end application models are scientific/numerical/simulation

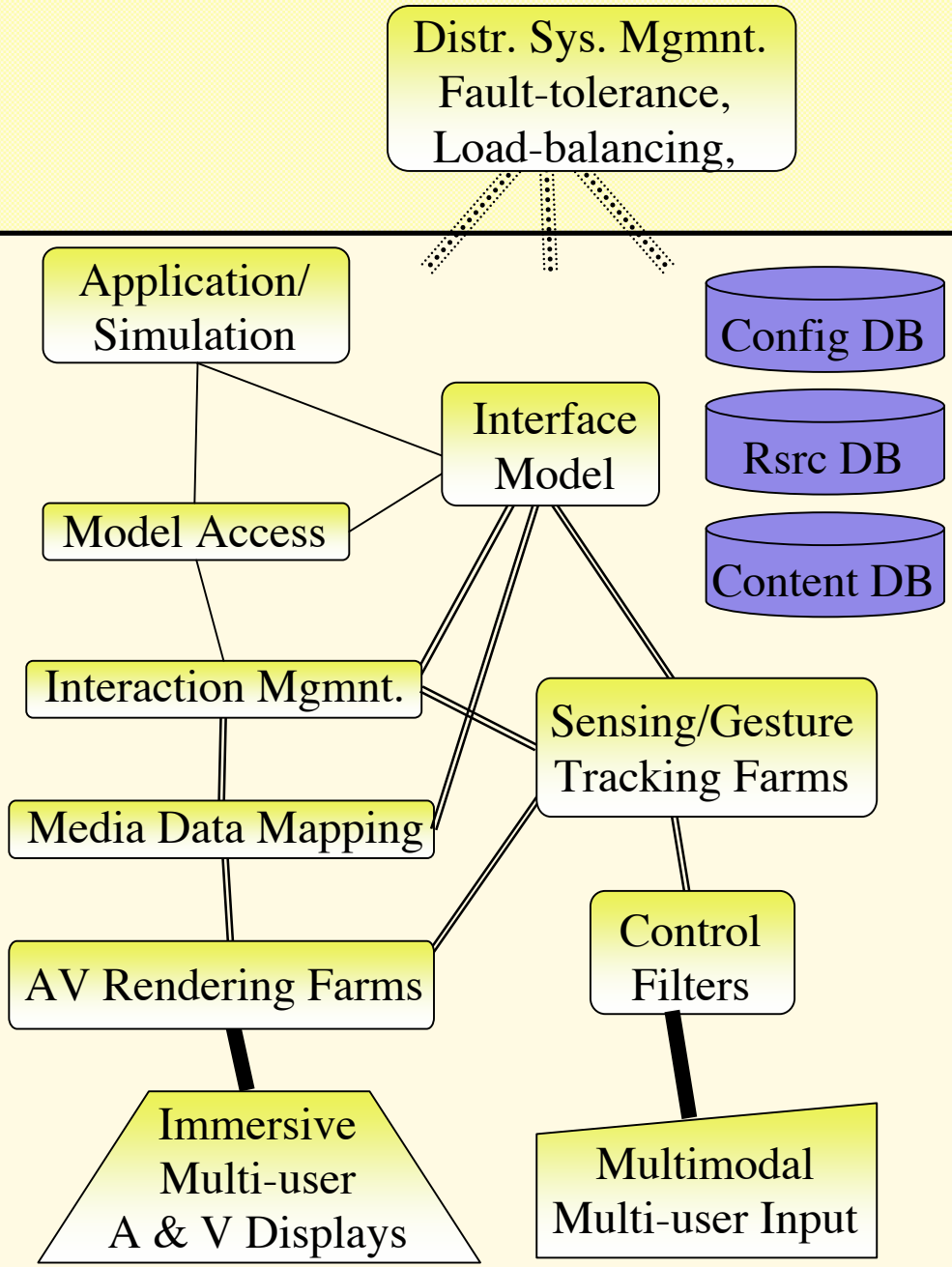
Multimodal multiuser **sensing/control** and tracking/mapping farms

Application = sensing/tracking policies + output data mappings

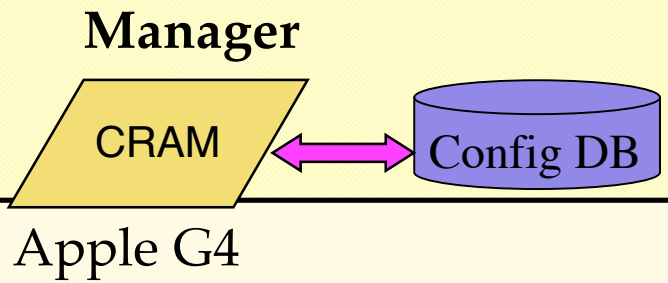
Presentation/interaction via CNSI Sphere, LAN/WAN streaming

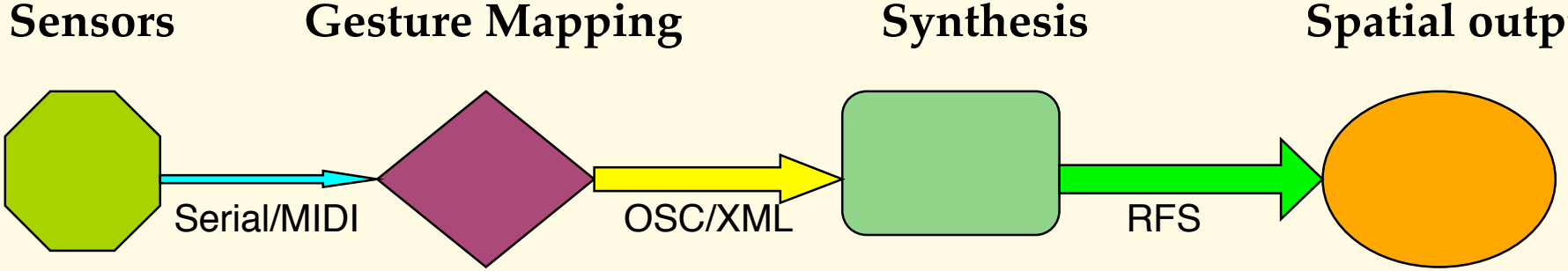
Infrastructure uses CRAM mgmnt

DBs for configurations, resources, and media content (renderers)



Current *Sphere-lite*





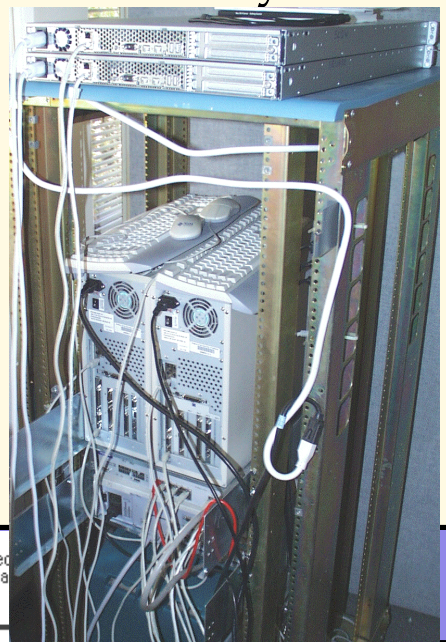
MIDI
Matrix
Graphonic
OT_Kbd
Creatovox
VR Trackers
Mot. Capture
AdC_Panner
(LAN is switched 1000BaseT)

Wintel PCs
Apple G5s

Apple Xserves
Apple G5s/G4s
Sun Ultras
SGI Octanes

Apple G5
Echo Layla

Interfaces
Occam/Macco
OscAR



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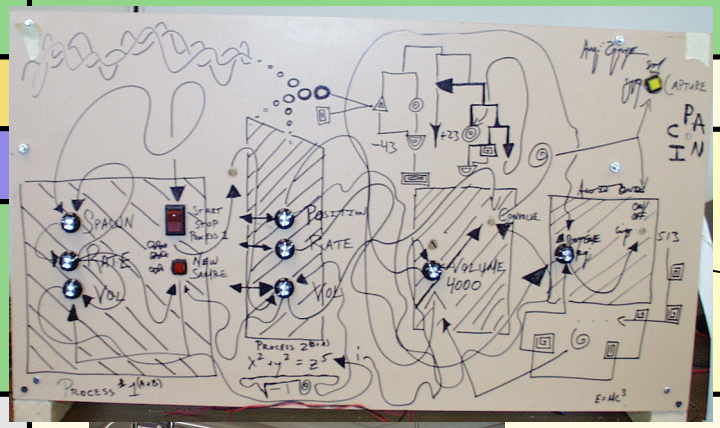
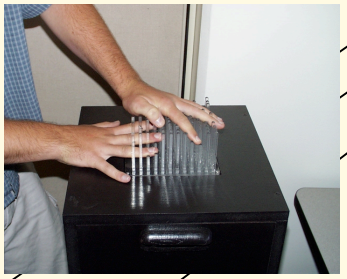
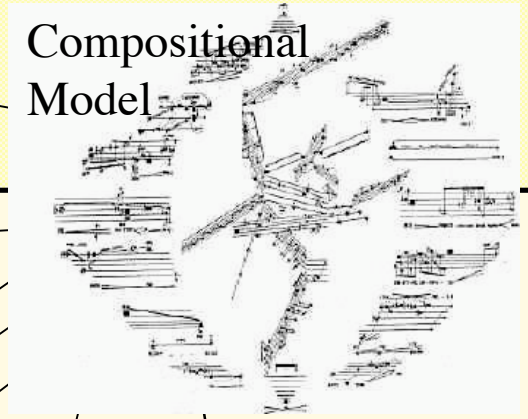
In Pictures

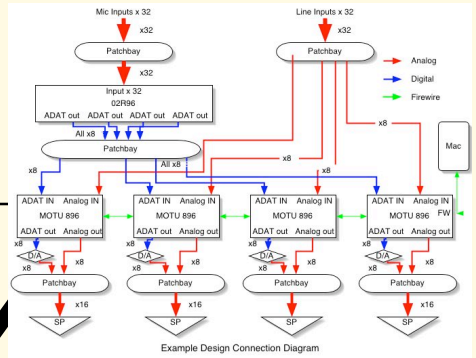




Compositional Model

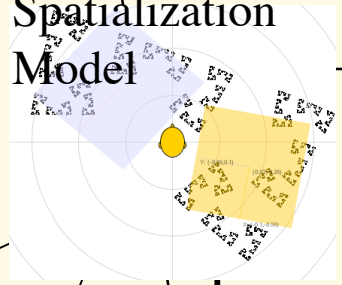


Output Drivers



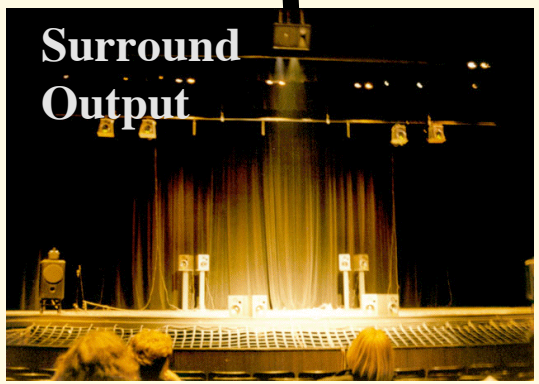
Gesture Sensors

Spatialization Model



CSL Server Farm

Surround Output



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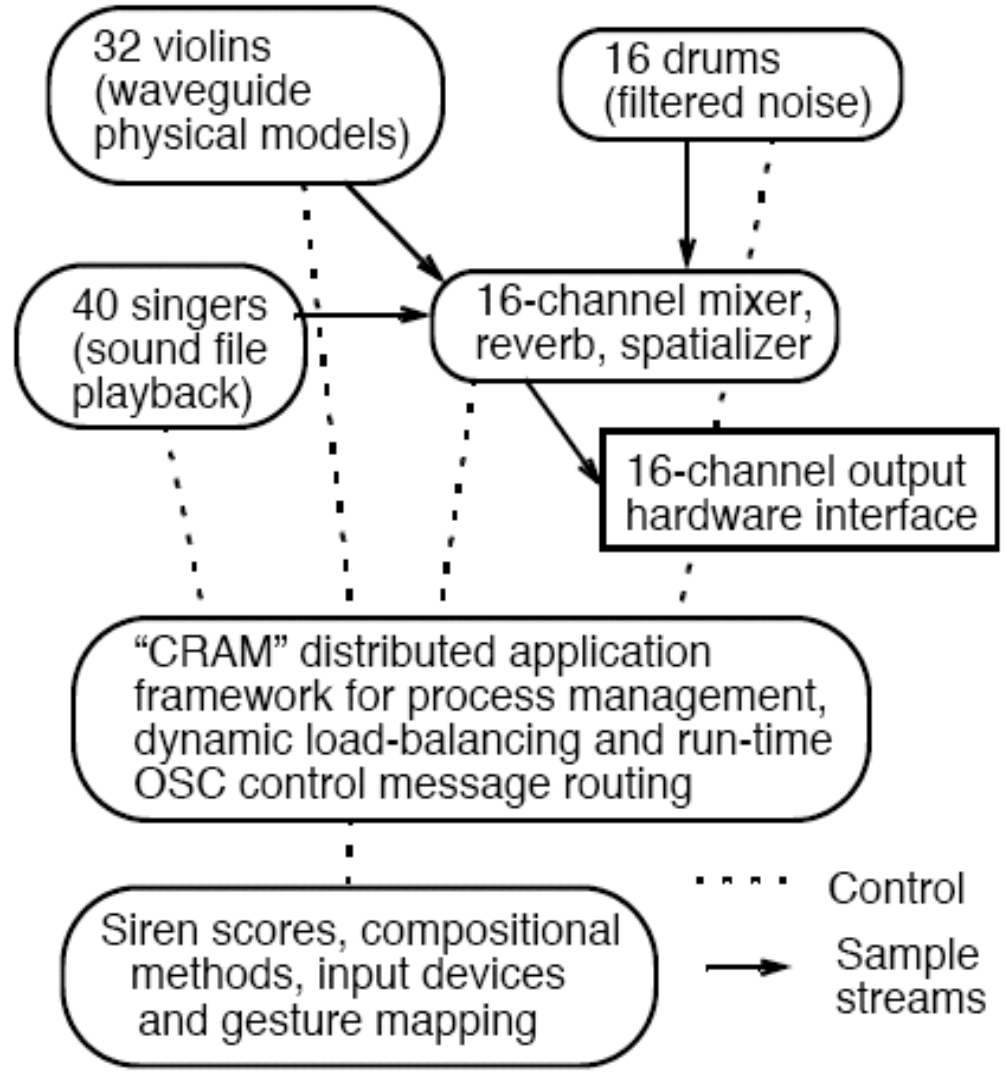
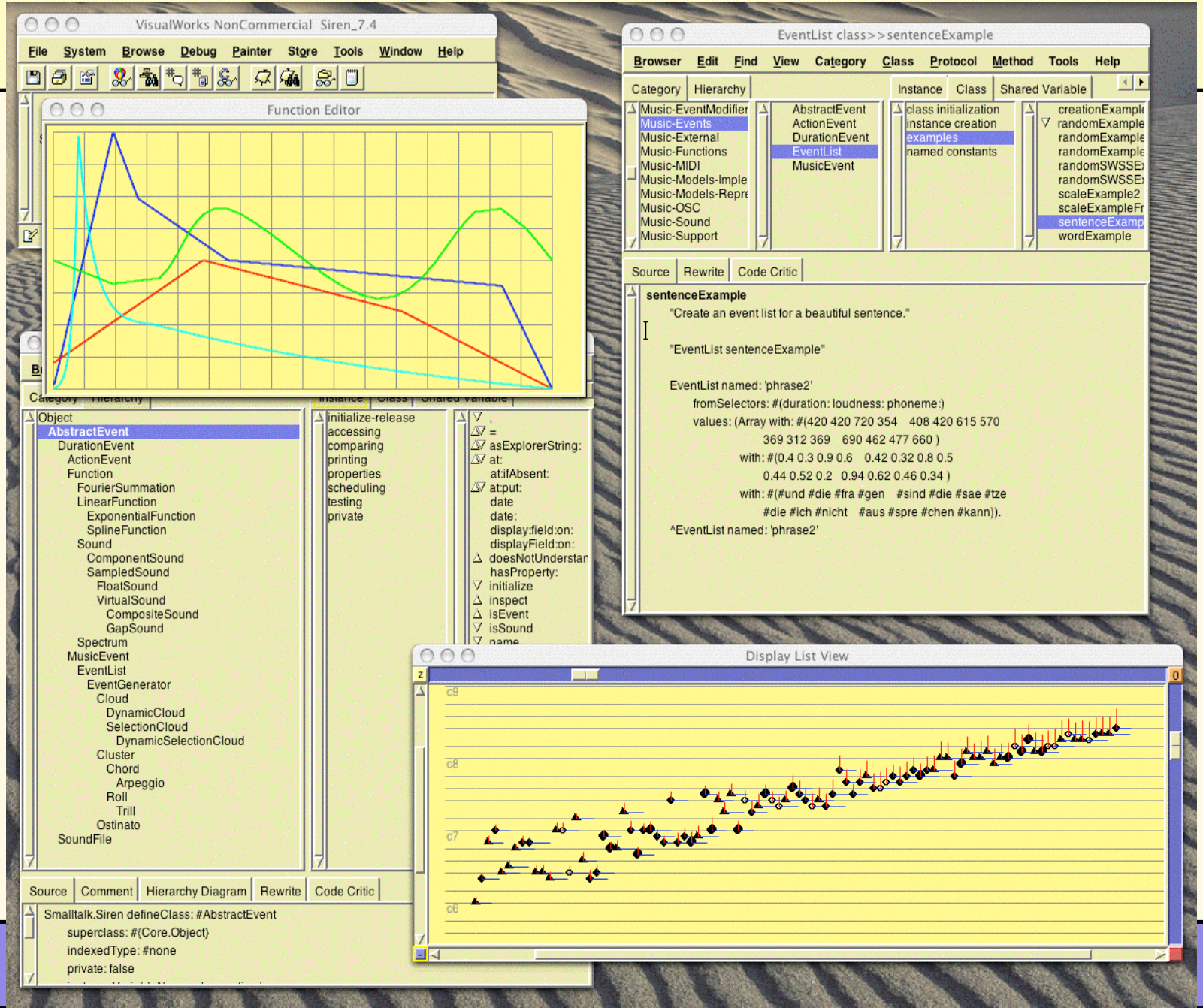
Networked Synthesis / Performance

- Managed "orchestra-scale" sound synthesis, multi-modal gestural sensing and control, and pluriphonic projection (up to 128 channel output in the CNSI sphere)



Siren 2003 (VisualWorks)

Demo

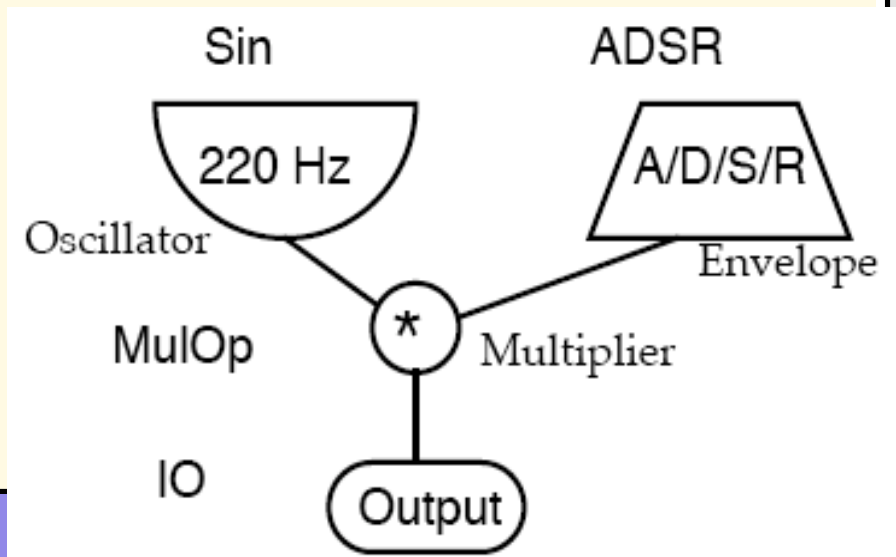


CSL "Hello world" Program

Demo

Sine wave with envelope

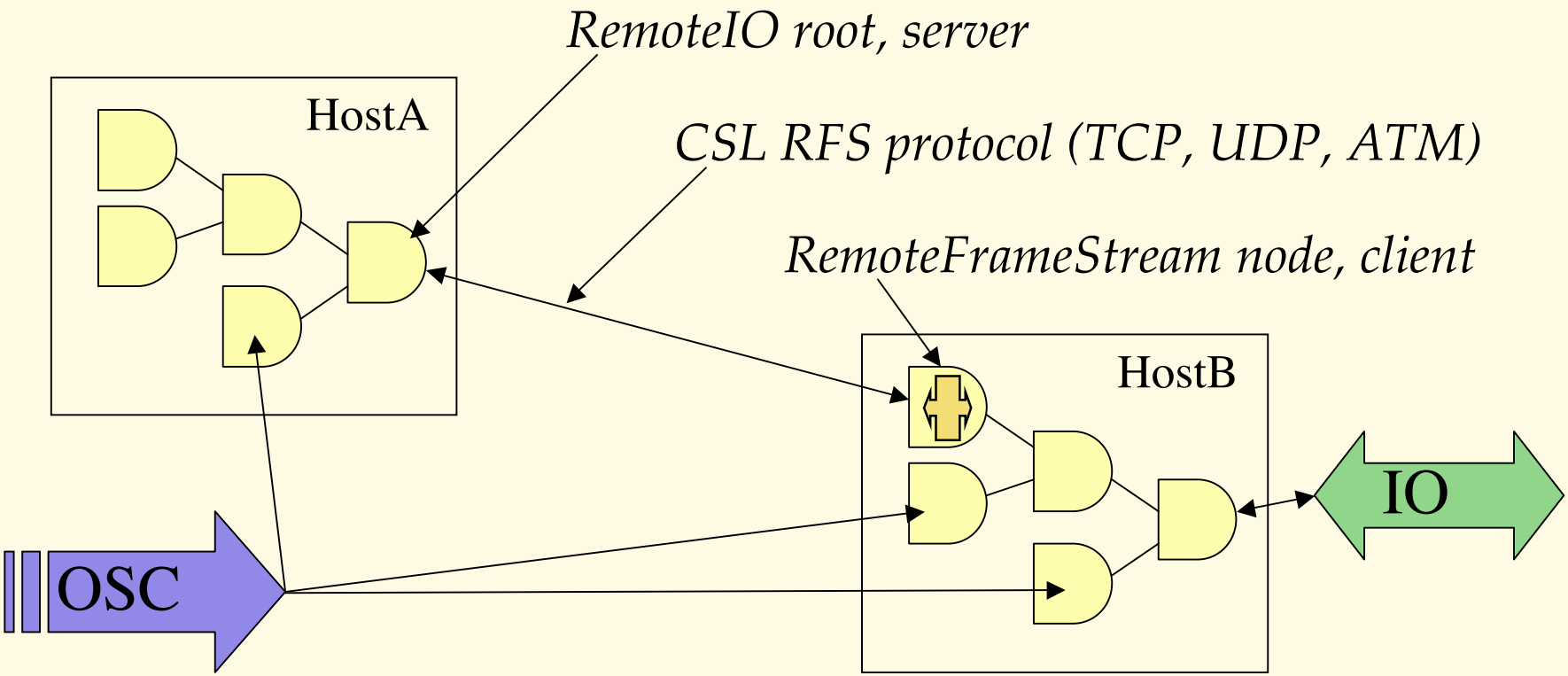
```
// Create a sine oscillator -- this is a comment
        Sine osc(220.0);
// Create an ADSR envelope -- args are (dur, a, d, s, r)
        ADSR env(3.0, 0.06, 0.2, 0.2, 1.5);
// Create a multiplier
        MulOp mul(osc, env);
// Plug it into the output driver
        globalIO.set_root(mul);
```



Multi-host CSL Graphs

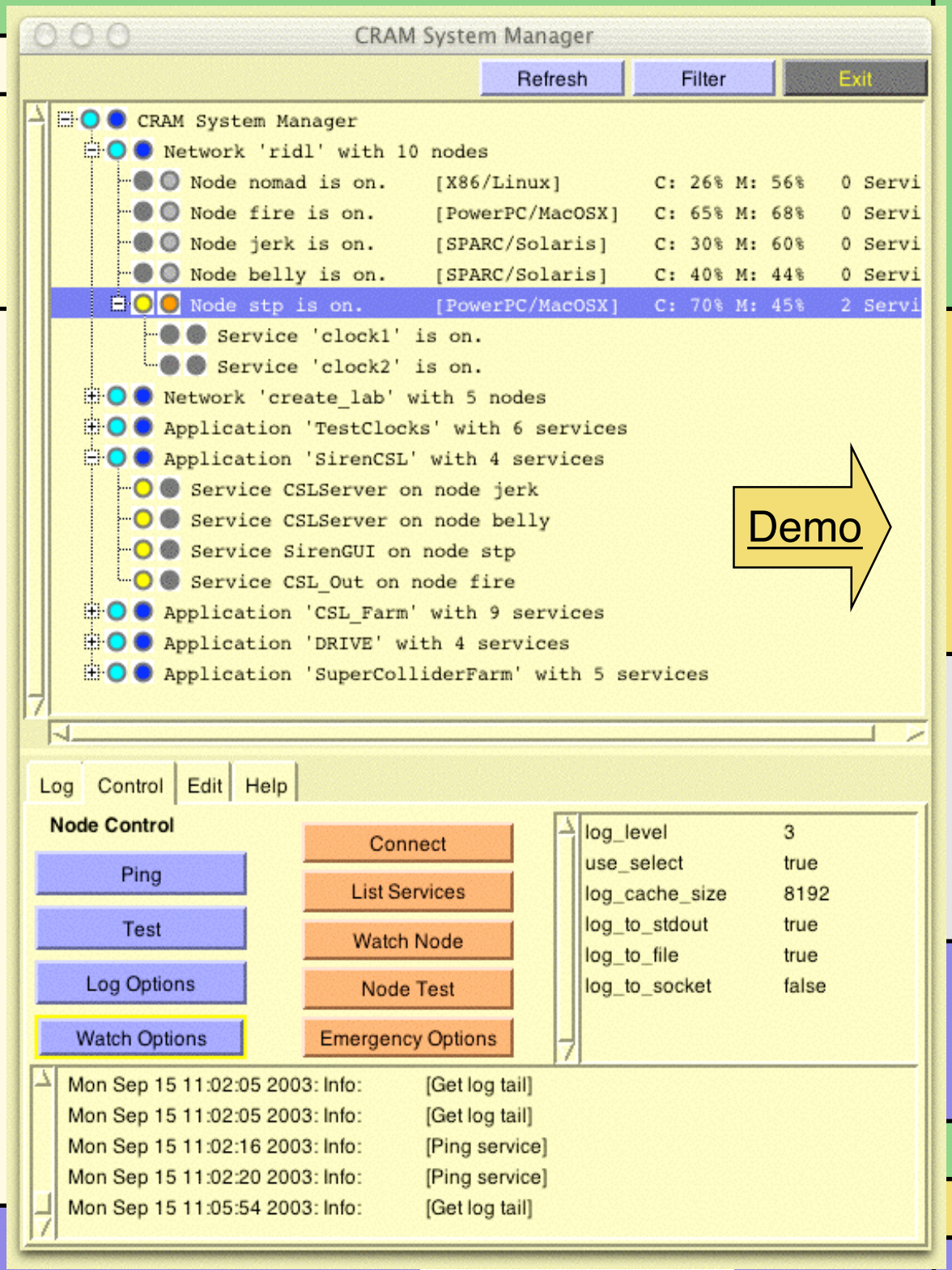
Demo

- Distributed sub-graph processing with RemoteIO and RemoteFrameStream, RFS protocol, buffering



CRAM Manager

- Network/Node
- Node/Service
- Application/Service
- Log/Control pane
  - Run-time monitor
  - Planning
  - DB play-back



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GestureSensor Drivers & Servers

- Reusable sensor driver framework
  - Serial in, cacheing/differencing/throttling, OSC out
- GestureSensors: receive OSC or MIDI

```
void * mData;            // data array (typically a float *)
char * mCmd;             // OSC command (without the '/')
char * mTypeString;      // OSC type string, e.g., "ffff"
```

  - Event input thread mgmnt
  - Parsing and differencing
  - Map to static or global data or messages
- Subclasses
  - Glove, Ebeam, Matrix, FOBirds, AdC_Panner, etc.

CV-to-OSC

- **Multiple-camera 3D motion tracking of multiple sources**
- **Data mapping for sound synthesis and transformation algorithms**
- **Intelligent trans-media system that learns and adapts, based on memory of the actions and states of the sensor space**

Siren (MODE, HSTK, DoubleTalk)

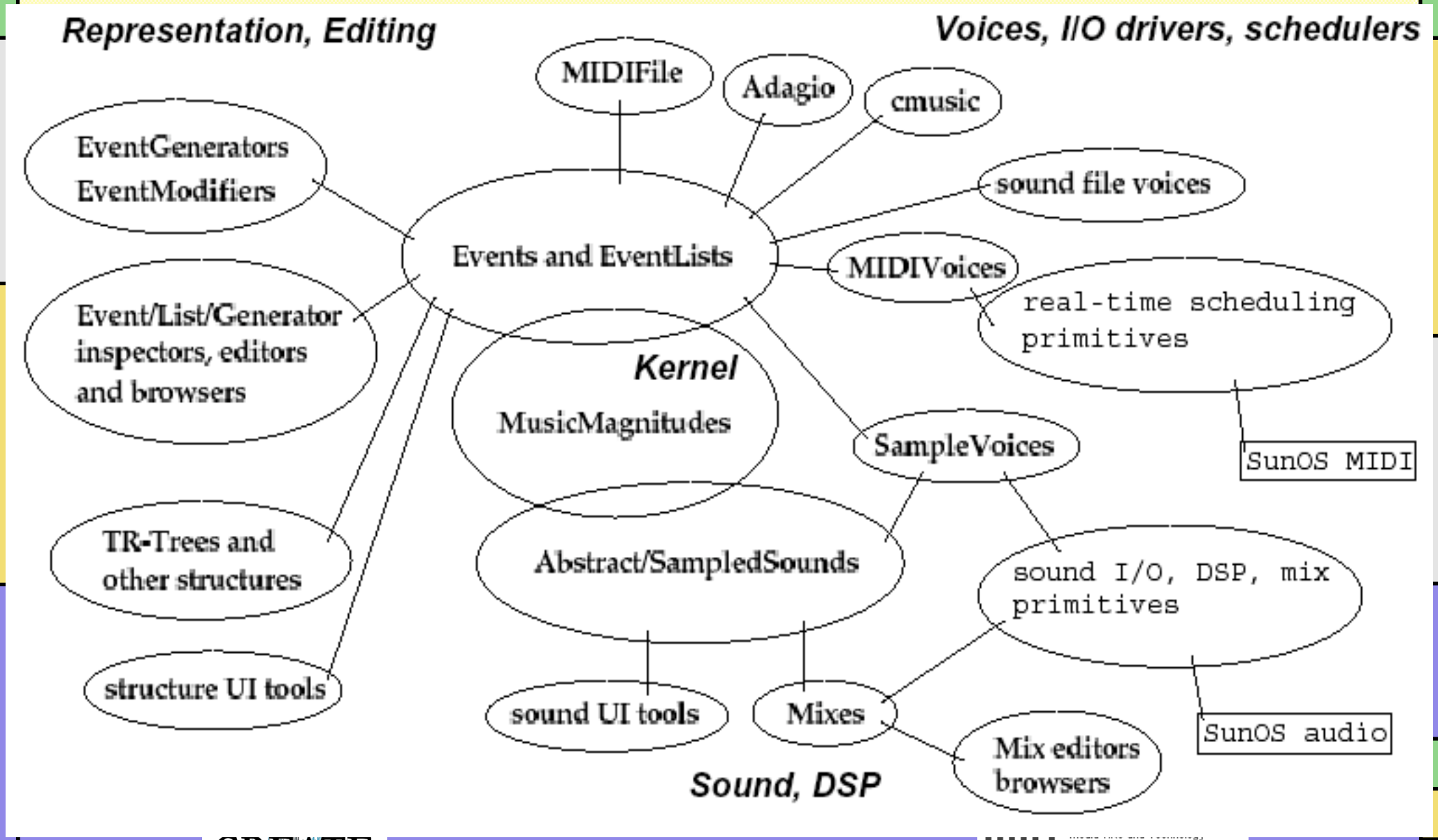
- Smalltalk-based object-oriented framework for sound/music description and processing, under development since 1984
- Focus on structure representation, control mapping, and composition, rather than on performance, DSP, or notation
- API/Platform for music representation and composition language development

What's Siren?

```
[440 Hz, (1/4 beat), 44 dB]
evtList mapPItches: gamut.
evtList playOn: Voice default.
```

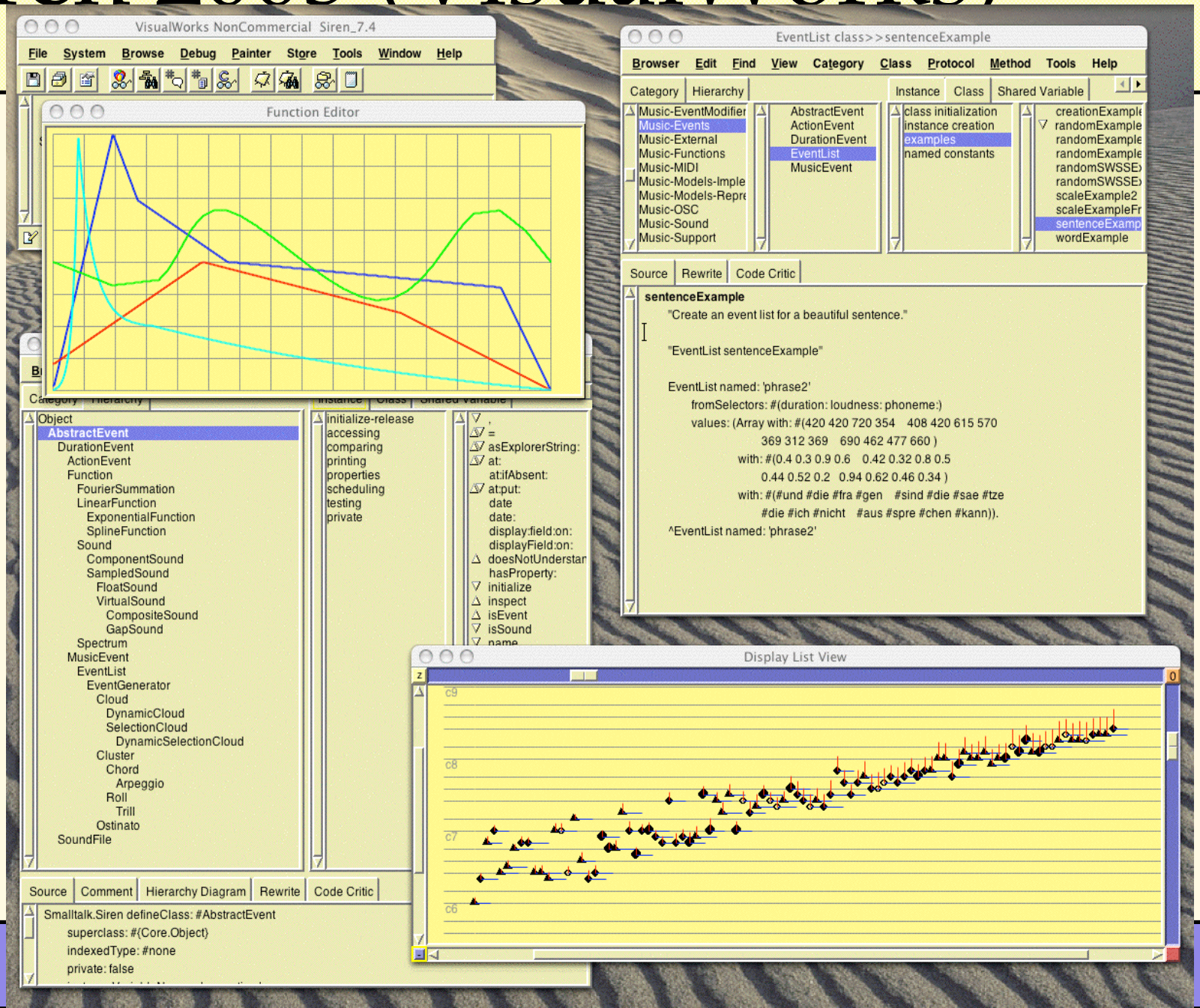
- **Smoke** music representation language
  - Music magnitudes, events, event lists, generators, modifiers, struct. algorithms, …
  - Organize timing, tuning, timbre, space, gesture, grouping, versioning
- I/O **voices** (players, property-parameter mappers) for many formats: (m11-SC3) note lists, OSC, MIDI, XML, CORBA, …
- Multi-threaded RT **scheduler**
- GUI **widgets** and apps for music
- (OO/R)DBMS interfaces for **persistency**

Siren Components (1992)

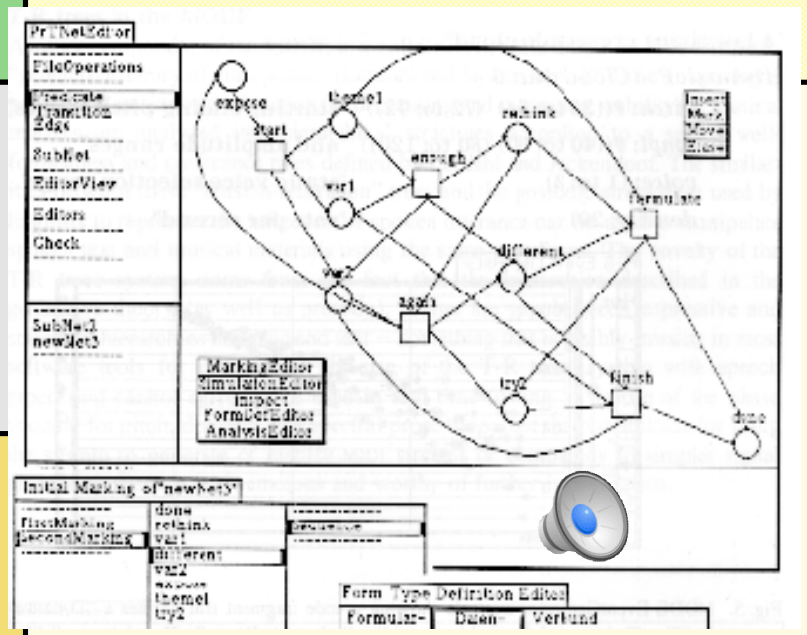


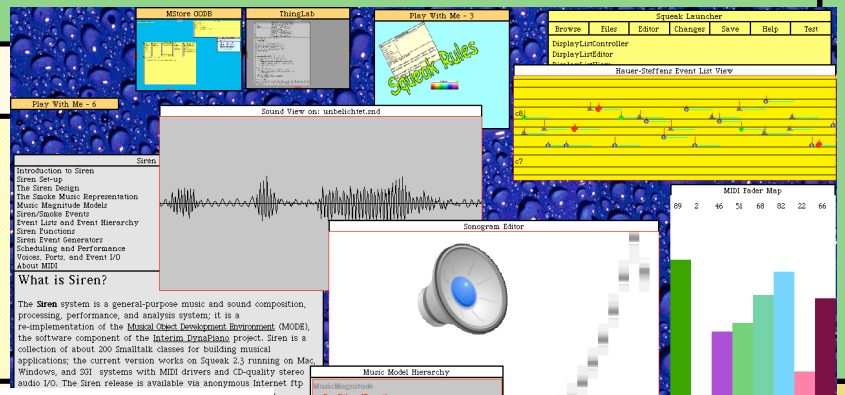
Siren 2003 (VisualWorks)

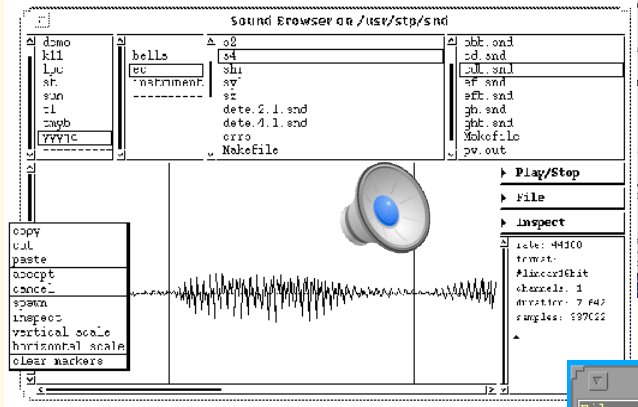
Demo

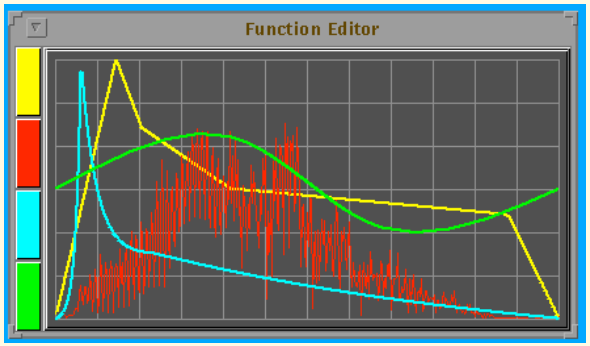


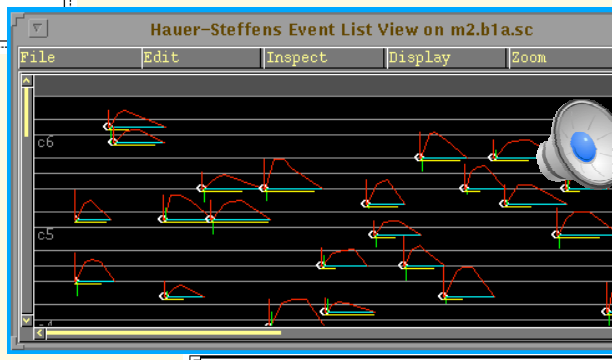
Siren Tools 1984-2004

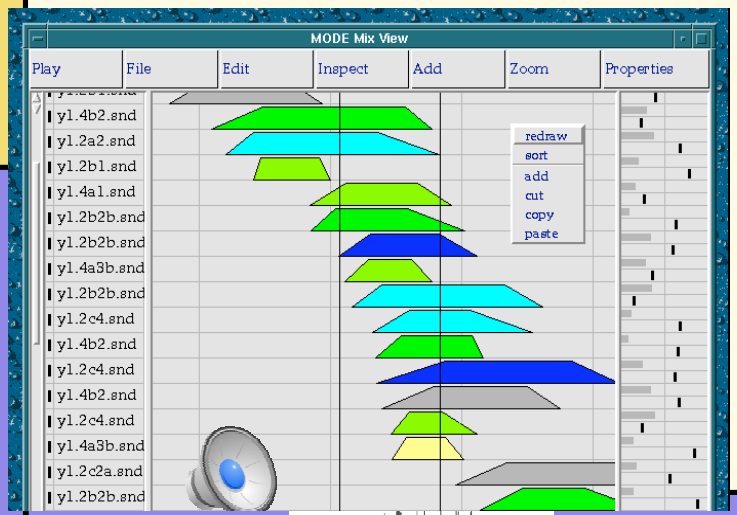


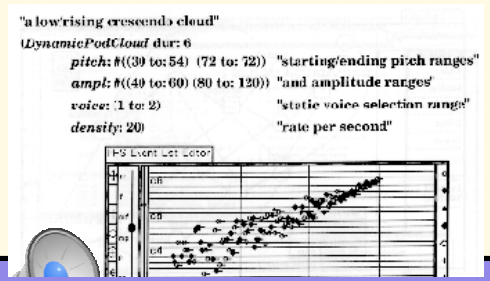


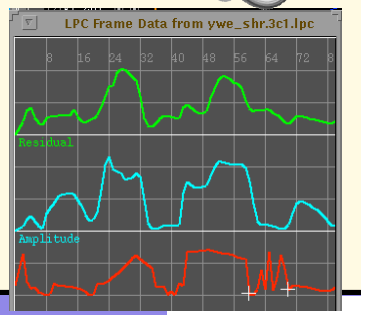


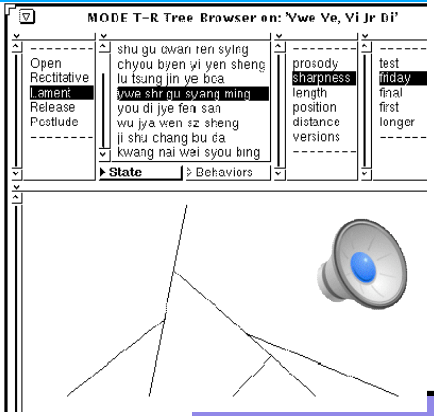












CREATE

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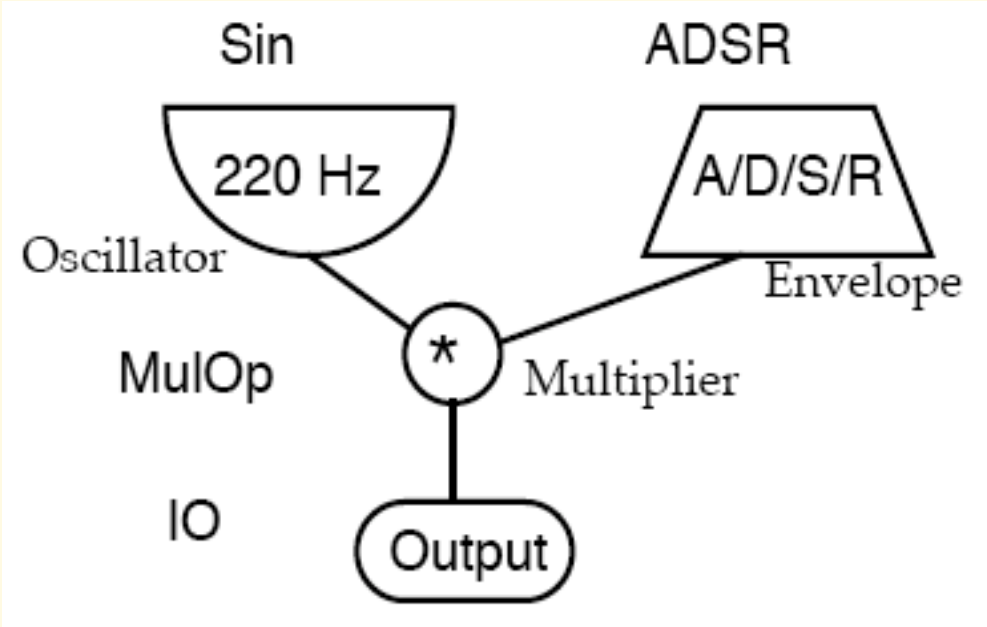
The CREATE Signal Library (CSL, "sizzle") ("chill?")

Demo

- General-purpose, portable C++ framework for distributed, real-time digital audio synthesis and processing
- Used for stand-alone applications, plug-ins, OSC servers, etc.



CSL Relatives

- Like Cmix, STK, Siren, JSyn, MxV, or CLM
  - Delivered as a library in a general-purpose programming language
- Unlike SuperCollider, Csound, Max
  - Not its own language
  - No scheduler
  - Uses C++ development environment

CSL3 Basics

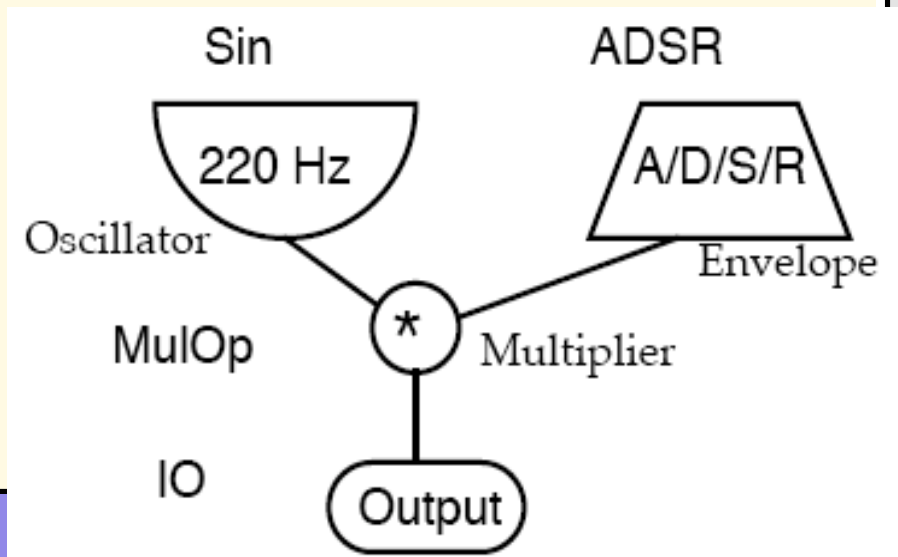
- **Buffer** objects (1-4 classes)
  - Multichannel non-interleaved sample storage
  - "Smart" object, not just a (float **), ptr. mgmnt.
  - Handle malloc/free, filling statistics, etc.
- **FrameStream** classes (Ugens) (many)
  - Respond to the message next_buffer(input, output)
  - Processors have a FrameStream as input
- **Mix-in** classes (vs. wrapper classes)
  - Phased, Positionable, Writeable, Cacheable, etc.

"Hello world" in CSL

Demo

Sine wave with envelope

```
// Create a sine oscillator -- this is a comment
        Sine osc(220.0);
// Create an ADSR envelope -- args are (dur, a, d, s, r)
        ADSR env(3.0, 0.06, 0.2, 0.2, 1.5);
// Create a multiplier
        MulOp mul(osc, env);
// Plug it into the output driver
        globalIO.set_root(mul);
```

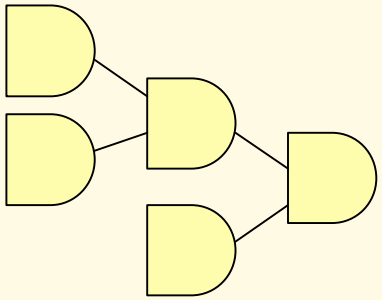


CSL Sources, Controls, and Processors

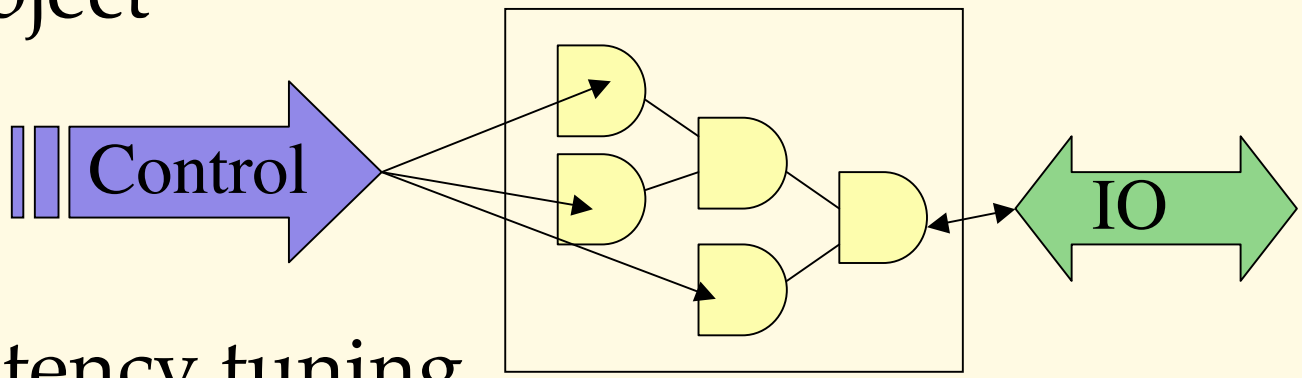
- **Sources**
  - Oscillators (perfect, BL), SumOfSines, Noise, SoundFiles, Chaotic/IteratedFS, IFFT, Physical Models, Granulators, Signal windows
- **Control**
  - Envelopes, LFOs, LFNoise, ProbDists, DynamicVariables, OSC, MIDI, GUI, CORBA, XML, note lists, Feature extractors, Input followers
- **Processors**
  - Operators, Mixers, Filters/banks, Reverbs, (N-M)Panners, DelayLines, FDN, WaveShape, Lo-latency Convolution, FFT/IFFT, LPC/FIR
- **Support**
  - RingBuffer, ThreadedFrameStream, BlockResizer, RateConvertor, Splitter/Joiner, FanOut (needed), Interleaver/Deint., Test main()s
  - Tools: FIR/Reverb IR Design, Spectrum DBs, Control-mapping

The Big Picture of CSL

- Basic DSP graph



- Connected to control input (OSC, MIDI, GUI, CORBA, XML), and IO object



- Buffering and latency tuning

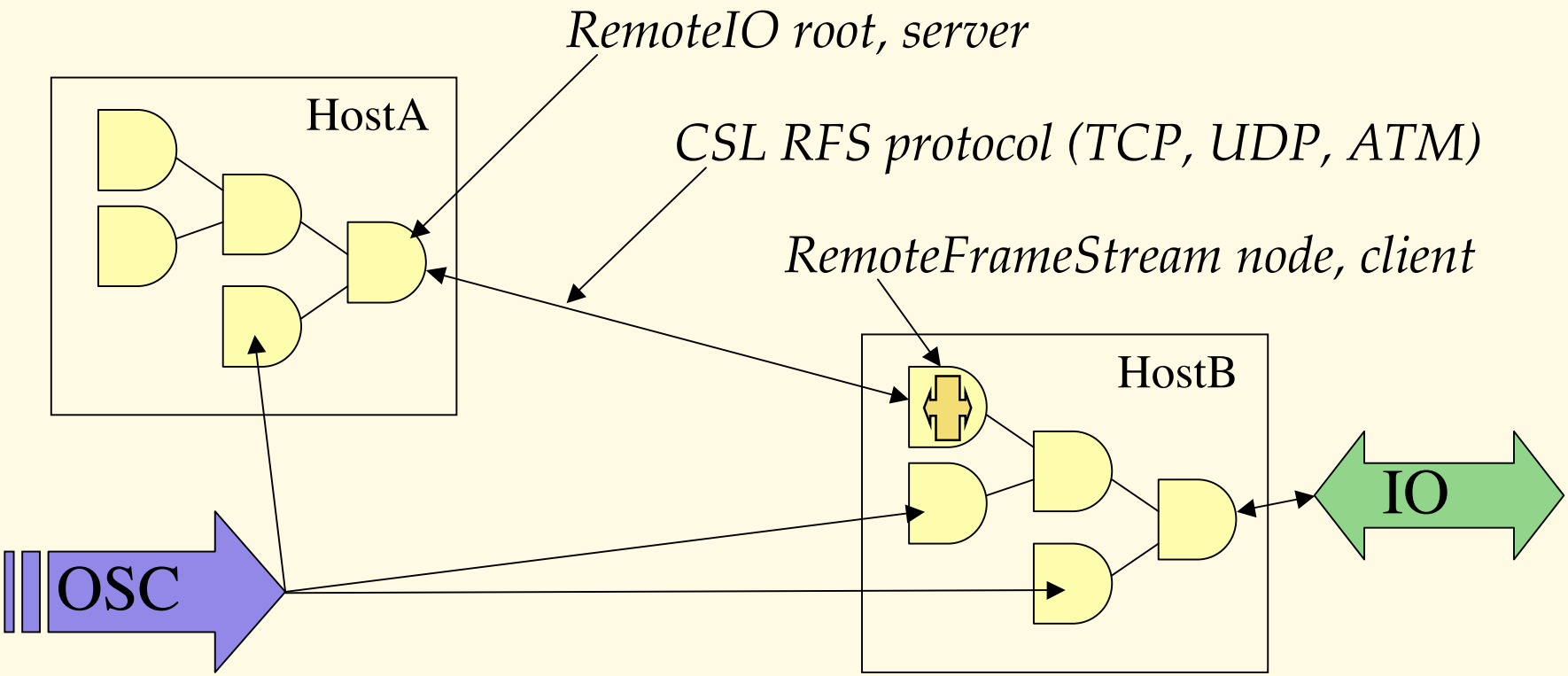
CSL DSP Graph Flexibility

- Sub-graphs can run at different:
  - Sample rates (for control),
  - Buffer sizes (for transforms),
  - Numbers of channels (for efficiency),
  - Buffer formats (interleaved or not),
  - In different threads, etc.
- These can be changed (within reason) at run-time (e.g., for load- or traffic-balancing)

Multi-host CSL Graphs

Demo

- Distributed sub-graph processing with RemoteIO and RemoteFrameStream, RFS protocol, buffering



Instruments and OSC/MIDI/XML

- Instrument object
  - Holds onto a DSP graph; adds "reflective" accessors
  - Generates OSC address spaces, MIDI maps, etc.
  - Server main() function loads an instrument library and publishes an address space on a listener socket
  - Example:

```
                                        // C++ accessor decl.
list[0] = new Accessor("du", set_duration_f, CSL_FLOAT_TYPE);
list[1] = new Accessor("am", set_amplitude_f, CSL_FLOAT_TYPE);
                                        // Produces:
        /i1/                            instrument 1's OSC address space
          /i1/du:                       set-duration command
          /i1/am:                       set-amplitude command
```

GestureSensor Drivers & Servers

- Reusable sensor driver framework
  - Serial in, cacheing/differencing/throttling, OSC out
- GestureSensors: receive OSC or MIDI

```
void * mData;            // data array (typically a float *)
char * mCmd;             // OSC command (without the '/')
char * mTypeString;      // OSC type string, e.g., "ffff"
```

  - Event input thread mgmnt
  - Parsing and differencing
  - Map to static or global data or messages
- Subclasses
  - Glove, Ebeam, Matrix, FOBirds, AdC_Panner, etc.

CSL main() for OSC Processing

```
    // Set up OSC address space root
init_OSC_addr_space();
    // EITHER: add the instrument library OSC addr. space
setup_OSC_instr_library(library, numInstruments);
    // OR: create a background thread for a GestureSensor
Thread * aThread = ThreadPthread::MakeThread();
aThread->fork_thread(GS_thread_fcn, & someArgument);
    // start the I/O callback thread
GlobalIO->start();
    // Run the OSC I/O loop function (doesn't return)
main_OSC_loop(theUDPPort);
```

OSC with a Shell Script

```
    # Shell script to test sending OSC messages to CSL
    # Create a convenient alias
alias ssoo "sendOSC -h localhost 54321"
    # Play a note on instrument 1
ssoo /i1/p;          sleep 3
    # Set a value and play another note
ssoo /i2/cf,50.0;    ssoo /i2/p;          sleep 3
    # play a note with parameters: dur/amp/car/mod/ind
ssoo /i4/pn,4.0,0.3,220.0,357.4,3.0;    sleep 4
    # load a sound file
ssoo /i8/fi,"$CSL_DATA/shine.snd"
    # play a sampled sound
ssoo /i8/p;          sleep 1
```

CV Input to OSC

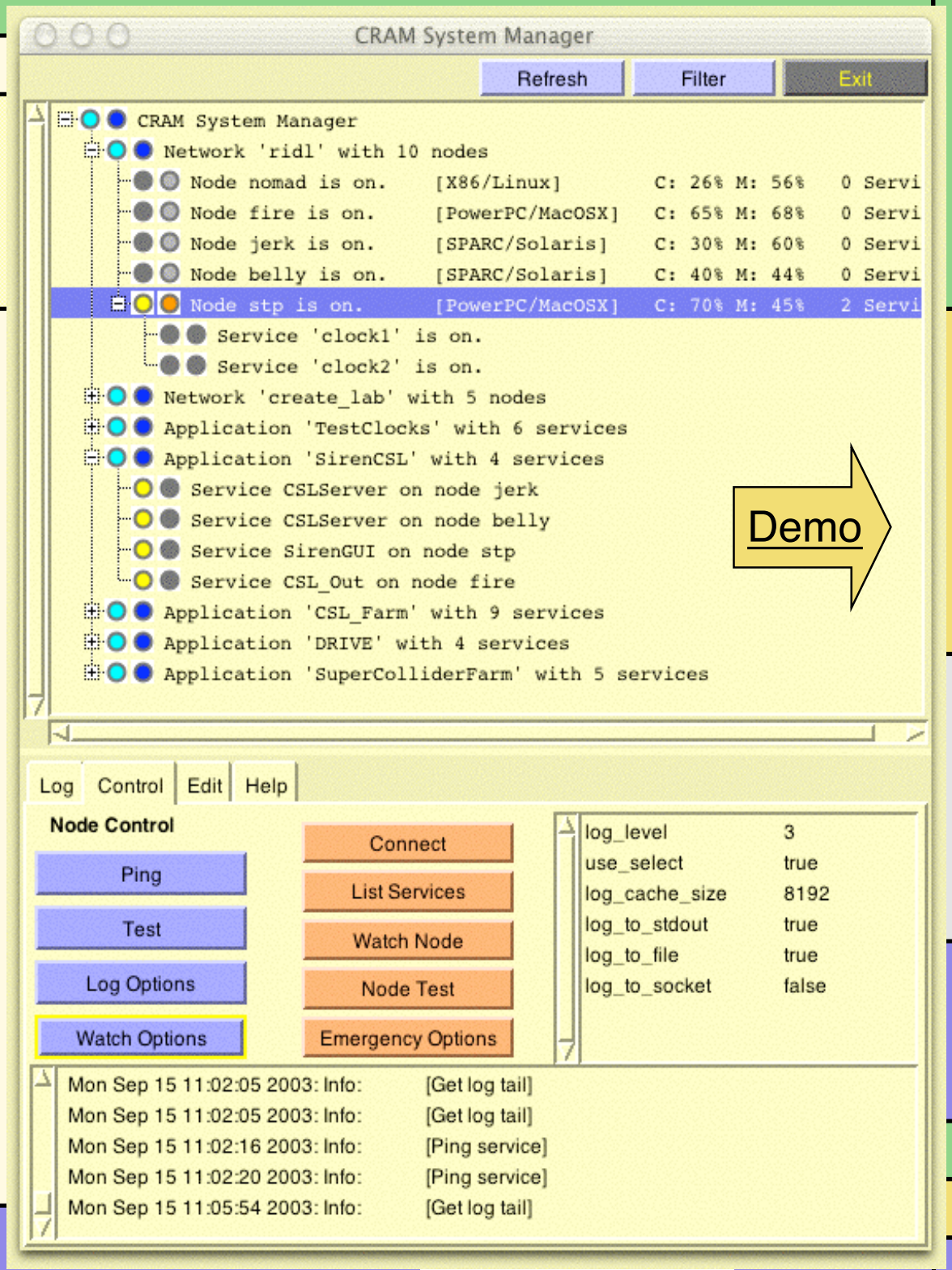
- **Implement multiple camera 3D motion tracking of multiple sources.**
- **Construct an intelligent trans-media system that learns and adapts, based on memory of the actions and states of the sensor space.**
- **Map the data to sound synthesis and transformation algorithms that will provide evocative and meaningful results.**

Managing Siren and CSL: CRAM

- CRAM: Yet another **Distributed Processing Environment** (DPE, Cluster Mgmnt. literature)
- Framework to deploy, start/stop, and monitor multi-host distributed real-time OO applications
- Provides fault-tolerance and load-balancing*
- CRAM is 3rd-gen. DPE implementation at CREATE (1996-2004) (HPDM/TAO, Yellow/CORBA_AV)
- Designed for robustness, simplicity, and low overhead; limited services and scalability/replication

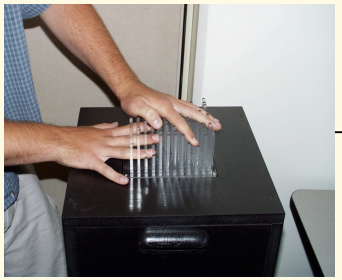
CRAM Manager

- Network/Node
- Node/Service
- Application/Service
- Log/Control pane
  - Run-time monitor
  - Planning
  - DB play-back



CREATE

CRAM Configuration for CSL



Manager

Config DB

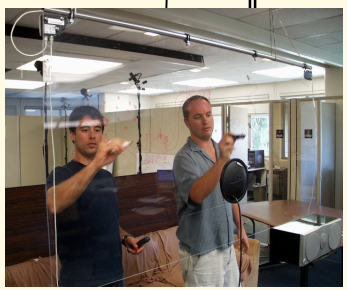
Bells

Voices

Noise

Mixer/
Spatializer

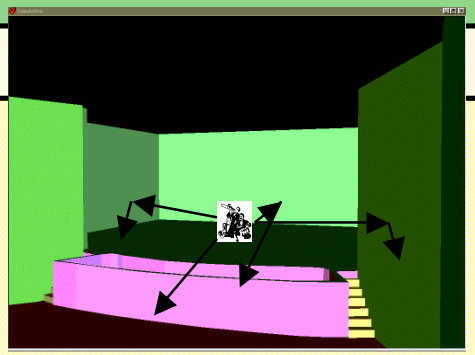
8-ch
Out

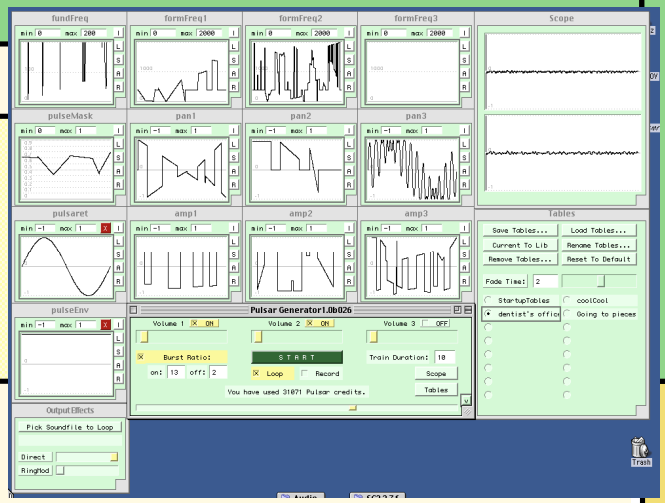


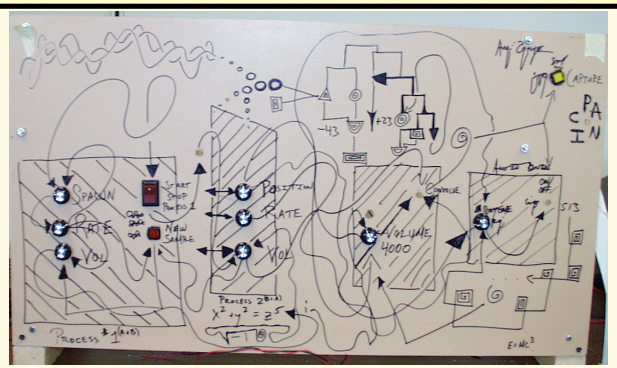
Demo

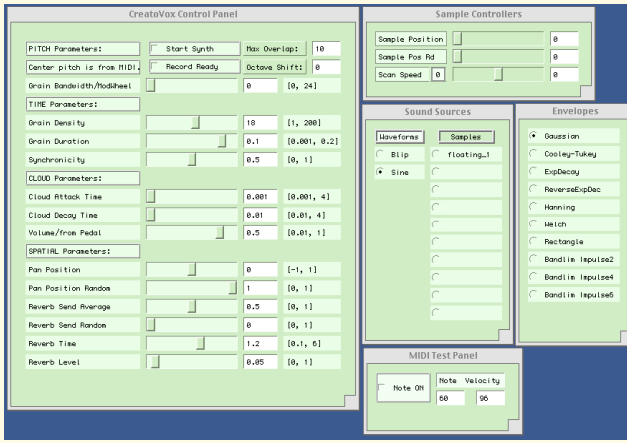
Related Projects at CREATE

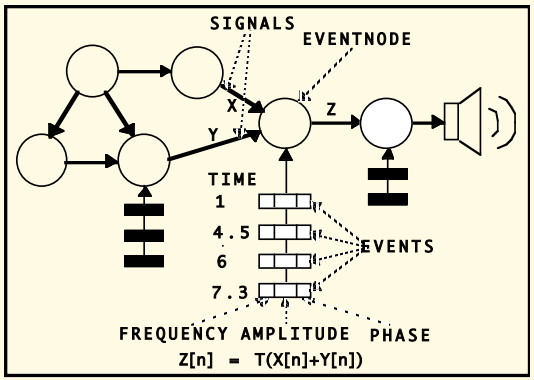
- Auralizer & VRML
- Pulsar Generator
- Creatovox
- MusicVisualization
- FMAK DB
- TimeMachine
- InteractEMGroup
- Creatophone
- Time-DDecomp
- SC_3 Work

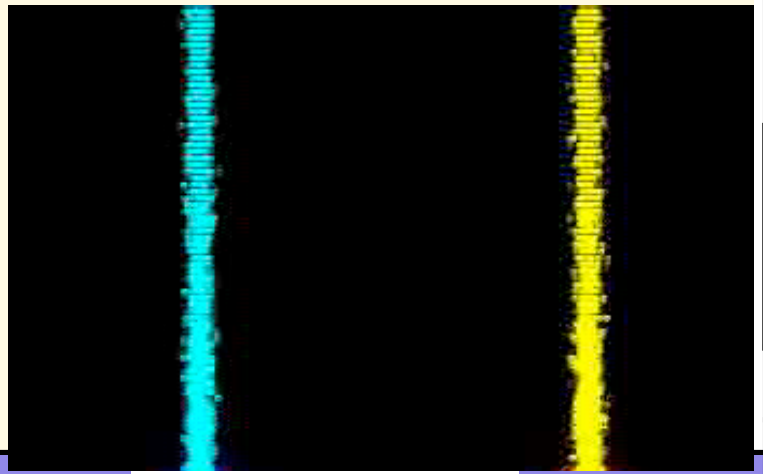


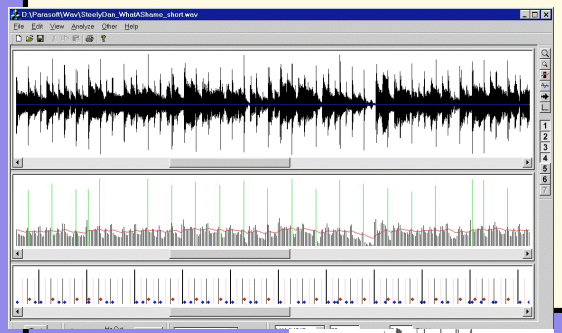


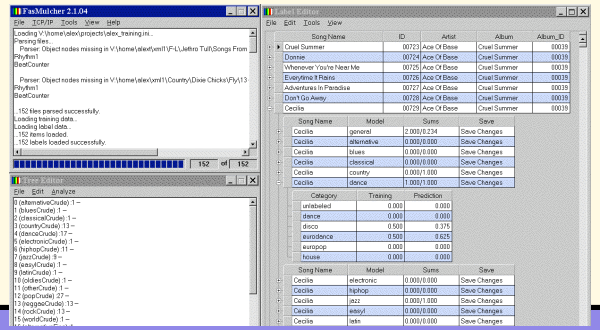












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