

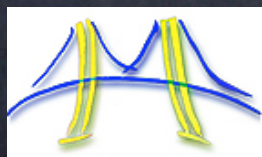
Music and Audio Applications

DAVID WESSEL



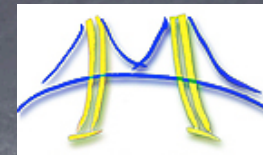
University of California ■ Department of Music

Center for New Music & Audio Technologies



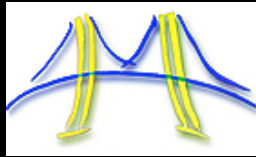
The **Parallel** Computing **Laboratory**

Department of Computer Science - UC Berkeley



App Areas

- New Computer-Based Musical Instruments
- Audio and Music Delivery Systems
- Hearing Aids
- Computer Aided Composition
- Music Information Retrieval



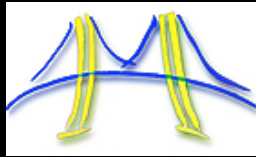
Voices, Streams, Channels, Tracks, and Lines

Music's Low Hanging Fruit Ripe for Parallelism

Usually a mix of task parallelism and data parallelism

David Huron's Musical Texture Space

Single Auditory Stream



Monody

100%
Homophony

Hymn Harmonizations
Barbershop
Happy Birthday Sober

Bach 2-part Inventions
Happy Birthday Drunk

Onset Synchroniation

Bach WTC
North & South Indian

Ligeti

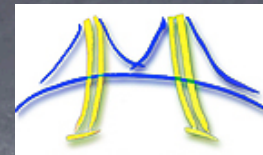
Polyphony

Heterophony

0%

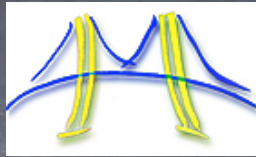
100%

Parallel Motion



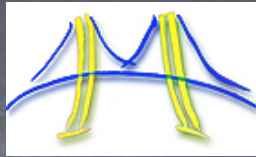
Computational Patterns in Music and Audio Applications

- Spectral Methods
- Dense and Sparse Linear Algebra
- Structured and Unstructured Grids
- Graphical Models
- Dynamic Programming
- Graph Algorithms
- Transcendental Functions



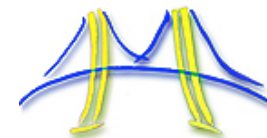
Structural Patterns

- Pipe-and-Filter
- Agent and Repository
- Process Control
- Event-based Invocation
- Model-view Controller
- Map Reduce
- Arbitrary Static Task Graph

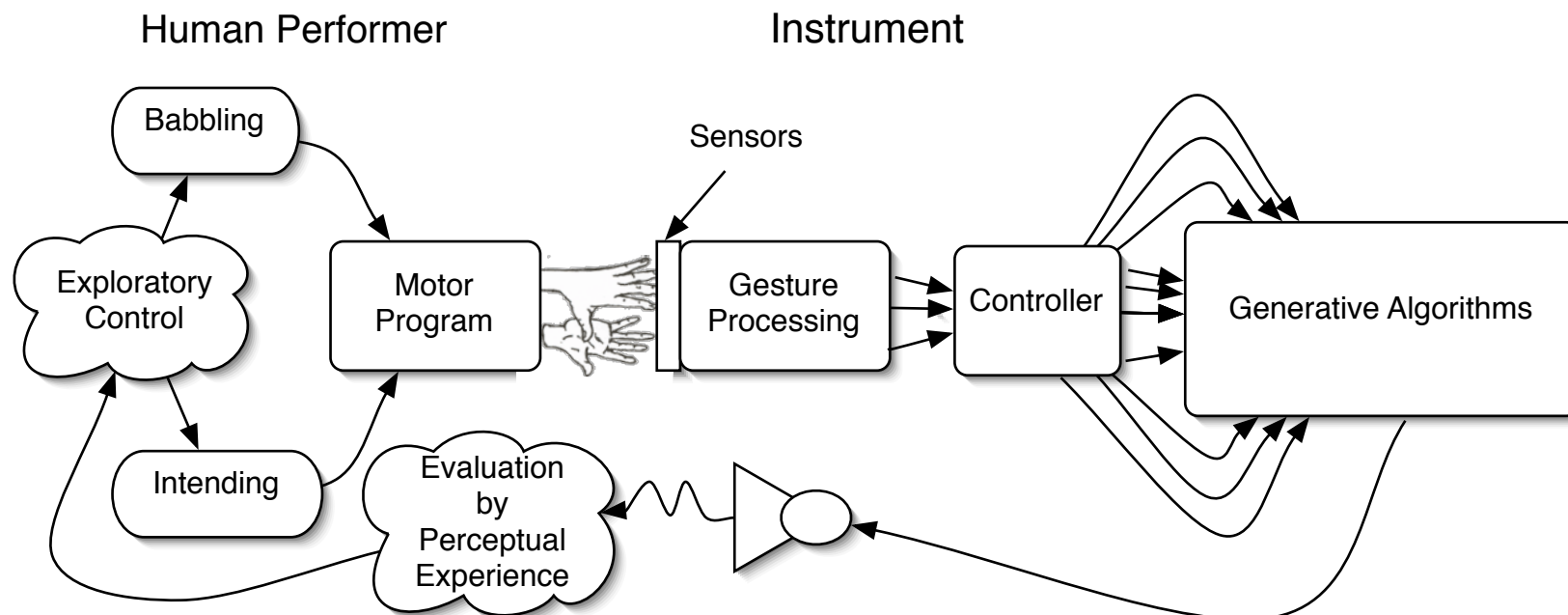


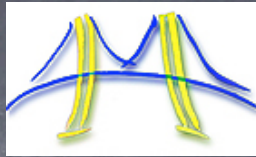
New Musical Instruments

- Primary Design Criteria
 - Bodily Engagement
 - Musically Expressive and Inspiring
 - Easy to Play at the Entry Level
 - BUT! Accepting of Lifelong Development of Virtuosity



Musical Instrumentation





Some numbers for real-time scheduling for audio, media, and music applications

Channel Synchronization < 10 micro-sec

Audio Input to Output < 1 milli-sec

Flams < 1 milli-sec

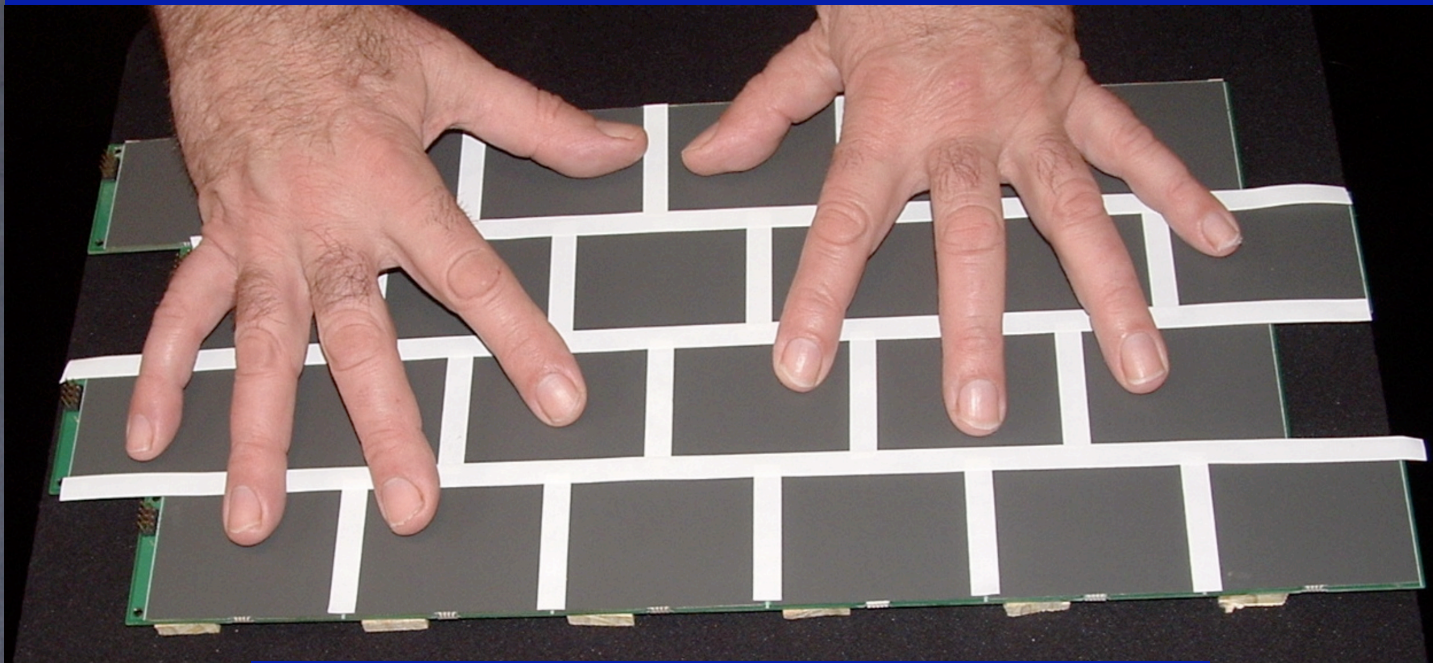
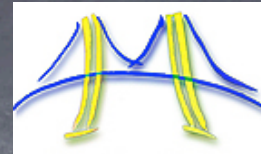
Gesture to Audio < 10 milli-sec

Audio-Visual Sych < 30 milli-sec

Images (no flicker) < 50 milli-sec

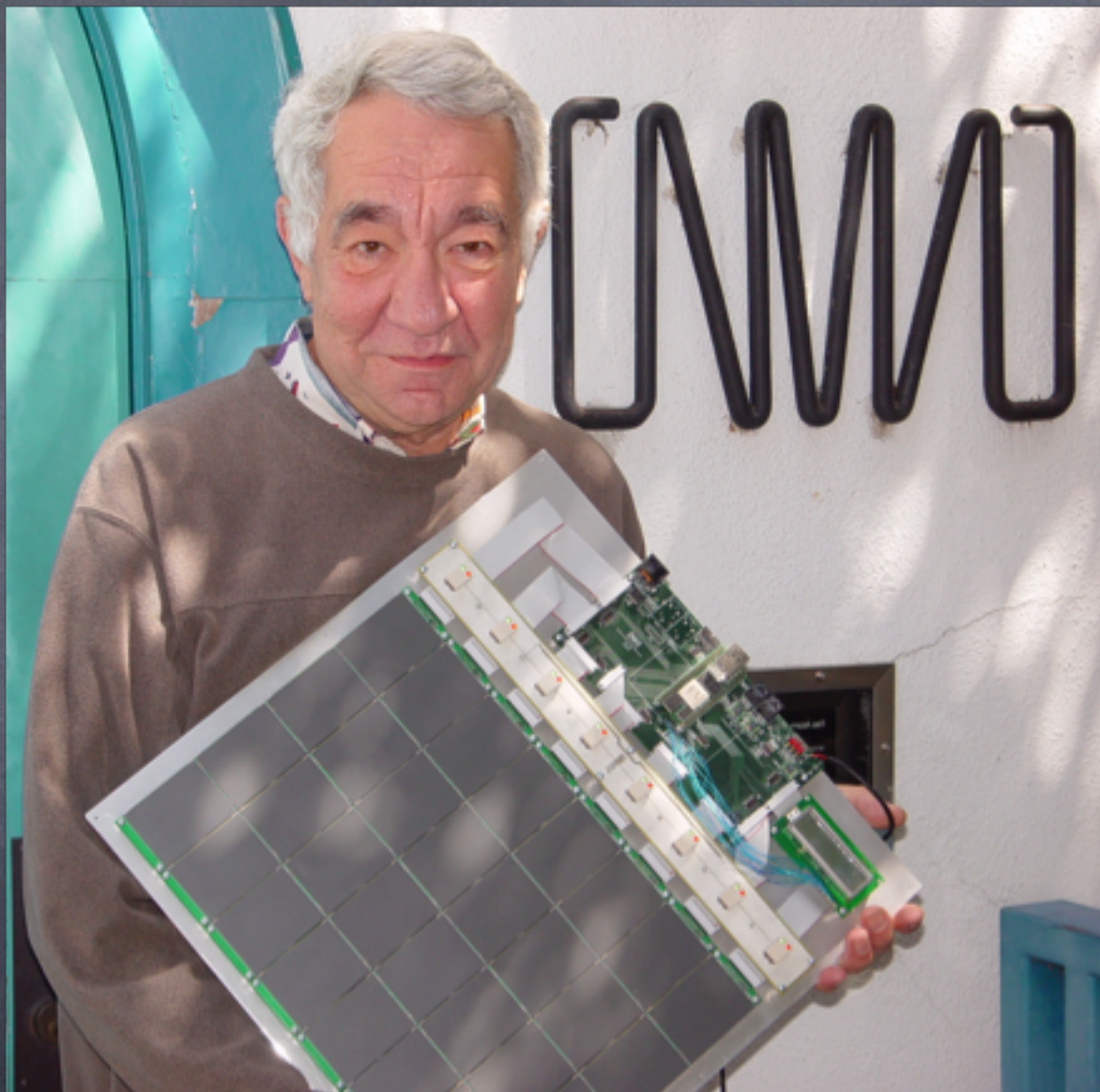
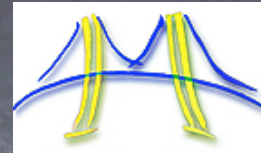
For audio jitter is forbidden.

Video is more tolerant.

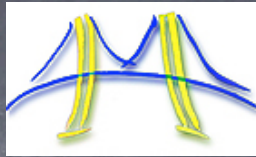


Interlink's *VersaPad*
semiconductive touchpad



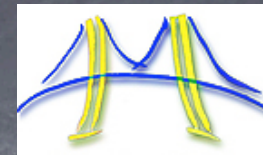


A Multitouch Sensor Array



The Hand Force Image

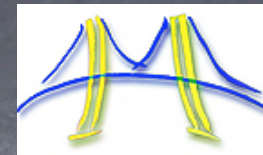




Computational Requirements for a Hand Drum-Like Multi-Touch Interface

Consider a 20x20 inch array with 100 taxels/sq in. If we use 12 bits per taxel and sample the array at 10k Hertz we end up with 4.8 Gigabits/sec.

Now consider the image processing requirements. We want to know how the hand-force image changes as a function of time and map it to a synthesis algorithm. That's more than 300 times the frame rates for typical video.



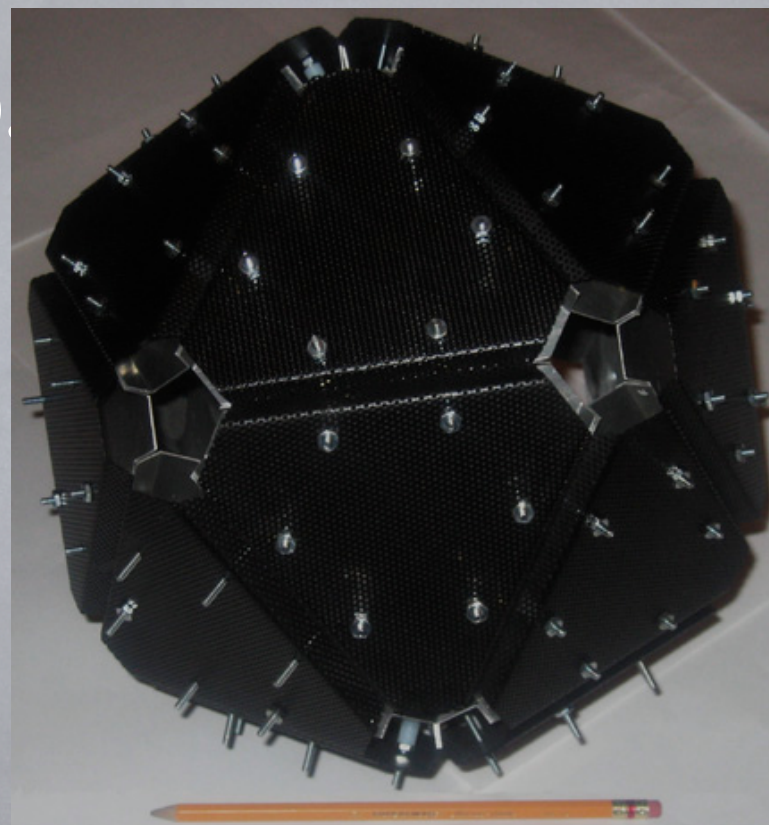
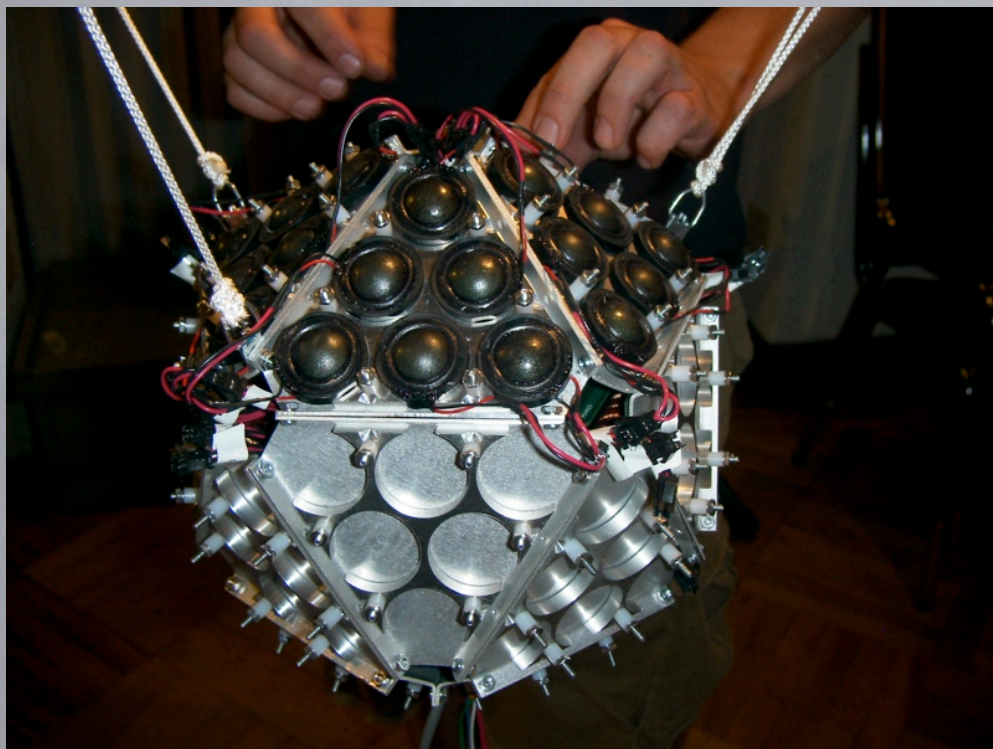
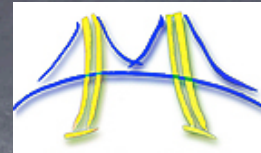
Many-Channel Audio Systems

Arrays of speakers and microphones

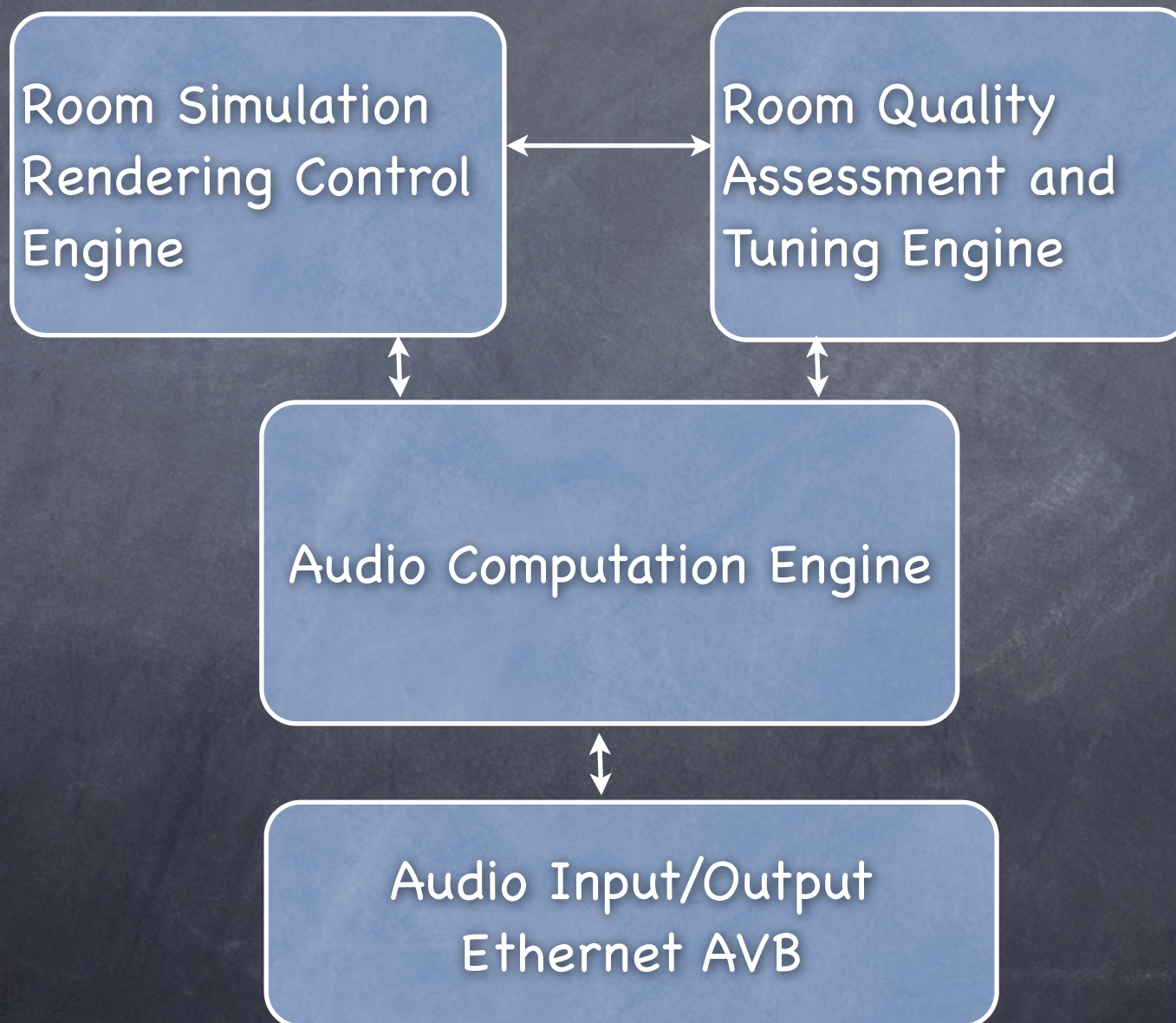
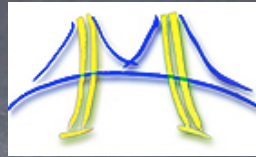
Huge number of independent channels (Already 100s)

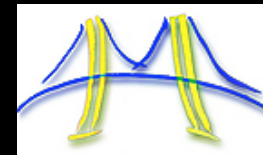
Extreme bandwidth requirements; Gigabit and beyond

Non-trivial computational requirements



An i7 (Nehalem) Based Audio Diffusion System

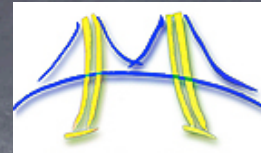




Voices, Streams, Channels, Tracks, and Lines

Music's Low Hanging Fruit Ripe for Parallelism

The new version of the **poly~** abstraction in Max/MSP (version 5) assigns voices and collections of voices to multiple cores.



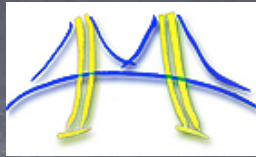
URL for the touch pad interface:

http://cnmat.berkeley.edu/user/david_wessel/blog//01/15/slabs_arrays_pressure_sensitive_touch_pads

URL for the Synful sound examples:

<http://www.synful.com/SoundExamples.htm>

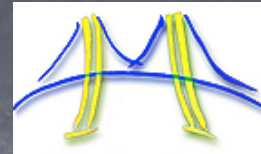
Special Thanks



Meyer Sound Laboratories - Berkeley

Rimas Avizienis and Adrian Freed for their work on the slab and connectivity processing.

Andy Schmeder of CNMAT for numerous discussions.



Thanks for your attention

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