USC IMSC

Distributed Immersive Performance

presented by Elaine Chew

Alexander A. Sawchuk, Roger Zimmermann,
Vely Stoyanova, Ilya Tosheff,
Chris Kyriakakis, Christos Papadopoulos,
Alexandre François, Anja Volk

University of Southern California
Viterbi School of Engineering and Thornton School of Music
Los Angeles, CA 90089

NASM Meeting 2004, San Diego, CA
November 22, 2004, 2:15pm

National Science Foundation Engineering Research Center

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OVERVIEW

- The **Distributed Immersive Performance** (DIP) project explores one of the most challenging goals of networked media technology: creating a seamless environment for **remote and synchronous musical collaboration**.

- WHY create and study remote synchronous music collaboration environments? (are we crazy?)
- WHO has tried this? (related work)
- WHAT have we done? (recent experiments)
- WHAT have we found? (latest results)
- HOW is this of relevance? (impact for musicians)

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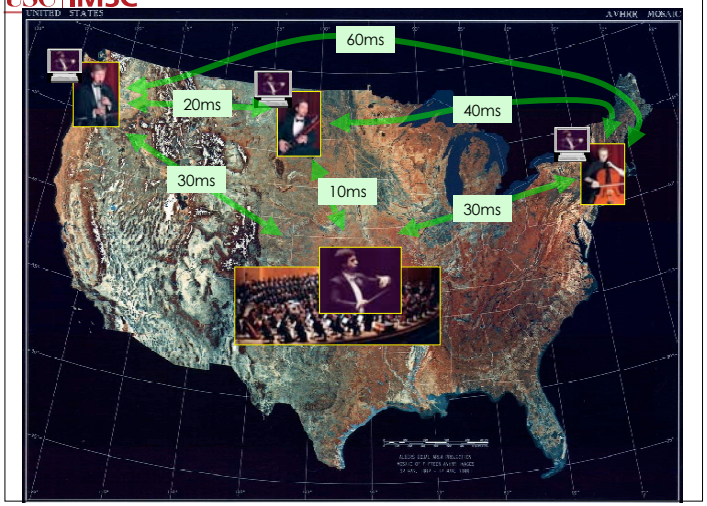

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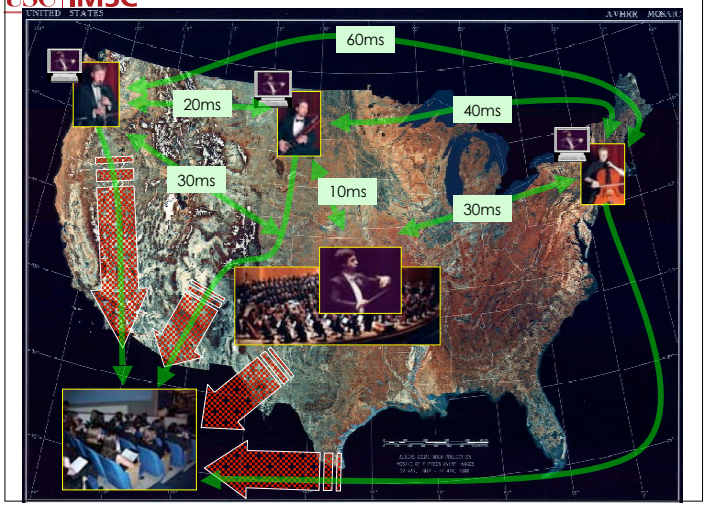

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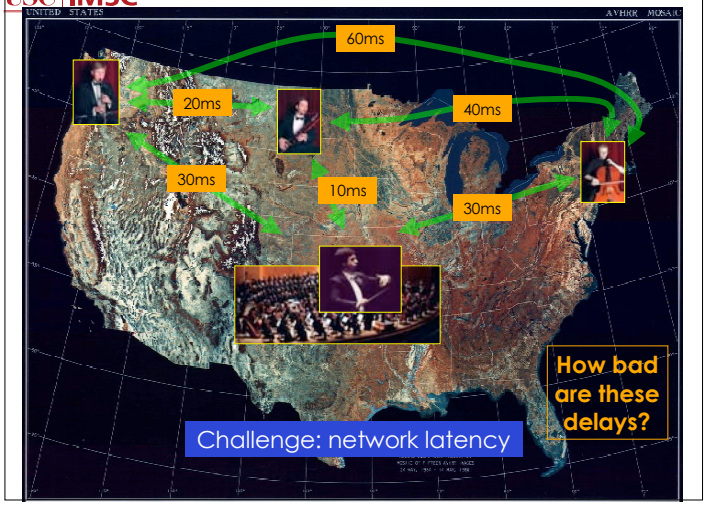

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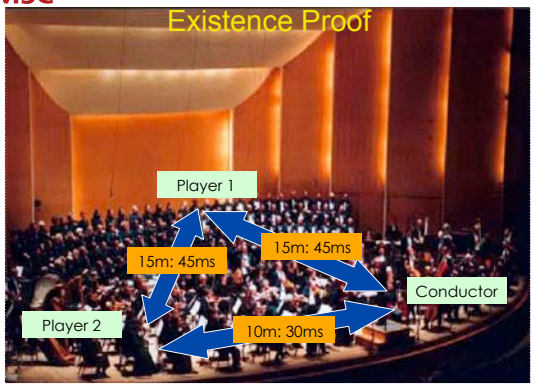

- Network latency maps to **audio delay** on stage
- **Visual delay** is zero

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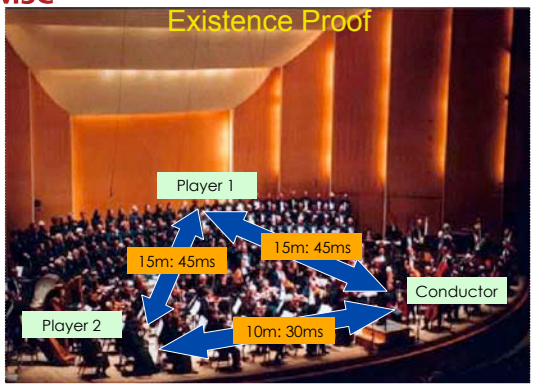

- Transmitting **low latency** audio and video among musicians
- Maintaining **constant delay** between players

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Related Work

- 1993 - USC Information Sciences Institute (ISI): distributed trio
- 1998 - “Melange a trois” (audio only) Warsaw, Helsinki, Oslo
- 2002 - CCRMA’s Network Jam (a/v unsynch): Stanford, McGill
- 2003 - UC Santa Barbara, Santa Barbara College
- 2004 (Jun) - CCRMA (audio only): CA, Sweden
- 2004 (Aug) - ICHIM Network Concert: Berlin, Paris

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- **2002 (Dec) - USC IMSC Distributed Duet (audio only): PHE, EEB**
- **2003 (Jun) - USC IMSC Duet w Audience (a/v unsynch): PHE, RMH**
- 2003 - UC Santa Barbara, Santa Barbara College
- **2004 (Mar) - USC IMSC DIP Experiment Set A & B**
- 2004 (Jun) - CCRMA (audio only): CA, Sweden
- **2004 (Jul) - USC IMSC DIP Experiment Set C & D**
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Timeline

2002

Jun — Remote Media Immersion (RMI) Initial Demonstration
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May — **A:** first time players perform under delayed conditions
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DIP v.0: Distributed Duet (Dec 2002)

Elaine Chew on keyboard in **Powell Hall** with 1-channel audio playback

Wilson Hsieh and viola in the **Electrical Engineering Bldg** with 10.2-channel Immersive audio

TECHNOLOGY:

- 10.2-channel immersive audio technology by Kyriakakis & Holman
- Low-latency multichannel audio streaming software by Papadopoulos & Sinha
- Actual delay controlled using Protools console

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on keyboard
in **Powell Hall**
with 1-channel
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Wilson Hsieh
and viola in the
Electrical Engineering Bldg
with 10.2-channel
Immersive audio

EXPERIMENT

- **Varying audio delay**: 0ms to >300ms
- Pieces: Hindemith's *Sonata No.4* and Piazzolla's *Le Grand Tango*

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on keyboard
in **Powell Hall**
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and viola in the
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WHAT WE LEARNED:

- Latency tolerance dependent on
  - tempo and onset synchronization: Hindemith *Sonata No.4* (mvt1 vs final mvt)
  - timbre of instrument: Piazzolla's *Le Grand Tango* (accordion 25ms vs piano 100ms)
- Sense of acoustic presence made more "natural" by 10.2-channel audio
- Perspective differences require recording of experience at both sites

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Remote Master Class (Jan 2003)

Student at the
New World Symphony
in **Miami Beach**

Ron Leonard,
cellist of the LA
Philharmonic
at **USC**

TECHNOLOGY

- 10.2 immersive audio by Kyriakakis and Holman
- Off-the-shelf video software/hardware (Star Valley MPEG2 codecs), large delays

RESULT

- Teacher reports improved presence with immersive audio:
  "student was really there"

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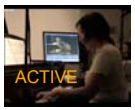
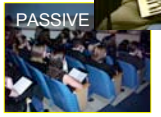
DIP v.1 - Duet with Audience (Jun 2003)



Elaine Chew in **Ramo Hall** w earphone and video monitor

Dennis Thurmond in **Powell Hall** with audience, 10.2 immersive audio and Large screen HD image



TECHNOLOGY

- Video: NTSC resolution, 31 Mb/s DV, software decode, **one-way latency: 110ms + <5ms** (compression + network)
- Audio: uncompressed, 16 or more channels at 1 Mb/s each, **one-way latency: <10ms + <5 ms** (processing + network)

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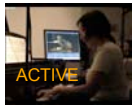

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EXPERIMENT

- Piazzolla's *Le Grand Tango*
- Approximate tempo is 120bpm
- Granularity of events is at 16th-note level, i.e. IOI = 125ms
- Even 60ms RT delay could be debilitating.

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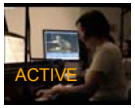
DIP v.1 - Duet with Audience (Jun 2003)



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WHAT WE LEARNED

- Video delay made it unusable as source of cues for synchronization. Audio (<<50ms RT delay) was used.
- Musicians compensated for delay by anticipating each other's actions and scaling back on spontaneity (low risk performance). Some artistic licence was exercised to "make ends meet."
- Co-location of audience with one musician caused imbalance in control. No matter what happened, performer at the audience site had to make the final performance "work".

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DIP v.2 - Two-way baseline user studies (2004)

- The **Objective**: To measure and document qualitatively and quantitatively the effects of delay and other variables on immersion, usability, and quality in the Distributed Immersive Performance scenario

- **A**: first time players perform under delayed conditions
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DIP v.2 - Two-way baseline user studies (2004)

Tosheffpianoduo.com

Vely Stoyanova and Ilia Tosheff (piano duo since 1997)
The first piano duo to audition and be offered admission to the Thornton School of Music
Pioneers in the *Protégé Program* (see Chris Sampson for details)

Described by critics and press as
"…*brilliant concert artists*…"
"…*captivating stage presence*…"
"…*fascinating temperament*…"
"…*charm and spontaneity that grabs the audience*…"

THE GRAND PRIZE – Tokyo, Japan • THE GRAND PRIZE – Dobrich, Bulgaria • FIRST PRIZE – Rome, Italy FIRST PRIZE – Rome, Italy • FIRST PRIZE – Sofia, Bulgaria • WINNERS – Zaragosa, Spain • WINNERS – Michigan, USA • WINNERS – Miami, USA • WINNERS – Los Angeles, USA • MUSICIAN OF THE YEAR in Bulgaria • PREMIO "Zinetti" – Verona, Italy • PREMIO "V.Bellini" – Caltanissetta, Italy • PRIZE – Groningen, Holland • PRIZE – Sofia, Bulgaria

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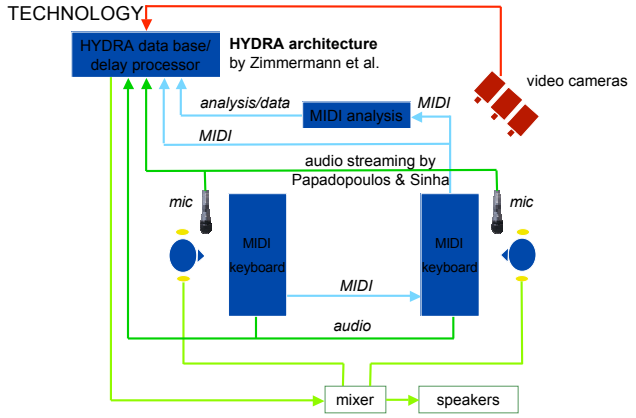

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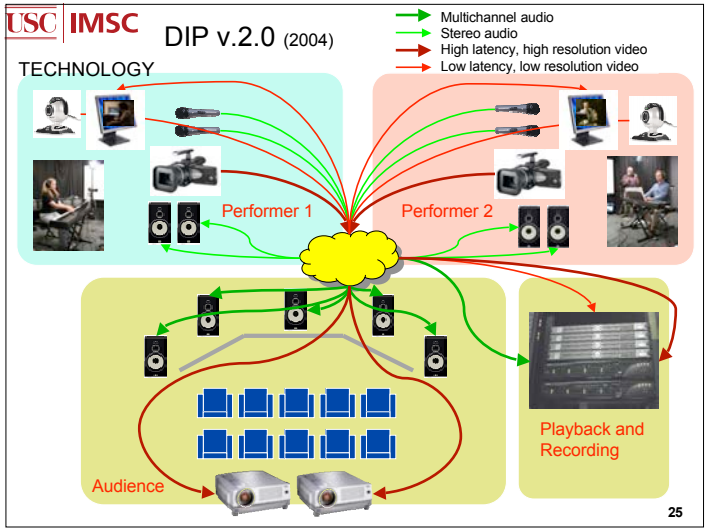
DIP v.2.0 (2004)



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DIP v.2 - Two-way baseline user studies (2004)

EXPERIMENTS

- Poulenc *Sonata for Piano Four-Hands*
  - *Prelude* (tempo = 132 bpm)
  - *Rustique* (tempo = 46 bpm)
  - *Finale* (tempo = 160 bpm)
- Questions:
  - How would you rate the ease of ensemble playing?
  - How would you rate the ease of creating a musical interpretation?
  - How would you rate the ease of adapting to this condition?
- Debriefing, observations
- Quantitative measures of musical synchronization (Chew et al.)

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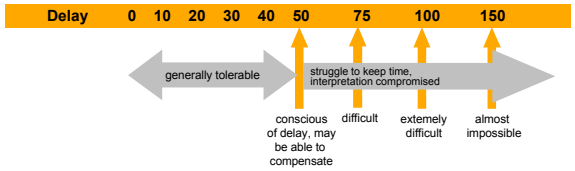
DIP v.2 - Two-way baseline user studies (2004)

- **A**: first time players perform under delayed conditions
- **B**: player 1 and player 2 swap parts (symmetry test)

- Two players in same room facing each other (visual delay 0ms)
- Variable audio delay: 0, 10, 20, 30, 40, 50, 75, 100, 150ms



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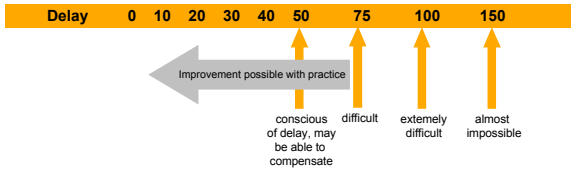

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- **C**: players practice to compensate for delay
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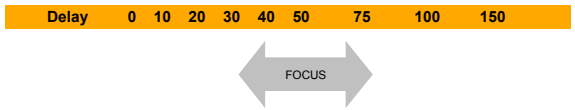

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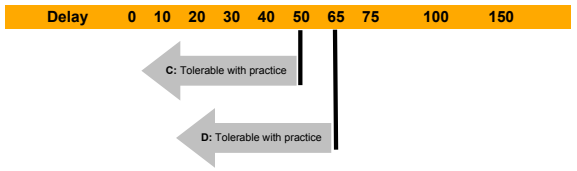

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IMPACT

- Better understand collaborative performance
- New modes of musical communication
- Preparing for the future…

The New York Times
October 5, 2004
Broadway Pit Shrinks;
Drummer Is Sent to Room

- References
  - DIP website *http://imsc.usc.edu/dip*
  - Chew, Zimmermann, Sawchuk, Kyriakakis., Papadopoulos, François, Kim, Rizzo and Volk (2004). *Musical Interaction at a Distance: Distributed Immersive Performance.* In proceedings of the 4th Open Workshop of MUSICNETWORK: Integration of Music in Multimedia Applications, Barcelona, Spain.
  - Sawchuk, Chew, Zimmermann, Papadopoulos and Kyriakakis (2003). *From Remote Media Immersion to Distributed Immersive Performance*. In Proceedings of the ACM SIGMM 2003 Workshop on Experiential Telepresence (ETP 2003), Berkeley, California.

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