The World Opera and the World Opera Stage

This is a white paper produced in 2010 that serves to document our thoughts and processed during our first World Opera tests during my tenure. We have certainly moved a long way since these initial efforts. The paper provides a nice reflection on our early efforts.

The World Opera, in association with our institutional, academic, government, and private partners, have just completed a three-month series of test implementing current and cutting-edge technologies for the distributed, interactive performance of operatic works in real-time across high-speed, high-performance audio/video networks. These tests occurred in at the Music Conservatory of the University of Tromsø during March, April, and May 2010.

March

In March we began with a two-room test, placing a pianist and conductor in a small rehearsal space opposite a solo performer in a larger black-box theater. Though World Opera partners and personnel have participated in similar test in the past, this was the first time a multi-node (more than one site) set up had been realized completely within the Music Conservatory at the University of Tromsø. In these tests we were able to connect the two spaces with bidirectional stereo audio and two unidirectional video transmissions.

The primary focus of the March test was to 'evaluate the possible'. Along with the assistance of students from the Music Technology course, we began to delve into the practicalities (and minutiae) of putting together an audio/video subsystem for supporting interactive, real-time performance over the gigabit network. For these tests we utilized CCRMA's JackTrip software to deliver bidirectional stereo streams alongside Ultravideoconferencing from McGill University to provide two one-way video streams between the rooms. Though we attempted to add a third room, we soon ran into network issues that prevented us from delivering video to this room. With the other technical issues apparent in simply getting two rooms up, we postponed the use of the third room until a later test.

Musically we attempted brief excerpts from Nørgård's opera *Gilgamesh*, which highlighted the challenges ahead of us. It is interesting to observe an artist as he or she first comes to the distributed performance experience. Without fail, the first comment is that there is too much delay, even though the audio latencies in this closed-network experiment were well below 10 milliseconds and relatively imperceptible. Though there is arguably a delay, perhaps it is the additional lack of physical presence that causes the temporal discomfort. Nonetheless, over the next few minutes, artists become completely accustomed to the time shift.

Video, however, with its higher latencies, introduces discrepancies across the network, particularly when a conductor is utilized to lead the work. The performing artists were quick to

remedy the situation by 'jumping' the downbeat in order to coordinate with the conductor. That is to say, the remote performer attempts to compensate for the latency by coming in early to match the downbeat at the local site. Further, we discovered if the conductor loosens his or her conducting pattern (not having a definitive ictus and loosely guiding the work) the result was much better. Here we may find the conductor of a distributed performance is not so much a metronome as a coordinator of events.


Finally, there was a realization that a larger space, with a more resonant, 'live' acoustic, tended to make the coordination of distributed events much easier, as such the space smooth over and dissipate small latencies. In smaller spaces, under near- to mid-field monitoring, the audio mismatch is much more apparent and, in the words of some participants, 'annoying.'

For these tests we used two DV cameras in each room and projected large-scale images of the participants onto an opposite wall. As you can see in the accompanying photographs, there is no formal recognition of an audience. The pianos used were close-mic'd and the performers were mic'd as close as possible. Our goal remains to capture the sound at the source and project it into the remote space, so as to mix in the acoustic naturally. Consequently, we are trying to not stamp the acoustics of one space onto another. It was during this meeting the proposal to use wireless microphones on all participants arose.

April

The April tests were caught off guard by the Eyjafjallajökull volcano in Iceland, which prevented our partners from Simula contributing. We were hoping to work with Alex Eichhorn and his students to implement his new two-way video portal and video server. Certainly we hope to revisit Alex's technology in the near future! Our tests were also limited by the availability of performing artists to participate. We were, however, happy to meet soprano Caroline Christensen who secured her vocal coach at the last minute, arranging an impromptu performance. Though the test was successful in that the network was eventually established (both audio and video), we encountered problems across the network that appeared (again) to be port issues.
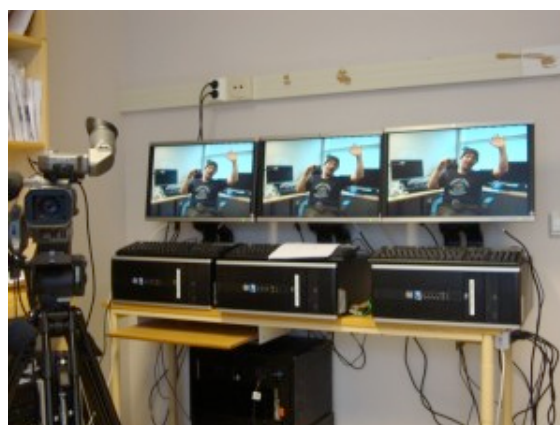
This coupled with the misconfiguration of physical (in the wall) ports left us able to send sound out of a room, but not be able to get sound into that room. Finally, the arrival of our newly purchased computers (9 Linux boxes) for the project, a mere week before the test, caused some headaches. We simply did not have enough time to properly configure the systems. What can be taken away from the April tests is that the integration of various analogue and digital technologies required for this to 'work' is not (yet) a fluid process! There are many connections, and one misconfiguration can cause hours of delay.

Toward the end of the second day, we picked up a trombone student to play some solo works. We found that capturing the sound of a larger, louder instrument would have its own

issues. We did play around with multiple microphone techniques and had some palatable results. In our efforts to present vocal works, we have perhaps spent too much time on techniques for capturing singers and pianos. We will need to work with all the instruments more fully in the future to develop the means for accurately capturing and transmitting their sound.

May

The May tests were by far the most successful. Here we were able to implement suggestions from our prior work to present a mini-concert with 3 performers, each playing from separate spaces. Again we worked with Caroline Christensen from our previous test along with Jannike Hansen who sang in test one. Laila Bråten joined as accompanist. Finally, for this last test we were able to establish three performers in three separate spaces and connect these artists over the network with robust audio and video.

For these tests we constructed impromptu human-sized projection screens in order to display each performer in proper relational size one another. With the help of a donation of six projectors from Projection Design of Norway we were able to realize our goal of representing 3 performers in each room. Only due to a hard disk failure were we unable to transmit Ms. Hansen into the third room, though we did have all 3 rooms up and running just prior to the fault. Further, we had worked with our partners at McGill to realize serial multi-casting, so that one camera could deliver its image to multiple projectors. Though Ultravideo was always capable of this feature, it took a few discussions to implement it successfully.

Video projection required a good deal of masking inside the computer to make the image properly fill (and not overflow) the screen as well as a good amount of trial and error to approximate human size. We would like to investigate the possibility of masking images directly in Ultravideo, as well as begin to utilize the background removal techniques that the program does employ.

For audio, we were able to use wireless microphones that greatly enhanced our efforts to capture (close mic) the human voice. We did discover, however, that the professional model microphones we used could color the sound a bit for certain voices. We believe this is due to the spectral profile of the microphones that are more geared toward a 'pop music' sound, though the results were entirely acceptable at this point in our development.

Sound for this test was further enhanced by the arrival of 6 loudspeakers from our partners Bang and Olufsen. The BeoLab 9 speakers were quite transparent, providing a flat frequency response that did not color the sound in any way. We placed the B&O loudspeakers to the right and left of the stage where they provide natural sound fill and reinforcement. To create a sense of located sound, we placed smaller near-field monitors directly behind the projection screens and routed the voices to the appropriate locations, such that singers' voices emanated from the area of the stage their projection occupied. We similarly placed mid-field monitors below the pianos. The results were quite convincing.

Conclusions

Over the past three months, we have made a few discoveries and determinations about the techniques and technologies we wish to deploy into our first World Opera Stage. In addition,

we have had the opportunity to re-examine performances that are not distributed and remind ourselves of the traditions and techniques that have come before us. We believe our goal should be to build upon and innovate traditional production designs and techniques. So, in no particular order, we conclude and suggest the following:

The performance space

1. Medium to large spaces with a 'live' sound are preferable acoustically. We are striving for a natural acoustic, and purpose built spaces (e.g., theaters and concert halls) are the preferred venues. Multi-use and alternative spaces are possible, if they have good acoustics or can be configured to have such. As previously mentioned, spaces with a resonant acoustic tend to 'smooth out' latency issues, where smaller, dry spaces tend to highlight them.

2. The World Opera Stage requires the placement and implementation of many performance technologies such as projectors, screens, microphones, mixers, theatrical lighting, and stagehands, to mention only a few. We believe a pre-existing performance space is the best venue for implementing our World Opera Stage as these venues already have the necessary infrastructure in place. Certainly alternative performance spaces are possible, however, the cost of retrofitting an alternative space with the necessary infrastructure to support such a performance might prove cost prohibitive.

Video

1. High Definition Digital Video cameras proved quite successful in our tests and we would like to continue to use such cameras. If necessary, lower resolution cameras could be used for non-critical applications such monitoring the stage or equipment from a remote site.

2. Performers tend to find the visual delay confusing and revert to intensive active listening to achieve performance synchronicity. In order to achieve a realistic interaction for the audience performers may need to be reminded to pay attention to the motions of remote actors, even though the image might be slightly delayed.

3. Besides the network, we need to achieve the fastest thru-put for audio streaming. This will require working with our partners to develop camera and projector technologies that perform with the least latency.

4. We need to implement some form of background removal and masking within our video software. Further, this software should allow for sizing of the image in two dimensions. Finally, our video software software needs a more intuitive user interface such that a designer/technician can easily make adjustment on the fly. The current command line interface might prove a barrier.

5. We need to develop an invisible screen to project upon. In fact, we will need multiple screens to project objects at varying depths and continuously across the stage. Though we believe an audience is accustomed to suspending their disbelief, especially in today's media environment, we would like to create a system that is as fluid as possible, presenting the theatrical event with few incongruities (e.g., performers arms being cut off when they reach beyond the end of the screen or actors becoming giants in relation to others when they step toward the camera).

6. We also realize that many of these 'incongruities' can be utilized to express and further narrative. These will need to be investigated on a case-by-case basis.

Audio

1. It is preferable to capture the performance with as close a mic'ing technique as possible, allowing the actual and virtual 'signals' to blend in the natural acoustic. We have ascertained that a wireless microphone system worked best for vocalists. We predict similar 'clip-on' and contact microphones might prove successful for the capture of instrumental sound.

2. Placement of speakers for both 'fill' and located sound reproduction has proved successful in creating a realistic sound field.

3. One issue not mentioned above was some difficulty with gain structure between the rooms. Since each room requires a distinctive mix from the resident engineer, it is important to ensure that there is enough signal at the receiving end with which to work. Again, we need time conduct some separate tests to find a proper balance between these signals.

4. We need obtain proper sound reinforcement equipment for future work. Though the digital side of the system worked well, we encountered ground hum and hiss across the analogue side of things. The quieter the system, the better the sound.

General

1. We believe the audio and video systems for the World Opera Stage should be kept separate, as to avoid complete systems failure. If audio goes down, we might still have visual, and vice-versa.

2. We need to develop a lowish-latency backup to use in case the main audio/video system goes down.

3. We need to begin utilizing a comm (communication) system to talk between production staff during performance that would link into the available 'house' system.

To close, I would like to personally thank the faculty, students, artists, and technicians who gave of their own time to participate in these tests. Attempting new things is always a challenge and your contribution to this new page in the operatic tradition is greatly appreciated. *Thank you all!*