

Interviews with Practitioners Shaping Internet-Based Collaborative Music-Making

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Abstract

This paper presents a qualitative study of networked audio based on interviews with nine leading artists, developers, and educators shaping collaborative music-making across distance, industry, and academia. Conducted between 2023 and 2025, the interviews provide firsthand perspectives from developer–researchers, artist–scholars–educators, and industry founders working in academic, commercial, and independent contexts. The study examines the experiences, values, and community practices sustaining networked music performance (NMP). Interviewees connect technical challenges—latency, audio quality, scalability, and accessibility—to broader social concerns, including pedagogy, inclusion, environmental responsibility, and artistic intention. Situating these developments within the longer history of telematic practice, the paper traces how open-source initiatives, commercial platforms, and artist-led organizations have collectively shaped NMP into a distributed socio-technical ecosystem. Special attention is given to women leaders whose mentorship and institutional initiatives have expanded access and strengthened professional networks. Three pedagogical case studies further demonstrate how network audio functions as a student-centered, intercultural learning environment across K–12 and higher education settings. Drawing together open-source, industry, and artistic perspectives, this paper argues that networked music is best understood not as a sequence of technological breakthroughs, but as an evolving cultural infrastructure co-constructed through artistic experimentation, pedagogical innovation, and institutional leadership.

Keywords

Networked Music Performance (NMP); Women Leaders in Music Technology; Socio-Technical Systems; Networked Music Pedagogy;

1 Introduction

1.1 Scope of the Work

A synchronous approach to networked music performance (NMP) relies on the real-time transmission and distribution of audio and control data over networks, enabling musicians in geographically

distributed locations to perform together remotely. This model expands access to participation and makes ensemble collaboration more inclusive and accessible [1]. In this paper, we focus specifically on the impact of network audio technology for transmitting high-fidelity, low-latency audio signals over the internet, which is essential when multiple performers or large ensembles aim to play acoustic or electroacoustic instruments or voice together. The primary objective is to minimize latency and audio glitches while maintaining high audio fidelity, allowing musicians in different locations to perform collaboratively as if they were in the same physical space. While other networked protocols such as OSC [2], MIDI [3], or similar data-driven control systems enable remote instrument or effect manipulation, these are beyond the scope of this discussion. This study does not aim to provide a comprehensive survey of all NMP practices, but rather a focused analysis of how a specific group of practitioner-leaders articulate the field’s development.

1.2 Social and Community Impact: Historical Context

Long before digital networks could support synchronous musical performance, artists experimented with telecommunications as a means of extending musical presence across distance. One of the earliest large-scale examples was the Telharmonium in the early twentieth century, which distributed electronic music over telephone lines to remote listeners During [4]. Although not interactive in the contemporary sense, the Telharmonium demonstrated an early coupling of sound, technology, and networked distribution to foster a remote listening community.

In 1957, Black jazz musician Paul Robeson performed remotely for a choral festival in Wales, transmitting his powerful voice from New York to advocate against segregation and racial discrimination [5]. Singing via a transatlantic telephone connection, Robeson demonstrated how networked sound could foster social connection despite technical constraints. Although synchronous ensemble performance was impossible due to latency and audio quality, the event demonstrated how networked sound could foster social connection and collective meaning despite technical constraints.

During the 1960s, telematic practices expanded through works such as John Cage’s *Imaginary Landscape No. 4*, composed for radios, is often cited as an early example of NMP thinking [1], while projects such as John Giorno’s *Dial-A-Poem* and the *Experiments in Art and Technology (E.A.T.)* series explored telecommunication as an artistic medium [6]. These works foregrounded indeterminacy, mediation, and the social dimensions of distributed listening.



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NIME '26, June 23–26, 2026, London, UK

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Digital network audio evolved throughout the late twentieth century because of the advancement in digital signal processing and networking, alongside a growing desire to connect musicians across distance. A key milestone occurred in 2000, when a jazz ensemble at McGill University transmitted twelve channels of uncompressed PCM audio to an engineer at the University of Southern California for real-time mixing, demonstrating both the technical feasibility and artistic potential of geographically distributed collaboration [7].

This momentum accelerated in the late 1990s and early 2000s at Stanford University's Center for Computer Research in Music and Acoustics (CCRMA), where the development of JACK (Jack Audio Connection Kit) and JackTrip provided open-source tools for low-latency, high-fidelity audio routing and transmission. While JACK enabled flexible audio management within a single machine, JackTrip extended these capabilities across wide-area networks, laying the technical foundation for networked ensembles, research collaborations, and distributed musical communities [8].

2 Methodology

Over the past two decades, network audio technologies have supported a wide range of practices, from experimental improvisation and large-scale ensemble work to music education, professional recording, and media/concert productions. Existing scholarship has examined NMP from technical [9], perceptual [10], and compositional perspectives [11], including latency thresholds, ensemble strategies, and system architectures. However, fewer studies foreground the perspectives of practitioners themselves: how developers, musicians, educators, and organizers narrate the field's evolution; how artistic goals shape technical design; and how values such as inclusivity, pedagogy, and environmental sustainability inform long-term practice. This paper addresses that gap through a qualitative, interview-based approach.

This study is based on semi-structured interviews conducted between 2023 and 2025 via video conferencing, in-person interviews, and written correspondence. Interviewees include trailblazers such as Chris Chafe (originator of JackTrip [12]), Scott Deal (co-founder of Deck 10 Media [13] /organizer of the "Earth Day Art Model" music festival) and Chuiyuan Meng (co-founders of Deck 10 Media), Miller S. Puckette (developer of QuackTrip and Netty McNetface [14]), Sarah Rose Weaver (founder of NowNet Arts [15] and Executive Director of the JackTrip Foundation), and Rebekah Wilson (founder and CEO of Source Elements [16]). Additionally, interviews were conducted with educators developing new NMP pedagogies and open educational communities globally, including Kenneth Fields at Central Conservatory of Music (China), Michael Dessen and Paulo Chagas at the University of California system. Together, these practitioners represent a spectrum of open-source research, commercial development, and artist-led networked performance and pedagogical initiatives.

Participants were selected through purposive sampling based on their documented contributions to the development, implementation, and institutionalization of network audio technologies. Selection criteria included (1) technical innovation, (2) sustained artistic or pedagogical

engagement, (3) organizational leadership within networked music communities, and (4) influence across research, industry, or education sectors. The aim was not statistical representation, but analytical depth across interconnected domains of practice.

This sample focuses on historically influential, institutionally established practitioners, primarily within North American and European contexts. While this enables in-depth insight into key infrastructural developments, it also limits representation of perspectives from the Global South, grassroots communities, and under-resourced contexts. Future research may extend this work by engaging more directly with these communities to develop a more globally distributed account of NMP practice.

While the author maintains professional relationships with several interviewees, this study does not aim to present neutral or exhaustive coverage of the field. Instead, it offers a situated account of NMP as articulated by a specific cohort of practitioner-leaders. To mitigate potential bias, interview material is interpreted alongside existing literature and cross-compared across participants, while acknowledging that alternative perspectives—particularly from less institutionalized or underrepresented communities—remain underexplored in this study.

Ethical procedures included obtaining informed consent from participants, offering the option of anonymity, and contextualizing quotations to avoid promotional framing.

Numerous additional network audio applications exist (e.g., SoundJack [17], LoLa [18] and works mentioned in Session 3.5), but this study adopts a focused case-study approach. This bounded scope reflects a qualitative case-study design rather than a comprehensive technological survey. The aim is to encourage further scholarly investigation into the historical, social, and community-building dimensions of network audio practices.

Interviews were coded thematically through an iterative qualitative analysis process. Interviews were thematically coded through iterative open and axial coding to identify recurring patterns and divergences. Themes were refined through repeated close reading to identify convergences, divergences, and recurring narrative patterns across participants. This process allowed both anticipated concerns (e.g., latency, audio quality) and unanticipated themes (e.g., environmental awareness, mentorship practices, accessibility, inclusivity, and sustainability) to surface organically.

Interview material is situated within existing literature from computer music, audio engineering, and media studies. Quotations are used selectively to illustrate analytical points. The goal is not exhaustive coverage of all network audio systems, but a historically grounded and practice-informed account of how internet-based collaborative music-making has developed over time from practitioners' perspectives.

3 The Emergence of Internet-Based Network Audio Systems

3.1 JackTrip and the CCRMA Lineage

JackTrip emerged from a specific research culture at Stanford University's CCRMA, where artistic experimentation, perceptual

research, and engineering were deeply intertwined. Interviewee Chris Chafe, the long-term driving force of JackTrip, describes the early years of JackTrip not as a product-driven development process, but as an open-ended inquiry into how the internet itself could be treated as a musical medium.

Chafe states early experiments explored the use of network delay as a compositional parameter, with latency conceived not solely as a technical obstacle but as an expressive affordance. As broadband infrastructure improved, JackTrip gradually shifted toward supporting synchronous ensemble performance. This transition required careful attention to packet loss, jitter, and clock synchronization, as well as to the perceptual thresholds within which musicians could maintain rhythmic cohesion. Chafe emphasizes that JackTrip’s design choices—such as transmitting uncompressed audio—were driven by listening-based evaluation rather than abstract benchmarks. Fidelity, phase coherence, and spatial clarity were prioritized because they directly affected musicians’ ability to play together.

Over time, JackTrip evolved into a flexible ecosystem rather than a single tool. Many other network audio technologies such as Netty Mcnetface and SunoBus also use JACK as their audio routing system. The introduction of hub-and-spoke server architectures enabled large ensembles, while pedagogical deployments demonstrated the platform’s value in education. During the COVID-19 pandemic, JackTrip supported dozens of institutional ensembles worldwide, revealing both the scalability of the system and the importance of organizational infrastructure beyond the software itself.



Figure 1. Eric Whitacre and Ragazzi Boys’ Chorus, Southern California Girls’ Chorus and San Francisco Girls’ Chorus network concert preparation. (Courtesy of JackTrip Labs)

Chafe highlighted a notable example: Eric Whitacre’s Virtual Choir, which unites singers worldwide through network audio technology. Originally a social media experiment, participants recorded themselves singing and uploaded videos that were synchronized into collective performances, beginning with Virtual Choir 1: *Lux Aurumque*. Over its 15-year history, including synchronous performances of *Sing Gently* via JackTrip in 2021, the project has engaged tens of thousands of singers across more than 145 countries, reaching global audiences through broadcasts, installations, and events such as the Olympics and TED [19]. Beyond its musical achievements, the Virtual Choir illustrates how networked music

enables large-scale collaboration and fosters global community, particularly during the COVID-19 pandemic.

3.2 Deck 10 Media & Large-Scale Telematic Performance

Deck 10 Media, pioneered by Scott Deal, and Chuiyuan Meng, represented a distinct yet complementary trajectory in network audio development. In interviews conducted in 2024, Deal emphasized that the platform’s goal was not simply low latency, but “reliability at scale.” Chuiyuan Meng stated that Deck 10 unified multiple aspects of telematic performance—audio, video, social interaction, and rehearsal management—into a single platform, eliminating the fragmented workflow of prior tools and enabling seamless coordination of large-scale performances. Meng noted that Deck 10 was particularly effective in educational contexts, enabling online masterclasses and ensemble rehearsals for students with minimal technical expertise, while maintaining high-quality audio and immersive interaction.

The platform supported numerous global events, including the Earth Day Art Model Festival (2019–2023), coordinating performers across continents for continuous 24-hour telematic events. Initiated in 2019, the project demonstrated environmental priorities independent of the pandemic.

Deck 10 also enabled major conferences such as the International Computer Music Conference (ICMC) 2021 and Society for Electro-Acoustic Music in the United States (SEAMUS) National Conference 2021, providing full remote participation, interactive listening rooms, and music archives for hundreds of attendees. Deal reflected on its societal impact: “Through Deck 10, people could connect in a meaningful way...if they want to have a reduced carbon footprint, they can take alternative participation options.”



Figure 2. Sonic Arts Telematic Ensemble performing *Live from the Multiverse* (2022) through Deck 10 Media. (Courtesy of Scott Deal)

Technologically, Deck 10 embraced temporal layering over strict synchronization and offered bandwidth-efficient solutions for ensembles, making it accessible to participants with varying internet capabilities. Deck 10’s design was motivated by environmental awareness and inclusivity. Deal explained that NowNet Arts, founded by Sarah Rose Weaver (in Session 4.2), included a 2018 conference panel discussion advocating for green conferences that leveraged network technology to avoid travel-related carbon emissions. This

philosophy directly informed the creation of Deck 10. Even with hybrid events post-pandemic, Deck 10 continued to support remote participation, reducing travel and promoting sustainable practices. It is worth noting that following Scott Deal's passing in early 2026, Deck 10's website is currently inactive; however, the platform's historical contributions remain documented through interviews, publications, and event records.

3.3 Quacktrip/Quaxtrip, Netty McNetface, and Patch-Based Approaches

Miller S. Puckette's work on Quacktrip and Netty McNetface, along with Quaxtrip (developed by Damon Holzborn), exemplifies both technical and pedagogical innovation. Designed within the Max and Pure Data environments, these tools allow network audio to function as a native signal-processing object within a Puredata or MAX/MSP patch, seamlessly integrating with composers' existing workflows.

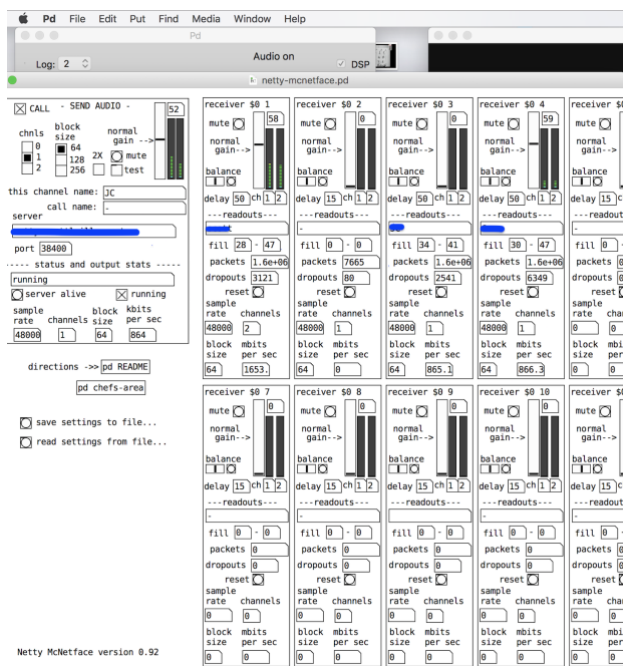


Figure 3. The GUI of Netty McNetface, displaying each node's latency and transmission data, providing separate tracks for improved post-production

Puckette stresses that the greatest promise of networked performance lies in remote rehearsal and flexible experimentation, rather than traditional telepresent concerts [20]. Early experiments, such as sending real-time audio analyses between sites, enabled creative, non-literal musical interactions, allowing performers to explore relationships among instruments, space, and sound in novel ways. As Puckette notes, networked rehearsal "allows performers to work economically over a longer span of time than might be possible physically...good musicians can learn to plan rehearsals in such a way that 50 or 100 milliseconds of round-trip latency don't stop them from exchanging ideas". By exposing network behavior directly rather than abstracting it away, these tools lower technical barriers while fostering exploratory applications that go beyond conventional

performance, supporting both educational experimentation and creative innovation.

Simplicity and transparency were central to Puckette's design philosophy. Quacktrip and Netty McNetface expose timing and buffering characteristics directly to the user, rather than hiding network behavior behind abstraction layers, enabling musicians to engage with the underlying technology hands-on. In a 2024 interview, Puckette explained, "McNetface was to make it easy for musicians to use Jacktrip, especially from their homes...since it's embeddable into Max or Pd, it's easy to incorporate in large electronic music or video setups...I'm still using Quacktrip to rehearse (and sometimes even perform) with collaborators Kerry Hagan and Irwin..." This approach allows students and composers to learn about networking and digital audio through practical experimentation and demonstrates how the tools facilitate both creative exploration and skill development in networked music performance.

3.4 Commercial Platforms and Professional Workflows

While open-source platforms emphasize inclusivity, pedagogical transparency and experimental flexibility, commercial solutions like Source Elements illustrate how network audio technologies have been adapted for professional music production workflows. Founded by Rebekah Wilson and Robert Marshall, Source Elements prioritizes stability, seamless integration, and customer support for existing studio practices, addressing the practical needs of media professionals. Wilson explains, "Our platform is designed specifically for recording and reviewing high-quality time-based media within the user's existing Digital Music Workstation and with the least set-up and technical knowledge possible...while also having good conversations with clients and collaborators who may be on a mobile phone or somewhere on the other side of the world." By focusing on predictability and ease of use, Source Elements differs from research-oriented tools, demonstrating the distinct requirements of commercial users who often prioritize reliability and efficiency over experimental flexibility.

Wilson's experiences in the early 2000s, from streaming remote performances at STEIM in Amsterdam [21] as their artistic co-director to co-founding Source Elements, illustrate the platform's development in response to real-world challenges. Predecessor technologies, such as ISDN lines and hardware codecs, were cumbersome and limited mobility. According to Wilson, "When the technical barrier is low and the media quality is high, people are happier to make the leap to working remotely." This approach has enabled voice actors, composers, and sound engineers to collaborate globally without sacrificing quality, efficiency, or access to professional resources, while also minimizing travel costs and environmental impact.

Source Elements also supports ambitious artistic and collaborative projects that extend beyond conventional media production. For instance, Wilson recounts the *Tuning to Rhythm* project [22] for the Venice Biennale, which connected musicians from Angola, India, and the Netherlands in a shared real-time session, and the *Hyperorgan* project [23], linking pipe organs across Europe and North America to

create immersive, multi-organ performances. She notes, “It’s important to me to make these tools available for creative experiments and I’m always looking for artists who are keen to try things out.” Through these examples, Source Elements demonstrates that commercial network audio solutions can meet professional standards while enabling new forms of distributed artistic practice, bridging technical reliability with creative exploration.

3.5 Mass-Market and Adjacent Platforms

Mass-market and open-source platforms such as Ninjam [24], Jamulus [25], JamKazam [26], and SonoBus [27] have introduced millions of amateur musicians to networked collaboration. While these systems often rely on asynchronous or latency-tolerant models, they demonstrate the widespread social appeal of distributed music-making and the ways communities form around shared inclusive musical experiences. Highlighting these platforms underscores the diversity of practices that coexist under the umbrella of internet-based musical collaboration. It shows that network audio technologies impact not only professional workflows but also grassroots and educational communities. Across these case studies, three distinct infrastructural models emerge: (1) research-driven open-source ecosystems; (2) artist-organizational telematic platforms; and (3) commercially stabilized production workflows. Rather than competing paradigms, these models collectively sustain the NMP ecosystem through differentiated priorities—experimentation, scalability, and reliability.

4 Women Leaders and Institutional Infrastructure

This section highlights women leaders not as a separate category, but as central figures whose contributions reveal how mentorship, institutional leadership, and equity-oriented practices have shaped the development of NMP infrastructure.

4.1 Pauline Oliveros

In the realm of networked soundscapes, the early and profound contributions of Pauline Oliveros take center stage. Widely recognized for her transformative Deep Listening practice [28], Oliveros’s telematic practice serves as a beacon illuminating the profound impact of technology on the musical creative process. Notably, key figures in this domain, such as this paper’s interviewees Chris Chafe and Sarah Rose Weaver, have been both students and collaborators of Oliveros, and they reflected on her influence in multiple contexts during their interviews.

The lasting impact of Oliveros is exemplified by tangible evidence such as the earliest collective network music manifesto, *Telematic Music: Six Perspectives* [29]. Transitioning to internet-based network audio technology in the late 1990s, Oliveros collaborated with Chris Chafe and Jonas Braasch to optimize latency and enhance audio quality. From early 2000s, by 2006, they initiated weekly low-latency, high-quality audio transmissions using JackTrip. They also incorporated UltraVideo conferencing software for real-time video communication during network performances. A milestone was reached in

November 2007, with 44 musicians participating in a three-site improvisation, guided by Sarah Rose Weaver and Mark Dresser [30].

Beyond 2007, Oliveros continued to shape network music through mentorship, workshops, and telematic improvisations. She participated in educational initiatives worldwide, fostering a new generation of network performers and composers who carried forward her telematic vision. Building on this foundation, network composers such as Sarah Rose Weaver began to integrate Oliveros’s principles of Deep Listening and telematic collaboration into their own projects, further expanding the possibilities of NMP.



Figure 3. Pauline Oliveros and her Collaborators Doug Van Nort et.al. at a Network Concert on March 12, 2009, of Triple Point [31] at the Emily Harvey Foundation (Photo credit: Troy Effner, courtesy by Doug Van Nort)

4.2 Sarah Rose Weaver

In the fall of 2006, Weaver began her journey into network music after studying Deep Listening with Oliveros for several years. She developed connections with leading network music technologists and emerged as a prominent conductor and composer for NMP. Her work integrates composition, conducting, and organizational leadership within NMP community.

Her *Synchrony* series addresses distributed time through flexible compositional structures and adaptive conducting techniques [32]. Weaver explains: “The practical goal of achieving synchrony is to overcome challenges related to latency and technology mediation, integrating them into the fabric of network music composition.” Her network music ensembles typically involve eight to 16 musicians across multiple sites, and her conducting—blending traditional and original gestures with innovative approaches such as Soundpainting—allows distributed musicians to perform cohesively despite latency. Building on this, the *Synthesis* series incorporates visual and real-time multimedia elements, enriching the technological and aesthetic dimensions of NMP [33]. Adapted to pandemic conditions, these works explore online and hybrid models, enhancing virtual and socially distanced chamber performances.

As founder of NowNet Arts (present) and Executive Director of the JackTrip Foundation from 2021 to 2023, Weaver has established institutional frameworks supporting education, research, and artistic experimentation. NowNet Arts, founded as a nonprofit in 2017 in

New York City, promotes high-quality, low-latency audio and video collaborations worldwide through concerts, festivals, conferences, and educational programs. Its projects have featured artists and ensembles across 25 countries, including partnerships with Experimental Intermedia, Harvestworks, and the Sarah Rose Weaver Ensemble.

The NowNet Arts Lab Ensemble, launched in 2020, provides an international platform for artists, engineers, and technologists to explore networked performance and develop performance-quality audiovisual technologies. Annual conferences foster dialogue on network music strategies, socially engaged practices, and innovations for hybrid performance, reinforcing NowNet Arts' global impact.

Reflecting on her leadership, Weaver emphasizes resilience and authenticity: "In my experience, the most effective approach has been to lead with my authentic work and to lead by example. The authenticity of the work overcomes challenges. I also advise cultivating self-confidence and inner knowing to guide through the challenges and to keep going with the work."

Weaver's current initiatives exemplify her multidimensional contributions. She continues developing the *Transmission Series* (2022–present), writing about her network composition system, collaborating with technologists and ensembles, and teaching network arts courses at The New School College of Performing Arts and New York University. She also serves as the Editor-in-chief of the *Journal of Network Music and Arts (JONMA)*. JONMA has been operating since 2019 as an open-access research journal published by Stony Brook University. The editorial board members include Chris Chafe and Margaret Schedel. Through her compositions, teaching, and organizational leadership, Weaver demonstrates how artistic vision, technical expertise, organizational skills, and leadership come together to advance both the practice and infrastructure of networked music.

4.3 Rebekah Wilson

Building on her technical innovations and the development of Source Elements, Wilson's work also exemplifies leadership, mentorship, and Diversity, Equity, and Inclusion (DEI) advocacy within a male-dominated audio engineering industry. She actively advocates for women and underrepresented engineers. She notes: "I've found strength and guidance in connecting with other women in technology and entrepreneurship; sharing experiences helps us navigate challenges and grow together." She encourages aspiring professionals to seek broad networks and mentorship beyond gender: "The key is to build supportive networks, continue learning, and embrace opportunities for growth, both personally and professionally."

Her commitment extends to systemic efforts. Wilson has supported young engineers in developing countries via Source Elements' Diversity program, providing tools, training, and global exposure. She also sponsors the Audio Engineering Society's (AES) DEI initiatives and fellowships, reinforcing equitable access to resources, professional networks, and economic opportunities, where women represent only 3–5% of the audio workforce [34]. Through her technical innovations,

entrepreneurial leadership, and mentorship, Wilson exemplifies how industry platforms can coexist with open-source practices, while simultaneously fostering equity, inclusion, and professional development in networked music production.

5 Inclusive, Student-Centered Pedagogy

Beyond performance, research, and production, network audio technology has increasingly become a tool for pedagogical innovation, a trend accelerated by the COVID-19 pandemic. The following three case studies show how network audio pedagogy bridges technical and social dimensions, fostering cross-cultural creativity, intercultural understanding, and resilient learning communities.

5.1 Case Study 1: the "Telematic Bridges" Project

The *Telematic Bridges / Puentes Telemáticos* initiative connects K–12 students from Santa Ana High School (California, USA) and Fundación Batuta (Manizales, Colombia) using network audio technologies for cross-cultural collaboration. Led by Michael Dessen, active in telematic music since 2007 [35], the program emphasizes improvisation, composition, and telepresence. Dessen observes the challenge of this innovative pedagogical approach, "Most music faculty and students simply aren't interested or have had negative experiences with tools like Zoom over the pandemic, which makes them very hesitant to get involved. My main interest here is to help them see that with the right tools and sufficient time, it can work very well and be a positive experience."



Figure 4. In a classroom of "Telematic Bridges" educational project using network audio technology

Originally a week-long summer course in 2017–2018, the program expanded to a three-week format by 2021. Students engage in improvisation, collaborative composition, and small group activities that explore telepresence and intercultural musical dialogue.

Dessen's curriculum emphasizes:

- Technical orientation: guiding students through low-latency performance setups and software/hardware interoperability
- Philosophical reflection: introducing critical writings on telepresence and networked arts

- Creative collaboration: enabling students to compose and experiment with ensemble interactions

Students encounter multiple pedagogical challenges. These include:

- Bandwidth limitations and uneven internet quality, which can disrupt synchronous performance
- Interoperability and software/hardware compatibility, requiring careful setup and troubleshooting
- Institutional support constraints, as network audio often requires special permissions, equipment loans, or non-standard software installation
- Limited technical proficiency among students and faculty, which Dessen emphasizes: “It is commonplace for both traditional music students and faculty members to exhibit a fundamental lack of audio technical knowledge, even in rudimentary tasks such as configuring microphones or interfaces. Addressing this early on is essential for successful remote ensemble work.”
- Geographical and temporal coordination, as collaborating across multiple time zones demands patience, clear communication, and active engagement
- Skepticism or resistance to new approaches, particularly when participants have experienced negative outcomes with standard video conferencing tools

Despite these hurdles, students develop resilience, problem-solving skills, intercultural sensitivity, and ensemble communication abilities. Tools such as JackTrip and Soundtrap enable them to collaborate creatively, producing compositions and recordings that transcend physical and cultural boundaries.

5.2 Case Study 2: Connecting East and West: The Pedagogy of Networked Chronotopes

Since beginning his teaching in network music in 2008, Kenneth Fields has developed a curriculum that integrates technological infrastructure, philosophical inquiry, and intercultural collaboration, positioning network music as a redefinition of musical time and collective presence. He frames NMP as an expansion of spatial and instrumental practice—a theoretical foundation he translates into pedagogy through critical readings and laboratory experimentation with JackTrip, Artsmesh (Mesh) [36], OSC, and custom systems such as the Netronome and Netronomia score platform [37].

His pedagogical focus is the “sync continuum,” which treats latency not as technical failure but as compositional material. In transpacific collaborations between North America and East Asia, audio transmission inevitably incurs far greater delay than performances across neighboring U.S. states; such latency cannot be eliminated or ignored and must instead be measured and musically integrated. As discussed in *Syneme: Live* [38], distributed performance produces distinct yet interconnected temporal experiences. Through the Netronome, latency is quantified and incorporated into shared pulse structures, enabling ensemble cohesion through negotiated temporal difference rather than strict simultaneity [38] [41].

Pedagogically, Fields also confronts resistance from musicians trained to equate ensemble performance with tight synchronization. Many students struggle to accept that musical coherence can exist beyond 50 milliseconds of latency. By reframing delay as aesthetic material, Fields challenges inherited assumptions about musical “togetherness.”

Beyond technical and rhythmic experimentation, Fields’ pedagogy emphasizes sustained international partnership. His long-term collaborations with institutions in China, Indiana, Canada, the U.S., Sydney, and elsewhere demonstrate his principle that networked music depends on stable, reciprocal nodes. His commitment to bridging Eastern and Western practices within electroacoustic and networked music cultures is reflected in his day-to-day teaching. Through these exchanges, students participate in transpacific performances that expand cultural awareness alongside technical competence.

Similar to the Dessen case study, Fields identifies several recurring challenges in networked music education:

- Technical complexity of signal routing and server architecture
- Student resistance to latency-based aesthetics
- Steep learning curves
- Institutional emphasis on low-latency optimization rather than conceptual exploration
- Isolation tendencies among computer musicians unaccustomed to ensemble thinking

To address these challenges, Fields advocates starting with simplified structures, cultivating ensemble listening habits, and gradually introducing complexity. His approach prioritizes shared durational awareness and collaborative restraint (“less is more”) to allow distributed groove structures to emerge organically.

Rather than treating technology as a compensatory tool for separation, his teaching positions networked music as a distinct artistic ecology—one in which temporal displacement generates new musical phenomena. Students who have continued this work in their own teaching extend a compatible network of practices, gradually building a distributed community of practitioners in China. In connecting East and West through sustained partnerships and shared technological platforms, Fields’ pedagogy implies a model of global musical citizenship grounded not in uniformity, but in relational difference.

5.3 Case Study 3: Teaching Transnational Telematic Chamber Ensembles

The transnational project *Our Music, Our Stories: Connecting Creative Communities* (Spring 2021) [39] connected students from the University of California Riverside Concert Band (Lauren Wasynczuk, director) and Ensemble LaFlauta at the University of São Paulo (Cássia Carrascoza, director). Conceived and technically directed by Paulo C. Chagas, the ten-week collaboration integrated telematic music into

chamber ensemble pedagogy through weekly rehearsals and four public performances.

Chagas notes, “Traditional chamber music is structured as a succession of linear events such as set themes and variations, while networked chamber music creates a dialogue that occurs in simultaneous time and space, and all players in all places make decisions relating to themes and their variations all at once. [40]”

Pedagogically, the project emphasized ensemble listening, technological literacy, and intercultural collaboration. Students rehearsed weekly using JackTrip for low-latency network audio, Max/MSP for signal processing, and Zoom for visual coordination and conducting cues. Working from home setups (mostly low-end audio interfaces, microphones, headphones, and wired internet), students confronted multiple challenges:

- Hardware and software compatibility across international systems
- Installation and troubleshooting of network audio platforms
- Coordination between audio and video channels
- Managing synchronic and asynchronous ensemble relationships
- Sustaining cohesion across geographic and temporal distance

Beyond technical coordination, the project incorporated distinct audiovisual and organizational strategies that shaped the telematic performance environment. Performers used Zoom background images representing their local ecological and cultural environments, creating a shared visual space that functioned as a form of visual polyphony alongside the musical texture. In parallel, Zoom chat served as a distributed conducting interface, enabling real-time coordination of entries, cues, and structural instructions. Rather than relying solely on gestural conducting—which can be unreliable in latency-prone environments—this text-based system supported precise ensemble coordination across distance. Together, these approaches demonstrate how telematic pedagogy extends beyond technical problem-solving toward the design of integrated audiovisual and communicative performance ecologies.

Rather than centralizing technical control, Chagas encouraged distributed problem solving. Students assisted one another in configuring software and resolving connectivity issues, transforming troubleshooting into a collaborative learning process. Technical competence thus developed alongside ensemble awareness.

Over ten weeks, the ensemble presented two telematic concerts with live audiences and two additional virtual performances. Participants reported a heightened sense of intercultural connection and adaptability. By situating virtual space as an extension of chamber practice rather than a substitute for physical presence, this case study demonstrates how telematic pedagogy can cultivate shared agency, technological fluency, and collaborative resilience across borders.

6 Discussion and Future Envisioning

When envisioning the future of network audio, interviewees consistently linked technical futures to broader social concerns. Anticipated developments include incremental improvements in latency, clocking, and spatial audio; AI integration; and deeper convergence of audio, video, and interactive media. Many practitioners described NMP as a means of reducing travel-related carbon emissions, yet they also acknowledge the paradox of increasing energy consumption and infrastructural demands required to sustain digital performance ecosystems.

Questions of accessibility, pedagogy, and interoperability are still central challenges. The absence of shared standards and unequal access to high-quality networks due to socioeconomic disparities continue to shape who can participate in networked music practices and their levels of engagement. Practitioners expressed cautious optimism that future developments would expand accessibility and inclusion while preserving artistic depth.

Across these case studies and practitioner narratives, a consistent pattern emerges: networked music performance is shaped not only by technical constraints, but by the design of interaction systems—temporal, social, and communicative—that mediate collaboration across distance. Rather than treating latency, infrastructure, and coordination as problems to be solved, practitioners repeatedly reframe them as compositional and pedagogical materials. This shift suggests that NMP is less a technical domain than a relational practice, in which musical, social, and institutional structures are co-designed.

7 Conclusion

This study positions network music performance as a distributed cultural infrastructure sustained through artistic experimentation, pedagogical innovation, and institutional leadership. Practitioner narratives reveal that latency, audio fidelity, and interoperability are not merely technical problems but sites where artistic intention, environmental ethics, and questions of access intersect.

Across open-source initiatives, commercial platforms, and artist-led organizations, NMP emerges as an evolving ecosystem shaped by collective practice rather than isolated invention. Pedagogical case studies further demonstrate that networked collaboration cultivates technological fluency, intercultural awareness, and adaptive musicianship in both K–12 and higher education contexts globally.

As distributed performance becomes increasingly embedded in artistic and educational practice, the future of networked music will depend not only on technical optimization, but on how communities negotiate sustainability, inclusivity, and shared authorship within global digital infrastructures.

Ethical Standards

The authors declare no conflicts of interest. All participants involved in data collection, including interviewees, provided informed consent. No animals were involved. All procedures were conducted in accordance with accepted ethical and professional standards.

Acknowledgments

I sincerely thank my interviewees for their time and insights, which made this research possible. I also extend my gratitude to those who provided photographic materials and assisted with documentation. A special tribute is offered to Scott Deal, whose contributions to the network audio community will be remembered fondly.

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