The Aesthetics and History of the Hub: The Effects of Changing Technology on Network Computer Music

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ABSTRACT

The author, a member of the group the Hub, discusses the aesthetic and performance history of the group and related San Francisco Bay Area live interactive music performance practices. The performance practice of the Hub—interactive computer network music—is discussed. Particular focus is placed on the impact of changes in technology. Future applications and directions of this musical approach are discussed.

From the beginning of our line of work, in the experiments of the League of Automatic Music Composers and other avant-gardists working at Mills College in the mid-70's, the emphasis has been on connections between musicians, the excitement of using computers to define a new social context for music making, as well as exploring the possibilities of systems too complex for direct control. Indeed, the roots of this work go back even further: to the vital experimental music scene of the San Francisco Bay Area, which since the 1930's has had a strong tradition of instrument building, live performance and multimedia collaboration.

—Tim Perkis, founding member of the Hub [1]

Music is, at its core, a means of communication; computers offer ways of enhancing interconnection. Computer network music uses the microcomputer's ability to interconnect with and communicate information to other microcomputers, creating interactive data environments that can be electronically transcribed into music. By exploiting these unique capabilities, composers and musicians are inventing new forms of live performance that enhance the inherent social attributes of music making. This practice runs contrary to the idea that contemporary electroacoustic musicians exert almost total control over all aspects of the music. Rather, computer network musicians attempt to "seek more surprise through the lively and unpredictable responses of these systems, and hope to encourage an active response to surprise in the playing" [2]. I have had the rare opportunity of creating this dynamic new music as a member of the Hub, a San Francisco Bay Area interactive computer network music group. I have observed the consequences of interfacing new technologies with concepts of earlier decades, seeing what worked, what failed and what fell away as the technology changed. Other viewpoints of the concepts behind this kind of work have been discussed in *Leonardo Music Journal* by two of my associates in the Hub: Mark Trayle [3] and John Bischoff [4].

Reviewing the historical context of the Hub (John Bischoff, Chris Brown, Tim Perkins, Mark Trayle, Phil Stone and myself) can help clarify aspects of the aesthetic setting from which the group sprang. From 1986 to 1997, the Hub was part of a new genre of music making. The advent of both the microprocessor and the affordable, multi-parameter, controllable MIDI synthesizer made possible a new type of network-based performance. This type of performance was also the result of a natural progression of developments in contemporary music practice that began with John Cage, David Tudor, Gordon Mumma, Pauline Oliveros and many others. These artists invented new forms of performance based on strict procedures that were directly related to the electronic equipment each of them used in performance.

Such procedures were established in one of two ways. In some cases, equipment became available that offered a specific functionality that inspired the composer to establish a sonic palette that utilized it. In others, the composer understood electronics well enough to design a circuit specifically for the purpose of creating new musical pieces. No longer tied to the centuries-old traditions of musical notation, composers created new notations that often were based on only a circuit design and a short set of performance instructions [5]. These pieces were not, strictly speaking, improvisation, since the indeterminate nature of the interactions between the electronics and the performers constrained the performances to the contexts of the particular functions of the electronics.

COLLABORATIVE REALIZATION OF COMPOSER INSTRUCTIONS

Each composer/performer puts together their own hardware and software instrument for collaborative live performance. This point is clearly demonstrated by a seminal work in this genre, *Rain Forest* by David Tudor [6]. This piece is very sculptural in nature. In preparation, the performers must devise ways to mechanically connect speaker drivers and other electromechanical transducers directly to large, suspended found objects. Very powerful amplifiers pass a variety of audio material acoustically through the suspended objects. There is no score in a traditional sense—only a set of instructions and notes about previous performances and performers and how they met the composer's criteria.

This kind of performer/composer collaboration is essential to the execution of a computer network piece. A performer's interaction with the material, both physical and auditory, generates a totally unique sonic environment that is driven by the procedure used to create it. The configuration

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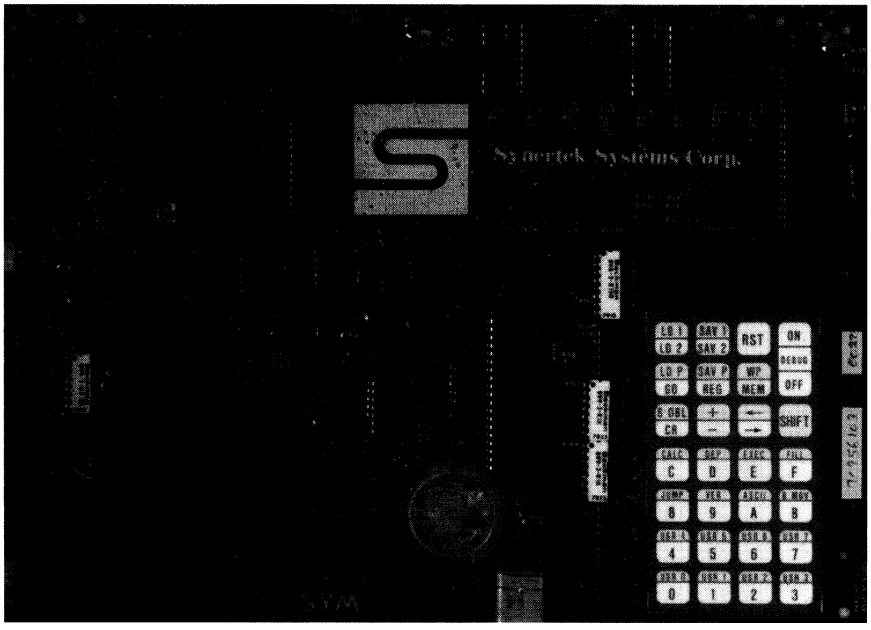


Fig. 1. In 1987 the hardware "hacking" environment of choice was the Synertek SYM 6502 single-board computer. Using Digital ADM3a terminals and a rudimentary assembler, Phil Stone wrote the software for Tim Perkis's hardware configuration. The configuration allowed three users on each of the two SYMs to use the RS-232 serial protocol to communicate with a 1-K memory pad. This pad was shared by the two computer systems over the phone lines. In rehearsal, a null modem cable was used. (Photo: Scot Gresham-Lancaster)

of the sound production system for pieces using these techniques is equivalent to the composition. The composer sacrifices certain parameters of direct control in order to create a new context that is unattainable by other means. These underlying concepts of collaboration and technical interdependence are the hallmarks of the Hub and related ensembles.

The works of Tudor, Mumma et al. and later De Marinis, Bischoff et al. were based directly on the technology at hand. Composers working in this context often stay in touch with and are aware of new developments in technology. Advancements in differing technologies generate new ideas and ways of thinking about sound and its relationship to musical form. In this way, composers often discover unintended ways of using new technologies. Most artists are faced with both the need to meet the consensus of society and the urge to express themselves. Available tools constructed from utilitarian elements are designed to meet prescribed purposes rather than the needs of a given sound artist. Interactive electronic music constitutes a continuing story of the ingenious use of technologies in unique and unconventional ways.

An engineer looking at Tudor's performance set-up noticed he was using a particular piece of equipment he had helped design was appalled to find that it was patched together "wrong." Tudor explained that although he was aware of its intended use, his own application generated a type of feedback that he found particularly stunning. The engineer was dumbfounded, the audience rewarded [7].

Direct Use of Electronics as a "Score"

Independent circuits developed by individual artists represented a further development in this genre. Mumma broke ground in this area with his *Hornpipe* (1967), *Mesa* (1969) and other circuits. The unique aspect of this type of work lay in the circuit's de facto equivalence to a score. For example, Paul De Marinis's *Pygmy Gamelan* (1973) is a small circuit that endlessly plays an ever-changing set of notes in a charming, bell-like tone.

A direct correlation exists between the state of electronics of a period, the developmental tools available and the content of the resulting circuits. Throughout the 1970s the complexity and availability of these electronic components increased dramatically with the development and proliferation of the microprocessor. These days the developmental tools have become too sophisticated for a non-engineer to use. The unfortunate tendency in our culture to stay up with state-of-the-art technology has often left perfectly viable means of artistic expression behind in the name of modernity. As the tools for hardware development become more accessible in the future, perhaps a resurgence in the direct, expressive use of electronics will be prevalent once again.

The League of Automatic Music Composers

Typewriter, it types us, encoding its own linear bias across the free space of the imagination.

—J.G. Ballard [8]

"The League," as the League of Automatic Music Composers came to be known, was founded by Jim Horton (the originator of the idea of a computer network "orchestra" or "ensemble"), Rich Gold and Bischoff in 1978 [9]. Over the next few years, Gold moved on and was replaced by Perkis. This trio developed the League idea extensively in composition and performance, bringing finished compositions by each member into the group context and playing them simultaneously with adaptations added for data exchange and resulting interactions between compositions.

Ballard's quote above hints at a fundamentally unique aspect of this genre of music. The content of the work is shaped by the design of the instruments being invented by the composers/performers. Each new piece conforms to a uniquely designed software/hardware configuration; new forms and new sounds based on these configurations subsequently emerge. Each composition is constrained by a strict adherence to procedure. The performance of this music is idiomatic and requires a special understanding of the software and hardware being used. The inherent ironies in this approach are clear: these pieces of music can never be repeated exactly, and it would be very difficult to reconstitute the exact state and set-up that made up a given performance. Subsequently, this music can be documented only in recordings and cannot be replicated accurately. Future musicologists will be hard-pressed, for example, to reconstruct the workings of an early single board computer, a Commodore KIM 1 and the software Bischoff used to realize *Audio Wave* [10].

The League of Automatic Music Composers and, later, the Hub arose within a tradition of cooperation and self-di-

rected, self-designed electronics uniquely configured for the expression of individual pieces. The concept of the score was embodied in this context. A score consists of the instructions needed to achieve the desired resulting sound. In the case of the Hub, scores consisted of sets of specific instructions that related the technical requirements to obtain the results the composer wanted to realize. This, necessarily, required cooperation and resulted in some surprises.

In some E-mail to me, Bischoff noted:

> My experience of the 2 groups [the League and the Hub] is that the relationship between issues of music time vs. hack time and robustness were not very different in the last analysis. I see both groups as having a slightly different angle on the concept of network music but at the same time being equally successful musically and technically [11].

Inevitably, however, the non-uniform interconnections and the lack of a common, shared protocol between individual players in this ensemble pointed to much-needed refinements.

The Network Muse Concerts

By the summer of 1985, several technological changes had taken place, paving the way for a concert series that was to stimulate the transformation of the League of Automatic Music Composers to the Hub. The advent of MIDI in 1983 had a major impact, enabling often-impoverished performers/composers to utilize these new, affordable instruments. Also, Apple Macintosh and Amiga computers introduced the beginnings of a software base of programming languages and music sequencer programs, which enabled individual composers to develop techniques that challenged conventional notions regarding the intended uses of these instruments and software.

These developments culminated in a concert series of four evenings at the Lab in San Francisco entitled "Network Muse," curated by Brown, then-director of the non-profit Ubu Corp. [12]. Bischoff and Perkis entitled their performance in the series "the Hub"—a term they had already used to refer to the act of generating shared musical information. (This brings up a point of confusion: Does "the Hub" refer to a configuration or a group of individuals? In addition, members of the group also referred to our hardware and software as "the Hub.")

The First "Hub" Concerts

In the fall of 1985, Nicolas Collins contacted Brown to propose a network-based concert from two sites in New York City: the Clocktower and the Experimental Intermedia Center. At this point the Hub was expanded from the list of performers from the Network Muse concerts to a group comprising Bischoff, Brown, Perkis, Stone, Trayle and myself. The idea was that the performers at both sites would play simultaneously over phone lines via modem; coordination of the project required a huge technical effort. Ultimately, we were able to support three individuals at each site (Bischoff, Perkis and Trayle at one site; Brown, Stone and myself at the other). Each trio traded performance sites on consecutive evenings. The two trios freely exchanged the information that constituted a given piece between the two sites.

This experiment occurred several years before the proliferation of the Internet and the general use of E-mail and yielded commentary from several journalists [13]. Although the group performed at separate locations a few times, it created its strongest and most interesting work with all the participants in the same room, interacting directly with each other and with the emergent algorithmic behavior of each new piece.

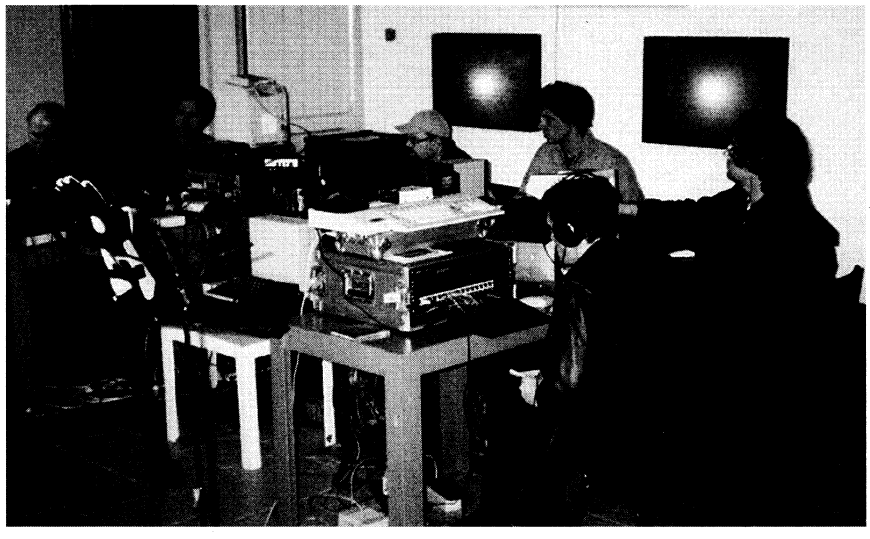
The early version of the Hub solved many of the pitfalls of the ad hoc arrangements previously used in the performance of network music. It offered a standardized format on which each participant could count during each rehearsal and performance. This format allowed a field of investigation that resulted in a body of rich and powerful work.

The following excerpt from Bischoff's notes on the first Hub audio compact disc (CD) (1989) regarding his piece *Perry Mason in East Germany* illustrates the procedure we used to create work in this context.

> Each of the six players runs a program of his own design which constitutes a self sustaining musical process. Each program is configured so that it can send three changing variables important to its operation out to the Hub and also to receive three variables from other players. Each player reads the variables put out by three different performers, and sends out for use by three different performers as well. This relationship of mutual influence results in a network structure that often yields a special kind of musical coherence [14].

This first generation of the Hub (Fig. 1) was modeled after what is referred to as a "blackboard system" [15]. Blackboard systems are shared data structures through which knowledge sources communicate. In this case the knowledge sources are the autonomous programs of each of the composer/performers in the Hub. All the pieces were designed around a shared memory, which strengthened the collaborative aspect already present in our work. We came to refer to this shared memory as "the Blob," a conceptual place in which we shared the active components of any given piece. Also, since using our systems in this collaborative configuration

Fig. 2. The Hub: John Bischoff, Chris Brown, Tim Perkis, Phil Stone, Scot Gresham-Lancaster, Mark Trayle performing at the Apollohuis in Eindhoven, the Netherlands, 1992. (Photo: Paul Panhausen)



was completely asynchronous and contained no specific timing information, the aesthetic context of a given piece was unconstrained by data type. Procedures drove the music forward, much in the musical tradition of Cage and Tudor.

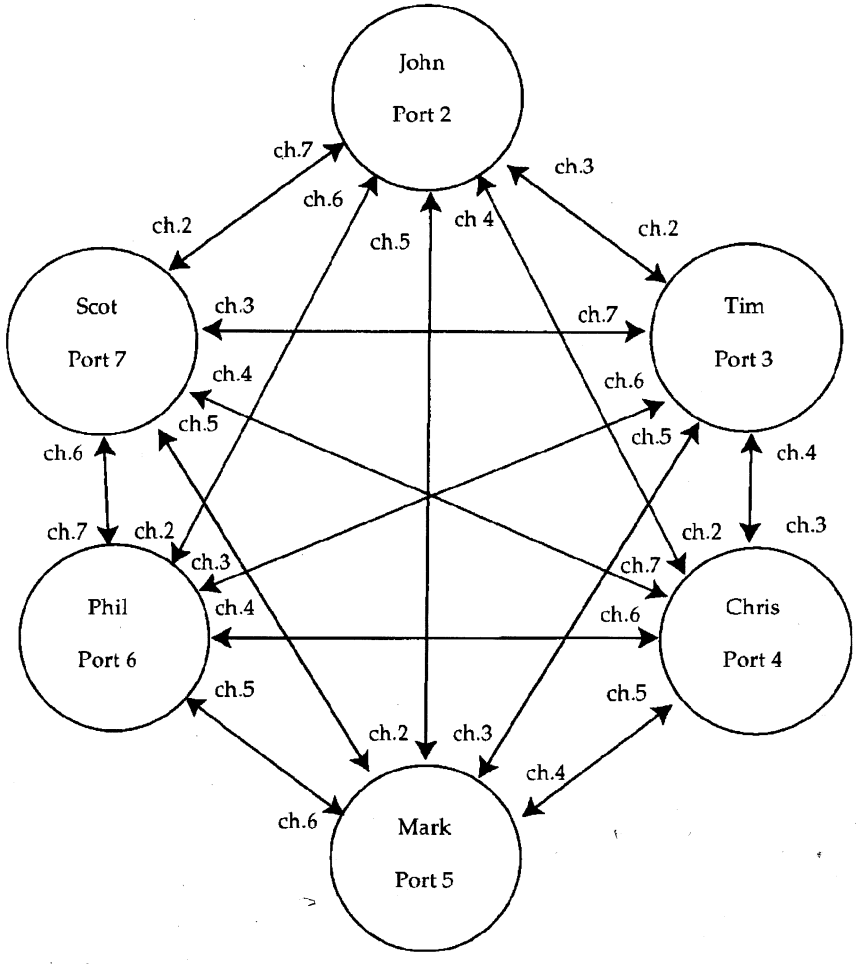
One piece of note from this period was a collaboration entitled *HubRenga,* performed and broadcast via Berkeley radio station KPFA in September 1989 [16]. The intent of this piece was to mimic the Japanese poetry form *renga.* The Hub wrote algorithms that played specific types of music for each word in a word list. Users on the Internet conference network Whole Earth 'Lectronic Link (WELL) utilized the words to make single lines of poetry that they posted on-line on the WELL's poetry conference. These lines of text were transcribed in real time from the on-line WELL conference in the performance studio at the radio station and read over the air by Ramon Sender, Barbara Golden and Kenneth Atchley. Simultaneously, the text was parsed by a computer program that searched for words from the word list. A number assigned to each word was passed to solo, duo and trio groupings of the six members of the Hub. Aleatoric methods were used to distribute these number groupings randomly among the Hub members. When a performer received a number, he would play the algorithm that had been written for that word through his music system.

This peculiar piece illustrated the problems of a music based on a large group of "interactors." In this case the Hub used all word combinations and impromptu lines generated by the poets. With the network open to all comers and the technology simplified, we assumed it would be an egalitarian victory for art. The varying range of taste and innate talent made for a pastiche that lacked finesse and cohesion, and despite the best intentions of the contributors, the results were mixed. Ultimately, the success of a work depends upon a careful design of the possibilities and outcome of each indeterminate decision. Without this, the refinement and sophistication needed for truly interesting work is absent. In the end, Bischoff and I edited *HubRenga* down from a 1½-hour performance to a 6-min, 58-sec final piece.

Most Hub recordings were made from live performances (Fig. 2) with occasional edits; in no case, including in the recording of *HubRenga,* did we use multitrack recording techniques. Live interaction, with its surprise and immediacy, is a fundamental aesthetic thread and a crucial element of our work.

This home-brewed, hand-built environment that we created carried with it some problems, the foremost being its non-duplicability. If anything went wrong with the hardware, especially on tour, we could not perform; there were no stores or special-order mail houses we could call to get a new Hub. As the system aged this became more of a potentially major problem.

Fig. 3. A graphic depiction of the data flow and MIDI channel assignments of the MIDI-based Hub 2. (Photo: Scot Gresham-Lancaster)



HUB 2: THE MIDI HUB

Around 1990, I was asked to be a beta tester for OpCode Systems' new MIDI interface Studio 5. After several in-depth conversations with Perkis, we realized that we could design a new type of MIDI-based Hub with the operating system of this new unit, which functioned around a much more dynamic design than the earlier version (Fig. 3). Each player was assigned a MIDI port (one input and one output), numbered 2 through 7. If the player on port 7 wanted to communicate a message to the player on port 2, he simply sent a MIDI channel-type message on MIDI channel 2. The player on port 2 received the identical MIDI channel message rechannelized on MIDI channel 7 and encoded with the identity of the person sending it.

In this way, each participant in the network could directly play the set-up of any other person in the group, which was not previously possible because all sound production had been based on interpretation of the information in the shared memory. This new arrangement allowed each participant in the group a direct and private MIDI message path to each of the other participants, making it unnecessary to access and interpret a shared memory space. This new context created new ways of thinking about the concept of a network for making music.

The most relevant piece in this regard is Perkis's *Waxlips*:

> *Waxlips* (Tim Perkis, 1991) was an attempt to find the simplest Hub piece possible, to minimize the amount of

musical structure planned in advance, in order to allow any emergent structure arising out of the group interaction to be revealed clearly. The rule is simple: each player sends and receives requests to play one note. Upon receiving the request, each should play the note requested, and then transform the note message in some fixed way to a different message, and send it out to someone else. The transformation can follow any rule the player wants, with the one limitation that within any one section of the piece, the same rule must be followed (so that any particular message in will always cause the same new message out). One lead player sends signals indicating new sections in the piece (where players change their transformation rules) and jump-starts the process by spraying the network with a burst of requests. The network action had an unexpected living and liquid behavior: the number of possible interactions is astronomical in scale, and the evolution of the network is always different, sometimes terminating in complex (chaotic) states including near repetitions, sometimes ending in simple loops, repeated notes, or just dying out altogether. In initially trying to get the piece going, the main problem was one of plugging leaks: if one player missed some note requests and didn't send anything when he should, the notes would all trickle out. Different rule sets seem to have different degrees of "leakiness", due to imperfect behavior of the network, and as lead player I would occasionally double up, sending out two requests for every one received, to revitalize a tired net [17].

The simplicity and clarity of the network and its emergent behavior in this piece were emblematic of the new possibilities the changing technological context brought to the work. Constructing and rehearsing a piece of this nature is a lengthy process of trial and error, troubleshooting and redefinition. Each participant had a unique software development environment and a different hardware and music production setup. We constantly upgraded versions of our software, including changing programming languages, synthesizers and even microcomputer platforms. This shifting context of hardware and software constantly updated the sound of the ensemble and made replicating old repertoire difficult. We would need to completely rewrite old versions of works for each new context, and troubleshoot and reestablish the reconnection between players for each piece.

Over the course of the decade, we used these hardware and software arrangements in a number of performances. The audience was often mystified by what they heard in relation to what they saw the performers doing. Audience members have commented more than once after a concert that, "The music was fantastic, but you looked like a bunch of air traffic controllers." Acoustic instrumentalists must assume the proper embouchure and/or posture to perform on their instruments, and the same is true for playing interactive computer network music. The vision of musicians hunching over their computers and synthesizers to create this music was unfamiliar to most audiences.

Experiments with Software Synthesis and the Internet

After years of a lack of uniformity between our systems, we recently began experimenting with the newly developed Grainwave software synthesis system [18] developed by Mike Berry. This flexible and modular system is representative of a type of software package that will become more prevalent as desktop computers reach the speeds necessary for real-time sound production. With Grainwave we can now create our sound production engine from scratch. Our roles as composers now also include designing the instrument(s) to be used in the composition, a development that is having an enormous impact on the sonic texture of the group. This fundamental change is steering our aesthetic toward a post-serialism in which the composer maintains strict control of all formal aspects of the music. We are again using a practice that had happened, to a more limited extent, in earlier stages of our work—trading verbatim code back and forth. Various members with like computers and development environments had been using each others' code for years; now, not only do we share the algorithmic code, but also the actual computer code needed to generate the sounds for the piece. This actually replaces the synthesizers we used in the past with the computer, resulting in a major shift in the low-level structure of how a performance and the sound of the pieces are put together.

Directly after this rather major shift of synthesis schemes—from MIDI and home-brewed hardware synthesis for each player to identical, do-it-yourself software synthesis instruments—we implemented another technical change with far-reaching aesthetic implications. We planned to return to a concert comprising geographically separate performances (such as the one in New York in 1987), but with a major difference. This time we planned to use the much larger span of the Internet. With the help of Matt Wright at the Center for New Music and Audio Technology (CNMAT) at the University of California at Berkeley, we acquired a special version of his (otudp) object running under CNMAT's OpenSoundControl communication protocol program [19] in Max. This custom module enabled us to make a Max-based patch that let us send MIDI messages directly to any computer's Internet Protocol (IP) address anywhere. This made possible a third-generation Hub that worked much like the previous generation, but with the much higher-speed potential of the Internet.

A great deal of effort went into our designing a prototype in such a way that we could represent the distant Hub members with proxy or ghost stations at each of the IP addresses; but invariably due to technical problems, none of the surrogate Hub members worked identically. During previous performances, we could recover from system crashes and reboots caused by our ad hoc software combinations while other group members covered our unintended silence. In this new, more exposed setting, a crash could cause the remote sites to freeze up. This effectively stopped the interdependency that was the hallmark of our work.

In the only test case so far, two of us performed from each of three sites: Bischoff and Stone at the Mills Center for Contemporary Music, Oakland, California; Trayle and me at California Institute for the Arts in Valencia, California; and Perkis and Brown at Arizona State University's Institute for Studies in the Arts. This formidable test actually ended up being more of a technical exercise than a full-blown concert. The Hub has always been a collective of technically savvy musicians; we are all aware that one must maintain a very difficult balance between technology and expression. The trick has always been to get the tools working and then to find the music in the newly built context. In this case, the technology was so complex that we were unable to reach a satisfactory point of expressivity.

This technical exercise brought up a series of issues that all of us in the group still grapple with. First and foremost is the question: Is there a difference between locally produced network music and music produced in the larger context of the Internet? In my opinion, there is a tangible difference in that the

use of the Internet must be met with new methods and aesthetics. Our experience with *HubRenga* illustrated that the process of network music to all comers requires prior planning, as does any activity that works with indeterminacy.

The work of the Hub has helped refine and define a context for the live performance of local computer network-based music. Our rich body of experience points to all sorts of unexplored regions of art production. As the tools for using computers in the arts improve, the collaborative techniques pioneered by the Hub should be used to explore these regions not only with music but with all artistic disciplines.

The disappointing outcome of the Internet experiment has caused each of us to reevaluate our relationships to this now decade-old cooperative. I think the aesthetic and technical weight of all the years of work has led each of us to different places. Through the means of consensus that the organization was based around, the Hub has now reverted to its original state—a concept of hardware and software combinations that generate what can be characterized as "computer network music." This is perhaps what it has been all along. Out of a sense of fraternity and a familiarity with our shared taste, we replicated the form and function of a conventional musical ensemble. Needless to say, the work continues, and the emergent behavior of network-oriented music production will retain the allure and mystery that attracted all of us to it in the first place. The intent to detach ego from the process of music making we inherited directly from Cage. To refine that impulse and to make it a living machine that both incorporates our participation and lets the breath of these new processes out into the moment: that is the unique contribution of the Hub.

> *Anytime you make a musical decision for a non-musical reason, the music suffers.*
>
> —Sam Ashley (spirit-possessed stand-up comic, shaman, composer, performer and witch doctor), transcribed from the ongoing research for "The Very Important Now" [20].

References and Notes

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7. From a conversation between the author and David Tudor in Amsterdam, June 1994.

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11. John Bischoff, unpublished E-mail to the author (18 June 1998).

12. Jim Horton and Bill Thibault's Web site, *The History of Northern California Experimental Music* at <http://tesla.csuhayward.edu/history>, is an invaluable resource for any scholar or interested party curious about examining the programs, reviews, press releases, etc. from the vital northern California experimental music tradition. Information on "Network Muse" is included in the site.

13. See Kyle Gann, "Musica Telephonica," *Village Voice* (23 June 1987) p. 83.

14. John Bischoff, liner notes to the audio CD *the Hub,* Artifact Recordings ART 1002 (1989).

15. See Robert Engelmore and Tony Morgan, eds., *Blackboard Systems,* The Insight Series in Artificial Intelligence (Reading, MA: Addison Wesley, 1988).

16. *HubRenga* was broadcast over KPFA, Berkeley, CA. See KPFA's monthly, *Folio* (September 1989) .

17. Perkis [2].

18. See Grainwave Web site: <http://www.mills.edu/LIFE/CCM/CCM_Software.html>.

19. See OpenSound Control Home Page: <http://www.cnmat.berkeley.edu/OpenSoundControl/>.

20. For more information on the author's new musical collaboration "The Very Important Now", see <http://tesla.csuhayward.edu/~scot/you.html>.

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