Computer Network Music Bands:
a History of "the League of Automatic Music Composers" and "the Hub"

Chris Brown and John Bischoff

Introduction
by Chris Brown

Many pre-industrial musical traditions share the concept that the sound produced by the bodies of living things express their spirits: the drum-skin or the horn speaks with the voice of the animal it came from, or the xylophone speaks the voice of the trees in the forest. The musician's role is to bring these voices out, allowing them to speak for themselves about the nature of the world.

20th Century composers like Edgard Varese, John Cage or Harry Partch reconnected with this idea in their use of materials like sirens, brake-drums or wine bottles, using the raw, unaltered sounds produced by found objects discarded by their industrial culture that expressed the unique qualities of its character. Each sound expresses the spirit of its own physical body, and all of these are uniquely worthy of musical attention. This point of view refreshed the music of a culture that had completely rationalized and limited its own musical resources, opening it to the noise that changed both instrumentation and means of organization.

As industrial culture moves from a physical to an electronic basis, does this approach still apply? Analog electronic technology remains physical even while it focuses on a shrinking physical scale — instruments like electric guitars or turntables zoom in on the vibrations picked up microscopically from above the points of wire-wound magnetic pickups, or through contact with tiny etchings in vinyl. But with digital technology, the source of the medium has become purely symbolic, all sounds are generated by collections and interactions of sets of numbers. Samples themselves may be images derived from physical objects, and when they are used to drive loudspeakers the air itself becomes the vibrating body; but this is a medium in which the shaping of those images and air is accomplished at root by mathematical or symbolic functions, and these functions have no body. The spirit, or poetry, of computer music, gives voice to a non-physical reality. It is the sonification of data, a genie with the ability to change shape at will, that moves from one physical body to another at the speed of light.

The network is the locus and a source for a new kind of music. The network provides the new technological way that representations of sounds, like all other physical forms, can be manipulated collaboratively, transcending the physical boundaries of individuals. Music in western culture since the Renaissance has been primarily a celebration of the individual as genius — composer, virtuoso, rock-star. A contrasting approach is exemplified by Southeast Asian gong music traditions, like Javanese gamelan, in which the focus is the group, and individuals strive to blend seamlessly and

anonymously within it. Similar to gamelan, computer network music is an expression of systems and architectures of connection created by individuals collaborating with each other, centering not on individual personalities but on the cultural macro-organisms revealed in their interaction. It involves a *distancing* of the physical connection between sound and individual body. This is perhaps the original and more important meaning of *distance* within the network medium: it is less important that people are interacting from long distances with each other, than that they are creating art in which physical proximity and display, the collision of their physical and personal identities, are transcended. Computer network music aims to reveal the voice of the system itself, the sound of the *network instrument*.

This article tells the story of two experimental bands that pioneered the use of networked computers in live performance: The League of Automatic Music Composers (1978—82) and The Hub (1985—95). The San Francisco Bay Area in the 1970s and ‘80s was fertile ground for composers experimenting with the use of microcomputers as musical instrument automata. For musicians of that time and place it was but a small step from the practice of acoustic music realized by the rigorous application of algorithms, including chance (Cage), stochastic (Xenakis), or minimalist processes (Reich), to the application of similar methods by machines in live electronic music. Concurrent with the flowering personal computer industry in the Bay Area, access to the new digital technologies and to the people who developed them was perhaps the best in the world. The local technology community included both the older

generation of successful engineers and entrepreneurs who had developed the vacuum-tube and transistor, and a younger breed of grass-roots experimenters, who saw the personal computer as the harbinger of a utopian society built on the principles of free and open access to information, and a comprehensively designed environment based on embedded intelligence.

Musically, this was also the environment that gave the world "New Age" music, a watered-down and commercialized version of the musics based on modes and drones that Pauline Oliveros, Terry Riley, and LaMonte Young invented here during the late fifties and early sixties. But West Coast music-making also included a free-wheeling, noisy, improvisational edge left over from the counter-cultural revolutions of the sixties. Defiantly non-commercial, and practiced by musicians coming from classical, free jazz, or experimental rock backgrounds, it favored compositions that changed with each performance, textures that emphasized a simultaneous multiplicity of voices, and a practice based on collaborative, communal or group-oriented activities. Another ingredient in this musical stew was the influence of the West Coast tradition of the composer as instrument builder (Harry Partch, Lou Harrison, and John Cage) which emphasized taking control of the means of making music itself, including the tuning systems and the instruments. Why NOT extend this approach to the new electronic technologies? Finally, the lack of significant opportunities on the West Coast for the support and presentation of art music made composers in the Bay Area more likely to embrace underground, experimental aesthetics. Since the audience was so diffuse, and opportunities for

careers so futile, why not spend one's efforts following the potential of fantastic ideas, rather than worrying about the practical applications of those ideas within traditional musical domains?

Both The League of Automatic Music Composers and The Hub came about as associations of computer music composers who were also designers and builders of their own hardware and software instruments. They approached the computer network as a large, interactive musical instrument in which the data-flow architecture linked independently programmed automatic music machines, producing a music that was noisy, surprising, often unpredictable, and was definitely more than the sum of its parts.

The League of Automatic Music Composers
by John Bischoff

The League came about through a confluence of technological change and radical aesthetics. In the mid-1970s, composers active in the experimental music scene centered loosely around Mills College in Oakland, California, were greeted by the arrival of the first personal computers to hit the consumer market. These machines — called microcomputers because of their small size compared to the mainframes of academia and industry — could be bought for as little as $250. Their availability marked the first time in history that individuals could own and operate computers free from large institutions. To the composers in this community it was a milestone event.

Steeped in a tradition of experimentation, they were busy at the time building homebrew circuits for use in 'live' electronic music performance. The behavior of these circuits often determined the primary character of the music. The idea of using the electronic system itself as a musical actor, as opposed to merely a tool, had started with composers like David Tudor and Gordon Mumma. A natural continuation of their example could also be found in the local composers who performed with self-modifying analog synthesizer patches as well. One of these players was the late Jim Horton (1944-1998). Horton was a pioneering electronic music composer and radical intellectual who was first out of the blocks in purchasing one of the new machines — a KIM-1 in 1976. Horton's forward-looking enthusiasm for the KIM quickly infected the rest of the community. In a short time many of us acquired KIMs and began teaching ourselves to program them in 6502 machine language. Programs were entered directly into the KIM's 1K of memory via a hexadecimal keypad, and saved onto audio cassette — the cheaper the cassette machine the better. Loading programs back into the KIM's memory from cassette was a notoriously flaky proposition often requiring frequent re-tuning of the control circuit onboard the KIM. There was a strong feeling of community among the composers who were learning to program these tiny computers. This shared spirit was particularly helpful when it came to getting a foothold on the more esoteric, and sometimes pesky, aspects of KIM-1 operation.

An informal discussion group sprang up during this time. A number of us got together on a regular basis to listen to

the music we were creating, some of it made by our KIMs and some by analog circuitry in conjunction with other instruments. There was much discussion about new musical ideas as well. In addition to Horton and myself, the group included composers Rich Gold, Cathy Morton, Paul Robinson, and Paul Kalbach among others. I remember a discussion one evening where Horton talked excitedly about the possibility of building a "silicon orchestra" — an orchestra of microcomputers linked together into an interactive array. The concept sounded impossibly far-out to me at the time they linked their KIMs together for the first time in a performance at Mills College. Gold interacted with his artificial language program while Horton ran an early algorithmic piece based on the theories of 18th century mathematician, Leonhard Euler. Early in 1978, Horton and I developed a duo piece for our KIMs in which the occasional tones of my machine caused Jim's machine to transpose its melodic activity according to my "key" note. I recall that these initial computer-to-computer linkages took us hours to develop and debug as we experimented with different methods of transmission, each method often requiring us to learn a new technical facet of the KIM. Typically, connections were made via the 8-bit parallel ports available on the KIM's edge connectors. In such a case, the program on the receiving end would either periodically check the port for new data or more casually retrieve whatever data was there when it looked. At other times we connected via the KIM's interrupt lines which enabled an instantaneous response as one player could "interrupt" another player and send a

burst of musical data which could be implemented by the receiving program immediately.

In the spring of 1978 the three of us played as a networked trio at the Blind Lemon, an artist-run space in Berkeley started by composer and instrument builder Erv Denman. David Behrman, who had moved west to become Co-Director of the Center for Contemporary Music (CCM) at Mills, joined us later that year in a "Micro-Computer Network Band" performance on November 26, 1978, again at the Blind Lemon. We did a 4-track recording of similar material that was edited down for one side of an EP and released on Lovely Music (NY) in 1980. By that time the group had become The League of Automatic Music Composers. The new group name was in part a reference to the historical League of Composers started by Aaron Copland and others in the 1920s. It also sought to convey the artificial intelligence aspect of the League's activities as we began to view half the band as "human" (the composers) and half "artificial" (the computers). As stated in our concert program, "the League is an organization that seeks to invent new members by means of its projects."

In the spring of 1979, we set up a regular biweekly series of informal presentations under the auspices of the East Bay Center for the Performing Arts. Every other Sunday afternoon we spent a few hours setting up our network of KIMs at the Finnish Hall in Berkeley and let the network play, with tinkering here and there, for an hour or two. Audience members could come and go as they wished, ask questions, or just sit and listen. This was a community event of sorts as other composers would show up and play or share electronic circuits

they had designed and built. An interest in electronic instrument building of all kinds seemed to be "in the air." The Finn Hall events made for quite a scene as computer-generated sonic landscapes mixed with the sounds of folk dancing troupes rehearsing upstairs and the occasional Communist Party meeting in the back room of the venerable old building. The series lasted about 5 months as I remember.

By 1980 Gold and Behrman had left the group to pursue other projects, and composer Tim Perkis joined the band. Tim had been a graduate student in video at California College of Arts and Crafts in Oakland and was an active player in local gamelans. Perkis, Horton, and I continued extensive development of the fledgling network music form between 1980-82 and concertized widely in the Bay Area, including a performance at New Music America in 1981 at the Japan Center Theater in San Francisco. Don Day also brought his Serge Modular analog synthesizer into the group for a time. During this period we would spend months working up a concert.

At our Shafter Ave. house in Oakland, an entire Sunday afternoon would consist of setting up our computer systems in the living room and laboriously connecting them together. As we desired more flexibility in configuring interconnections between machines we started to use "solderless socket" strips to patch our port pins together rather than hard soldering them — a electronically dangerous method as one misaligned connector could blow out an entire port. With wires running everywhere and our computer programs finally debugged, we eventually got the system up and musically running. For two or three hours we played, tuning our systems and listening

intently as our machines interacted. When surprising new areas of musicality appeared, we took notes on the parameter settings of our individual programs with the hope that recalling those settings in concert would yield similar exciting results. The structural form of our concerts was essentially an agreed upon series of such settings, the moment to moment details, of course, always remaining in interactive flux.

In 1982 the League joined forces with the electronic music band the Rotary Club to develop a concert of works under the name "Rota-League." The Rotary Club, which consisted of a younger generation of graduate students just finished at Mills, based their performance style around an automatic switching box designed by member Brian Reinbolt. Using an industrial timing wheel scavenged at a local surplus outlet, Reinbolt interfaced the switching box and the wheel in such a way that the turning wheel would affect the configuration of switches in an ongoing fashion. As the band members played, their sounds were routed through the switching box and chopped into a stunning, real-time collage of bits and pieces. The results fit well with the League’s devotion to algorithmic music structures coupled with live human interaction. The combined group Rota-League performed an evening of music in September at Ed Mock's Studio in San Francisco, with the performers including Sam Ashley, Kenneth Atchley, Ben Azarm, Barbara Golden, Jay Cloidt, and Brian Reinbolt.

Around 1983 Horton developed severe rheumatoid arthritis and performing became difficult. The League's activities

slowed to a halt and the group finally disbanded later that year.

The League didn't compose network "compositions" as such but rather whole concerts of music. We didn't give titles to these concerts--we thought of them as public occasions for shared listening. Initially, we let the networked stations run on their own in performance, unattended, and retired to the sidelines to listen along with the audience. After awhile it seemed more fun to perform along with the network so we began to sit around our large table of gear, adjusting parameters on the fly in an attempt to nudge the music this way or that.

League members generally adapted solo compositions for use within the band. These solos were developed independently by each composer and were typically based on algorithmic schemes of one kind or another. There was a distinctly improvisational character to many of these as the music was always different in its detail. Mathematical theories of melody, experimental tuning systems, artificial intelligence algorithms, improvisational instrument design, and interactive performance were a few of the areas explored in these solo works. More often than not, the composer designed real-time controls so that a human player could adjust the musical behavior of the algorithm in performance. These "openings" in the algorithm became important features when adapting the solo within the network band context--they were natural points where incoming data from other players could be applied. The solos, played simultaneously in the group setting, became interacting "sub"-compositions, each sending and receiving data pertinent to its musical functioning. In actual practice,

at the start of a new project members would begin with an informal meeting over coffee at a local café where we would throw around ideas for linking "sub-compositions" together. One composer might say: My program generates elaborate melodic structures—does anyone have pitch information to send me? Another might respond: Yes, I generate occasional sustained tones—how about if I send you the pitch I'm playing encoded as a frequency number? The first person might respond: Yes, I could retune my melodies to that frequency whenever it comes in. And so the structure of interconnections would be created a link at a time.

Listening to the combined result, one hears independent musical processes at work—each station has its distinct musical viewpoint—along with the coordination of those processes through a real-time choreography of data flow. The whole can be seen as a kind of expanded polyphony, though in this case a polyphony of "musics" rather than "notes." And just as in traditional polyphony, the League's music makes use of many styles of vertical alignment between parts--from strictly synchronous, to closely proximate, to distantly related in time.

> What we noticed from the beginning was that when the computers were connected together it sounded very different from pieces just being played simultaneously. If you imagine four pieces of music together at the same time, then coincidental things will happen, and just by listening you make some musical connections. But by actually connecting the computers together, and having

> them share information, there seems to be an added dimension. All of a sudden the music seems not only to unify, but it seems to direct itself. It becomes independent, almost, even from us.[1]
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> (The League) sounded like a band of improvising musicians. You could hear the communication between the machines as they would start, stop, and change musical direction. Each program had its own way of playing. I hadn't heard much computer music at the time, but every piece I had heard was either for tape or for tape and people, and of course none of them sounded anything like this. I felt like playing, too, to see whether I could understand what these machines were saying.[2]

The Hub
by Chris Brown

In the early 1980s I was a fan of the music of the League and the Rota-League, while my own music was changing from its focus on home-made electroacoustic instruments towards an involvement with computers. In 1986 John Bischoff, Tim Perkis, and I began producing experimental music concerts at galleries and community music spaces, and in the summer of 1986 we decided to produce a mini-festival at "The Lab", a converted church building on Divisadero St. in San Francisco, devoted to Automatic Music Bands. This was a collection of composers working with computers who were collaborating in

duos and trios, connecting their computers in various ways in networks to share sound, control data, or both. We called the festival "THE NETWORK MUSE — Automatic Music Band Festival".

John Bischoff and Tim Perkis called their duo performance "The Hub", because they were using a small microcomputer as a mailbox to post data used in controlling their individual music systems, which was then accessible to the other player to use in whatever way and at whatever time he chose. This was the beginning of the band, "The Hub": the other composers who joined to become The Hub were also performing on different nights in different groups using uniquely different network architectures. After the festival, the idea of using the standalone computer to serve as a mailbox for a group (which Tim Perkis had initiated) seemed like the best way for all of us to continue. The original KIM-based Hub had four UARTS to allow four players to network using 300 BAUD serial connections. Perkis and Bischoff soon began to use the Kim-Hub in a trio with Mark Trayle called "Zero Chat Chat".

In 1987 composers Nick Collins and Phill Niblock invited members of the Hub to create a performance that would link two performance spaces (Experimental Media and The Clocktower) in New York City, to exemplify the potential of network music performance to link performances at a distance. This commission was the impetus for the six of us, John Bischoff, Tim Perkis, Mark Trayle, Chris Brown, Scot Gresham-Lancaster, and Phil Stone to begin to collaborate together as a group. Two trios performed together in each space, each networked locally with one of two new, more robustly built, identical Hubs, and the Hubs communicated with each other automatically

via a modem over a phone line. Each trio performed music that sounded different from that performed in the other space — but data generated from each ensemble was shared within the Hub, so the trios were informationally linked. This was the premiere concert of the Hub.

The NYC debut of the Hub was a success, and provided a notoriety for the group that launched a 10 year career.But the beginning of the band was a commission for a musical stunt, which became both a blessing and a curse. The idea of having musicians play with each other from distant locations was then, and has been ever since, of considerable interest to promoters, publicists, and audience. Kyle Gann's review in the Village Voice review titled "musica telephonica" emphasized the idea of the physical disconnect, the capability of creating music without being physically present, "phoning it in". But the band itself was always far more interested in the aspects of performer interactivity, algorithmic complexity, and the web of mutual influence that the network provided. The network was a way for computer musicians to create a new kind of musical ensemble that allowed them to interact in ways that were unique to their medium. We were interested in the sound of idiosyncratic, personal computer music instruments that could influence, and be influenced by each other. The Hub became a way to extend compositional ideas from the solo electronic performer to an ensemble, creating a new form of chamber music. (The fact that the chamber could be expanded in distance was not entirely irrelevant, but never really the point). It was also part of the Hub's mission to point the development of computer music away from the paradigm of

dominance to one of creative anarchy. To quote from Tim Perkis:

> I see the aesthetic informing this work as perhaps counter to other trends in computer music: instead of attempting to gain more complete control over every aspect of the music, we seek more surprise through the lively and unpredictable response of these systems, and hope to encourage an active response to surprise in the playing. And instead of trying to eliminate the imperfect human performer, we try to use the electronic tools available to enhance the social aspect of music making.[3]

Yet what Perkis later called "the gee-whiz aspect" never really escaped us. Constructing and coding were the way we practiced, and were "the chops" that were required to make the music happen. But, as in any music, the mechanics need to be transcended to reach to the aesthetic goal; and in the technology dominated context that fed our publicity engine (modest though it was), it became hard to get the audience, much less ourselves, to always focus on the musical issues. The real musical work the Hub was able to achieve can nevertheless be described as the sound of individual musical intelligences connected by networked information architectures. What is the sound of the network? It goes beyond whatever sound producing means we as artists chose in voicing the compositions we made, to the ways in which those individual voices interacted with each other. These modes of interaction were themselves the specifications for Hub

compositions: a Hub piece was defined as a protocol defining the types of musical information to be automatically shared within the group, and the means of sharing it between the members. Each composer was responsible for programming their unique computer/synthesizer instrument to communicate within these protocols. The progression of the ideas that formed a few of these compositions trace the development of the group, and can be heard on the group's two cd releases, "The Hub", and "Wreckin' Ball" (both on Artifact Recordings and available through www.cdemusic.org.)

The common memory provided by the twin-Hub hardware was the new musical resource explored first by the group. In effect, this was a simple server-client architecture, in which requests from each player to read or write to common memory were responded to by the two linked servers. There was a non-uniform latency to this process, which could be up to one second because the two servers had to update a mirror of each others' memories over a 9600 BAUD connection, but the group made designs that were forgivable of temporal precision, and this in turn affected the music's character.

Mark Trayle's "Simple Degradation" exemplified the idea of using the Hub's common memory to contain information that all players used to directly control the sound output of their systems. Its interactive architecture was one-way: Mark conducted the ensemble electronically by feeding information to the Hub that governed the behavior of all the other players. At the same time, as in most Hub pieces, the instructions specified only one aspect of the sound each

player could produce, in this case the moment-to-moment volume:

> One performer generates and processes a waveform, simulating the response of a plucked string. This waveform is then broadcast on the computer network, the other performers using it for amplitude modulation (loudness variation). The rate at which the waveform is played back by the performers is determined by the performer who generated the waveform. The performers are free to choose whatever timbres and pitches they wish. The waveform may only be used for amplitude modulation. Pitch may only change after one complete cycle of the waveform.[4]

A much more demanding protocol for using the shared memory resource that the Hub provided was created by Phil Stone for his piece "Borrowing and Stealing." Its subject and title anticipated what would eventually become the battleground for networked musical technologies — the plunderphonic reality that digital information as symbolic representation of sound is all too easily and perfectly replicated, that such information cannot really be owned, but to be kept alive must be continually transformed.

> Melodic riffs are composed by individual participants and sent to the Hub's shared memory, where they become fair game to be appropriated by the other participants. A "borrowed" (or "stolen", depending on one's perspective)

> riff may then be transformed in any of a multitude of ways, and replayed. The transformed riff is in turn sent to the Hub and made available to the other players. In this way, musical information flows instantly and reproducibly among the members of the ensemble without regard for copyright, attribution, or other proprietary notions.[5]

Other works used the common memory for text communication. In Scot Gresham-Lancaster's "Vague Notions of Lost Textures", each player wrote text messages to their own data area in the Hub, and could read all other players' data areas, scanning for new messages. The topic of conversation in this primitive chat-room was the co-ordination of the improvised music around a formal shape: a simple ramp of increasing note density, timbral brightness, and amplitude that peaked at around 80% of the pre-arranged duration of the piece, followed by a smooth return to a texture of low density, brightness and amplitude, where the music stopped. Chats kept track of the progress of the band through this shape, and were often used to describe the character of the music that resulted, providing a running commentary on how the performance was going. During the New York premiere the audience was free to wander around, observing the band's evaluation of its own performance on their computer screens.

An virtuosic elaboration of this text communication system occurred in 1989 when the Hub joined with San Francisco composer, writer, and performance artist Ramon Sender in a piece called "HubRenga". Ramon was already collaborating with

poets on the Bay Area's pre-Web network "The Well", extending concepts from the traditional Japanese collaborative poetry form called *renga*, which is related in its syllabic structure to *haiku*. In *renga* the participants trade writing lines, linking each line to the next using common themes. With the support of a grant from the InterArts Program of the National Endowment for the Arts, we produced a poetry/music/radio performance on KPFA, the flagship Pacifica radio station in Berkeley, described below from their program guide:

> Tonight's show is a live performance from KPFA's sound studio of "HubRenga", an audience-interactive, music/ poetry piece made possible by the communication between two computer networks. The collaborators in the creation of this piece are Bay Area computer music band The Hub, novelist and musician Ramon Sender, and poets from the poetry conference of The Well. During the performance poets will submit poetry to the piece through the Well. At KPFA, Ramon, as moderator, will browse through the submissions as they come in, reading them aloud as a part of the music. One Hub member will be also receiving the texts on his computer, which will be programmed to filter it for specific "key words" that have been determined in advance of the performance to trigger specific musical responses from The Hub. During the performance, poets will be listening to the piece over the radio while they are shaping it through their communication with The Well. The purpose of the piece is to create with this technology a situation in which a large network of

collaborators is tied together from various remote locations in creating an interactive performance.[6]

The Hub pieces described so far were all performed with our twin-SYM Hub system, using standard RS232 serial communications. Most of us were also increasingly using MIDI communications devices to control our individual instruments. In 1990 Scot Gresham-Lancaster obtained an Opcode Studio 5 MIDI interface, which combined the functions of a computer interface, MIDI patchbay, processor, and synchronizer in a single box. It quickly became clear to him that it could be programmed to function as a MIDI version of the Hub, which would allow faster, more flexible messaging between computer players than our homebuilt RS232 Hub provided. This would also implement the concept of the group on a standard music technology platform, which we hoped would make our work more open and accessible to other musicians. But like electronic musicians everywhere eventually find out, upgrading the system meant either changing the existing music so that it could play on the new instrument, or else creating a new repertoire made specifically for it. We took the latter route; but changing the messaging system also changed the kind of music we made. The MIDI-Hub worked as a switchboard, not as common memory. Instead of a server containing messages in any possible custom format, the MIDI-Hub provided the ability for each player to send any other player any MIDI message tagged with an identifier of who had sent it. No longer was it up to each musician to read information left by other players, but instead messages would arrive in each player's MIDI input

queue unrequested. And if information was needed it had to be requested individually from each player, who was required to respond immediately. This networking system was more private, enabling person-to-person messaging, but broadcasting to the whole group was more problematic. Messages were exchanged more quickly and with temporal precision under the MIDI-Hub, leading to an intensity of data traffic that was new in the music.

"Waxlips" (1991) by Tim Perkis, exemplified this newer MIDI-Hub music, in that it sought to directly sonify the architecture of its networking system.

> Waxlips 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 in some fixed way to a different note, 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 input will always cause the same new message output). 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 a lead player I would occasionally double up — sending out two requests for every one received — to revitalize a tired net.[7]

What is left out from the above description is that the playing of "notes" really did not imply what it usually does in terms of tuned pitches. The actual "notes" could be any mapping of MIDI note numbers to sounds of any kind. But Waxlips was still used as "tune-up piece" for the Hub in its tours of the early 1990s — what was tuned was the integrity of the Hub's interconnections and software. Once the piece reached a state when it would continue to generate its barrage of sounds without the necessity of providing further input to the system, we knew that everything was functioning correctly. We often stood up from our computers at this point, and walked around the stage or concert hall, just listening, like other members of the audience, to the musical automaton.

Afterword

by Chris Brown

At the Hub premiere in New York City in 1987 there were a number of "techies" in the audience who commented to the band afterwards about the primitive nature of our serial communications network, and asked us why we were not using ethernet instead. While we were aware of that technology, it was simply not within our means at that early date, as the hardware and software that supported it were not yet available for our personal computers. This story emphasizes an important point about the League and the Hub: we were musicians first, and technologists second, and so we implemented solutions that were practical for musicians in our time and place. As such, we were the first (as far as we know) to make interactive, live electronic music in a computer network, and despite the primitive nature of that network we were the first to experience its potentials and its problems.

One of those problems is *distance*, in at least two senses of the word. First, a distancing of person from instrument — as instruments, and ensembles get more complex, the observable connection of people with their own sound becomes difficult to maintain. Computer music instruments are at their best when they take on a life of their own, surprising their creator/ performers with a liveliness and character that cannot be predicted; but there remains a need to guide them directly, to nudge their behavior in this direction and the next with

gestures, and to hear the results of those gestures immediately. A computer network mediates those gestures further, and a disconnect takes place that can alienate the player, and the audience, from interaction with the music.

Another problem has to do with physical distance: the Hub's first concert, and the publicity we got from it that fueled our career of over a decade, happened because of the public's fascination with the idea that musicians can play with each other in spite of being physically separated by great distances. But our own interests were actually never really aligned with concerns about telepresence. We were more interested in a sonification of the network: in the ways that networking changed the music, rather than in creating the means for networks to be transparent to it. The audience, and grants available for research into it, were definitely smaller than if we had embraced this distance issue. In fact, a failed attempt in 1997 to reproduce the group's music on the internet became the swan song of the Hub: "Points of Presence", a live performance produced by the Institute for Studies in the Arts (ISA) at Arizona State University (ASU), linked members of the Hub at Mills College, the California Institute for the Arts, and ASU. We succeeded only in performing 10 minutes or so of music with the full network: the technology, and physical distance, had defeated the music.

The music of the League of Automatic Music Composers and the Hub was a *local* music, made by individual composers fascinated by the musical implications of musicians sharing information in a network. It was never intended to facilitate physical distance from each other, even though the

technologies that we explored would allow it. Rather we were exploring a new instrumentation for collaboration, and we chose to make a music that reflected the nature of our instruments. We collaborated in real-time, but also in the design of the systems that made the connections and interactions between the flow of our automatically generated musics. The success of our music required that each composer give up the desire to control every detail of the resulting sound, and delighted us most when the systems took on a life of their own. We were conducting musical experiments, and the music that resulted was the result of a process we embraced.