A Network for Music Research, Composition and Pedagogy in the University of Glasgow

Stephen Arnold
Department of Music, University of Glasgow
14 University Gardens, Glasgow G12 8QH, Scotland, UK
Stephen Arnold<stephen@music.gla.ac.uk>

Abstract

Between 1991 and the present, we have established a large network of 48 NeXT workstations in a variety of locations around the Glasgow University main campus. This paper outlines the network topology and the purposes to which it is being put in the areas of research, composition and pedagogy.

1 Organization and Topology

In the University of Glasgow, activities in the fields of Computer Music and Music Technology have for years been centred on the Department of Music. Recently, however, a Centre for Music Technology has been established to coordinate teaching, research and composition and the activities in these areas in the Departments of Music, Computer Science and Electronic and Electrical Engineering. The Computer Music Studios are directed by Stephen Arnold, and are served by two support staff, Chris Scudds (chris@music.gla.ac.uk) (Systems Administrator) and Ken Linton (knl@music.gla.ac.uk) (Studio Manager), both practising musicians.

The installation currently provides 36 user seats distributed around three physically separate sites on campus, the Department of Music, the Computer Music Studios, and the Department of Electronics and Electrical Engineering. In the Department of Music, there is an Audio Lab with 10 seats, a Research and Systems Administration room with 5 seats, a General Access Room with 6 seats, and a further eight machines in individual staff members' offices. In the Electronics Department is a second 10-seat Audio Lab, which is a clone of the first, plus a machine in a staff room. In the Computer Music Studios, there are two work-rooms each with a single NeXT. Because even a highly configured NeXT is not really suitable for serving a very large user community, the total serving load has had to be distributed amongst the remaining machines. These do not provide user seats, but fulfil various server functions, serving user accounts, netbooting, software, printers and a FAXmodem. Some of these are run headless, i.e. without keyboards or monitors. Total disk space on the net is around 20 Gb of which 3.6 Gb is dedicated to soundfiles. In the Audio Labs and the two Computer Music Studios, each seat has a highly specified computer, with at least 20 Mb RAM and at least a 200 Mb hard disk, audio support, with headphone or loudspeaker monitoring, MIDI, DAT or cassette recording, digital I/O, a high-quality mixer and extensive synthesis and processing equipment. Small-scale audio installations are also associated with the computers in the Research Room and some of the staff rooms. The network currently has about 150 user accounts, with around 110 belonging to undergraduate students, 26 to research and support staff, composers and postgraduate students, 12 to academic members of staff and 2 to administrative staff.

2 Research

In 1990, the Department set about securing a special, postdoctoral Research Fellowship funded by the Leverhulme Foundation for candidates from the Commonwealth or the USA. The unexpected outcome was that, in a competition open to all subject areas, both the available Fellowships came to Music. The Fellowships went to Stanislaw Krupovicz (Stanford University) and Richard Karpen (University of Washington)(karpen@u.washington.edu), both of whom, as well as conducting programmes of research, completed compositions as detailed below.

Krupovicz's work as a Leverhulme Fellow centred on a study of the physical characteristics of the violin, and the effects on the instrument's sound resulting from the techniques employed in its construction. This study deduces that particular constructional methods are likely to have been employed by famous makers such as Stradivarius, and suggests that modern makers could make their instruments "sound better" by following the practice of elastically bending the ribs "cold". Krupovicz gives the details of the nature and effects of these suggestions in his ICMC paper last year [Krupovicz 1992].

Karpen's work concentrated on the independent time and frequency alteration of digitized sound using time-domain processing. Processes such as phase-vocoding and linear predictive coding, which are the commonly used analysis/synthesis techniques for making

independent time and frequency alterations to digitized sounds, can be very slow and create large quantities of analysis data. Karpen's new time-domain technique operates directly on the signal. It is fast and does not create any intermediate data. It currently operates only on mono and stereo NeXT soundfiles. The algorithm has been written as a Csound unit generator called "sndwarp", the arguments to which include a time-warp factor and a frequency-warp factor, both of which can be constants or time-varying. It is possible in the case where both are time-varying to alter a sound such that it gets faster and faster in the time-domain while getting progressively lower in pitch! Incorporating the algorithm into Csound makes it possible, and relatively simple, to combine this technique with other signal processing techniques using Csound's library of unit and function generators. Because of Csound's sound I/O technique of writing out buffers of the summed samples of all active notes, it was ideal as a prototyping environment as well. At the University of Washington, there is now also a version operating in MAX on the ISPW running in real time and allowing the user to change the various parameters of time and frequency while the sound is being heard. An expected future use is in a live-performance context, where, instead of playing the preprocessed computer music from tape, the computer part could be "performed", with the kinds of subtle changes in time and even in intonation that musicians often desire in such situations. *The Other* and *The Silence of Time* are two works which Karpen has composed using the "sndwarp" technique (see **Composition** below).

A Glasgow University *New Initiatives* grant was awarded to Stephen Arnold to support research into real-time audio DSP on standard workstations. The aim is to develop a low-cost, easy-to-use, digital audio workstation capable of functioning independently of the host computer, as a performer or as an integrated multichannel recording facility.

An interdisciplinary group based in the Centre for music technology has been established to work on this project.

Ken Linton (Music) and Ken Sharman (Electronics) (ken@music.glasgow.ac.uk) are the primary contributors to the hardware design. Linton's research interests lie in the extension of real-time audio DSP, particularly within the recording studio environment. Extremely fast real-time multi-processing (M-P) engines are required to meet the functional and sonic requirements of such DSP-intensive applications. Consequently, he has undertaken a systematic study of taskforce allocation strategies and alternative M-P architectures [Linton, 1991]. Sharman advocates a hardware design based on multiple custom DSP audio

cards which use local hard-disk storage on a per-card basis to overcome the communication bandwidth problem. This permits the cascading of several cards to form a multichannel audio system independent of the host computer, which is used solely to provide the user control and display interface. A high-speed parallel digital audio bus has been developed to provide communication between the cards and, via a standard 8-bit parallel interface, the host computer

A considerable body of knowledge exists on the application of non-linear dynamics to composition at note level. With the *New Initiatives* award, there is significant scope for the application of similar algorithmic methods, such as the Wavelet transform, at audio sample resolution for effects manipulation and synthesis. As digital audio systems are not limited to mechanically-linked control sets, machine interfaces will derive the full benefit of MMI techniques. In summary, the emphasise here is to continue the evolution of hardware architectures, software paradigms, and MMI methodologies appropriate to synthesis, processing, and audio mixing.

Bill Findlay (wf@dcs.gla.ac.uk) and Crawford Tait (ctait@dcs.gla.ac.uk) of the Department of Computing Science are primarily interested in using the multi-processing capabilities of the workstation as a test-bed. They are working towards a methodology for mapping musical computations onto concurrent processing resources that may either share memory (as in a multiprocessor), or be physically distributed and interact via a network. They hope to be able to develop both a conceptual framework and a set of tools that will allow this kind of parallel decomposition to be undertaken easily and cheaply, and without requiring specialist knowledge of concurrency, distribution, or data communications.

A number of other researchers are embarking on a variety of projects.

Nils Pettersen (nils@music.gla.ac.uk) is a graduate student in the Music Department working on the identification of individual voices in a polyphonic audio-input source. The objective of this project is to simulate in software the human ability to identify individual voices in a piece of music. The system is divided into two main parts: the first obtains spectral information by using techniques such as short-time-Fourier-analysis, peak detection and peak continuation; the second tries to filter out harmonics, leaving only the fundamental frequencies. This is done by using neural network techniques. Considerations of, on the one hand, the extent to which the human listener makes this analysis on the basis of timbral information, and, on the other, of the extent to which it is achieved by musical intuition and

expectation, will be addressed by exposing the system to a variety of appropriate musical examples.

Gavin Starks (gstarks@music.gla.ac.uk) is a graduate student in the Music Department who is working on a 3D-stereo compositional tool for Csound. His system aims to provide the composer with an intuitive GUI operating within a musical context. While current systems often involve only one input and are usually aimed at manipulating sound in a post-processing manner, Starks' system performs spatial processing via specially written unit generators within Csound to which all relevant values are sent. While Csound permits multi-channel output, this implementation limits the composer to stereo, allowing manipulation on 3 axes: left/right, up/down and near/far for headphone or loudspeaker reproduction. The nature of the new unit generators allows the composer to program the parameters directly into the orchestra and score files in the usual manner, but data can also be input via a graphical interface which allows the user to position or move the Csound instrument(s) in relation to the listener. Other relevant parameters such as room size and wall absorption are included in this editing tool.

3 Composition

On a number of occasions since 1987, groups of composers from many countries have come to work in the Glasgow computer music studios. The model we try to follow is to arrange for a group of visiting composers to work alongside local Scottish composers to commissions from Glasgow festivals, such as *Musica Nova*, *Polish Realities* and *New Beginnings*. Composers from Armenia, England, Estonia, New Zealand, Iceland, Poland and the United States have been guests in the City and the University.

The most recent project of this kind took place in the summer of 1992, when two senior Icelandic composers, Thorsteinn Hauksson and Karólina Eirfksdóttir, visited under the auspices of *Breaking the Ice*, a festival celebrating Icelandic culture and the links between Glasgow and Iceland. They worked alongside the Leverhulme Fellows, Stanslaus Krupovicz (Poland/USA) and Richard Karpen (USA) and Nicky Hind, a recent Glasgow graduate. The five works (*cho* for flute and tape, Hauksson; *The Well* for 3 female vocalists and tape, Hind; *The Other* for tape, Karpen; *A Lighter Shade of Grey* for violin and tape, Krupovicz; *Scottish Dompe* for tape, Eirfksdóttir), all created on the NeXT, were presented in a special concert launching the new NeXT-based computer music facilities in October 1992.

The international flavour was mirrored in the performers used: the Icelandic flute piece was performed by the Icelandic flautist, Kolbeinn Bjarnason, the Polish violin piece by the Polish violinist, Dominique Starosta-Binnie and the Scottish vocal piece by *Vocem* electric voice theatre, directed by the Glasgow-born soprano, Frances Lynch. The sound diffusion was by the BEAST, whose exploits at the Glasgow ICMC in 1990 will be well remembered. The works by Karpen and Hind are included in concerts at this year's ICMC.

Those who have been involved in these projects over the years have found them most fruitful, fostering as they do the valuable stimulation of close, professional collaboration.

4 Pedagogy

The potential of an extensive and fully networked environment was not immediately apparent when the first two NeXTs were acquired in 1990. At that point, the machines were seen primarily as a straightforward and elegant solution to a long-standing problem of a lack of suitable resources to run adequately synthesis programs such as Csound. The creation and expansion of the network has had far-reaching effects on course organisation, teaching methods and, more recently still, the delivery of course material. Certain courses are now conducted entirely without paper, with student assignments being submitted, marked and returned via the NeXT's multimedia mail facility. The same software has made possible personal tutorials which did not have to be scheduled. In future, both group and individual teaching will be further facilitated with the introduction of ScreenCast, which enables the broadcast of the monitor display on one machine to other nominated machines on the net. Receivers can interact with the broadcast display using their own keyboard and mouse.

On the administration side, a system is under development whereby all personal course details, including assessments, are entered and maintained on a relational database which carries out the necessary calculations associated with weightings, late submissions and carry-overs, so that it is always possible for both staff and students to know exactly where they stand in relation to the course requirements.

A major development in the last year has been the government-funded initiative to establish a nationwide programme, known as the Teaching and Learning Technology Programme (TLTP), of courseware development in a wide range of academic disciplines. The aim of TLTP is to improve productivity in higher education through more efficient delivery of teaching and more effective learning. In Glasgow, we are

currently contributing to two projects. One, Teaching with Independent Learning Technology (TILT), is a large, three-year inter-disciplinary project based at the University of Glasgow, for which we are contributing to a multimedia group by developing sample pieces of NeXT-based courseware in a wide range of musical areas. The other is a consortium of 19 Music departments contributing extensive courseware, mainly for PC- and Mac-based environments, covering most areas of the traditional music curriculum including aspects of music history (including source studies), acoustics, aspects of music technology and electro-acoustic composition, aural perception and analysis. The emphasis in both of these projects is on the delivery of fully tested and independently evaluated courseware which will be made available at cost throughout the UK higher education sector. Arrangements are being made with a major publisher to handle distribution beyond this sector. In Glasgow, we have the services of a Research Assistant, Celia Duffy (celia@music.gla.ac.uk), who, in addition to having excellent musical qualifications and experience, has worked for many years in a company specializing in the production of custom computer-based training packages.

The first part of our work has been to acquire and evaluate all the NeXTstep multimedia authoring software we could locate. There is no space to give a full appraisal, but the packages reviewed include CraftMan, Callisto, HyperSense, MediaView and ShareME.

It quickly became apparent that the entire TLTP project faces serious problems caused by the lack of widely supported multimedia file formats and the consequential difficulties of interoperability between platforms and authoring software packages. In Glasgow, we are attempting to ensure that courseware developed on PC and Mac will run under NeXTstep. So far, we have succeeded in porting Mac HyperCard stacks to the NeXT. An ethnomusicological stack on African drumming by Peter Cooke of the University of Edinburgh which has examples coded as MIDI files has been adapted to run under HyperSense using the NeXT DSP chip. Another major problem concerns the use of intellectual materials, such as music in its printed and performed manifestations, copyrighted text and the protections of contributing authors' rights. So far, no-one has found the painkiller to make this headache go away. It is hoped that some generalized, government-sponsored solution will emerge.

An more amenable issue concerns the nature of the delivery environment itself. Since one aim of TLTP is to provide for a general increase in student numbers, a huge increase in the number of computer labs, is necessary. Since it is unlikely that Music as a discipline will command the resources for large, multimedia labs, it is important to ensure that music courseware will be as far as possible useful on general-purpose, centrally provided workstations. Courseware which depends on special-purpose music peripherals, such as MIDI devices, will tend to restrict its general utility, but certain kinds of educationally valuable interaction require the input of student responses using such peripherals: establishing the correct balance between these conflicting considerations is necessary for each piece of courseware. At present, the distribution medium is expected to be CD-ROM, but certain materials may be well-handled by CD-I, a medium whose capital costs are less than one third those of a multimedia workstation. Unfortunately, it is not clear that CD-I is doing very well in the format wars.

5 Future Plans

With the demise of NeXT hardware, there is a clear need for us to consider carefully how to migrate to new platforms. Our first step is to acquire a high-end Intel machine running NeXTstep to be used for research. If and when the position of the MusicKit (as of NeXTstep itself) on Intel becomes less precarious, there would be justification for providing additional teaching resources based on this configuration. In the research field, we plan to bring fuller and more detailed reports on the workstation project to the attention of colleagues. In composition, it is our intention to continue with programs which link composers from different countries and which provide an immediate public context for the works they produce. The most likely outlet in future is the *Musica Nova* international festival of contemporary music. We also welcome proposals, particularly for the summer months, from composers who wish to make use of our resources. On the pedagogical front, we hope to be involved in an extension of the TLTP music courseware development to ethnomusicology and popular music.

References

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