Why a laptop orchestra?

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In 2005, the Princeton Laptop Orchestra (PLOrk), an ensemble of fifteen laptop-based meta-instruments, began its first season. In this article, the author explores the motivations for starting a laptop orchestra, both in musical and cultural terms, and some of the aesthetic, technical, and compositional issues that face those interested in working with such an ensemble.

1. LAPTOPS AND ORCHESTRAS

That the notion of a 'laptop orchestra' is seemingly paradoxical is one of my prime motivations for creating one; the pairing of these two inventions is perhaps obvious only because of its apparent impossibility. One is an almost archaic institution whose continued existence is something of a miracle, the other a technological newcomer that has become commonplace and seems likely to be with us, at least in some form, for quite some time. One serves to perform primarily European music from centuries ago, while the other is a convenient tool for editing text, crunching numbers, browsing the Web, and checking e-mail. Never the twain shall meet.

And yet, making music with laptops and performing with them is by now commonplace and seemingly here to stay. Orchestras also remain and seem unlikely to vanish any time soon, in spite of the decades-long obituary that is continually being written, and there have been nascent efforts to integrate electronic technology with the orchestra.[1] Both endeavours remain problematic. The future of the orchestra is the subject of regular nail-biting, and the maintenance of such an expensive, slow-footed institution poses enormous challenges; experimentation is possible only rarely. Laptop performance itself is also often the subject of criticism, some arguing that 'performing' with a laptop and making 'successful art' is essentially impossible (Ostertag 2002).

Let's begin by considering some salient features of the orchestra:

- The orchestra is large.
- The orchestra typically lives in a reasonably large performance hall with good musical acoustics.
- The orchestra's sound is the net sum of many relatively proximal instruments filling this hall.
- It is divided into sections according to the nature of these instruments.
- These instruments typically take decades to master, and have been under refinement for even longer, sometimes centuries.
- The orchestra is usually conducted.

And now for the laptop, in terms of performance:

- The laptop is typically used alone, and only rarely in more than threes.
- The laptop plays in all sorts of spaces: bars, clubs, sometimes concert halls.
- The laptop's sound is typically amplified through a centralised PA system, or sometimes through a localised mono-directional amplifier.
- The design of the laptop instrument is constantly in flux, sometimes even being generated during the actual performance (live-coding), and it is usually created by its player.
- Mastering an instrument might take a few minutes or much longer, though probably none take anywhere near as long to master as a typical orchestral instrument (except, perhaps, live-coding).
- The laptop is often not thought of as an 'instrument' even when being used to create music live.

In spite of these differences (or because of them), the laptop orchestra – as a working ensemble aiming to make compelling music from a range of aesthetic sensibilities – has the potential to both guide the development of new instruments and technologies and also suggest new ways of invigorating the traditional orchestra. Its very existence also poses significant and interesting musical problems; simply imagining how it might work, what kind of music might be composed for it, and what it would be like to play in is inspiring.

[1]For instance, the American Composers Orchestra has begun an orchestra technology initiative called *OrchestraTech*.

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2. A LAPTOP ORCHESTRA

How should we go about designing a laptop orchestra? Fortunately, there are precedents. We can look to the League of Automatic Composers and the Hub for inspiration, especially with regards to their work with networks (Bischoff, Gold and Horton 1999). There are also groups like Mimeo which bring a variety of technologies together into a reasonably large ensemble, and organisations like TOPLAP (http://toplap.org), the Moscow Laptop Cyber-Orchestra (http://cybork.theremin.ru/), Virgil Moorefield's Lucid Dream Ensemble at Northwestern University, Stephen Rush's Digital Music Ensemble at the University of Michigan, the Behaviour Laptop Orchestra at Bath Spa University, Nathan Wolek's Mobile Performance Group at Stetson University, PB_UP (http://pbup.goto10.org/), and others, all that have produced multiple-laptop performances. The approach described here grows out of the work I have been doing for several years with collaborators Perry Cook and Curtis Bahn (Bahn and Trueman 2001).

It begins with an instrument called the Bowed-Sensor-Speaker-Array (BoSSA, Figure 1). The idea here is, in retrospect, quite simple: design a speaker that allows for omni-directional, variable radiation of sound (inspired by the way traditional orchestral instruments work), and 'play' the speaker through the use of instrumentally inspired sensor configurations. In more detail: BoSSA consists of a violin fingerboard fitted with sensors (that detect finger position and fingerboard orientation) and a 'bridge' that has four sensors (the 'strings'), both attached to a twelve-channel spherical speaker. The bridge is bowed with a violin bow that is laden with sensors (that detect bow position, pressure and orientation).

I have been performing this instrument for several years, solo and in small groups, and it has been well documented elsewhere (Trueman and Cook 2000). BoSSA is in some ways a thought experiment and proof-of-concept; I don't imagine this specific instrument being mass produced and developing a repertoire that is passed down through the ages. Rather, I see it as an illustration of an approach to working with electronic sound and computation in a way that deeply involves the body and invites a somewhat traditional approach to making music (chamber music, living room jam sessions, and so on).

Asking what it might be like to make music with a large group of people playing similarly inspired instruments motivated the original genesis of the Princeton Laptop Orchestra, or PLOrk, which I co-founded in the Fall of 2005 with Perry Cook. And while this simple question impacted the design of the orchestra down to its smallest details, the resulting ensemble poses much broader questions and invites a wide range of aesthetic approaches. Before outlining what some of these questions are, let me summarise the design of our particular laptop orchestra:

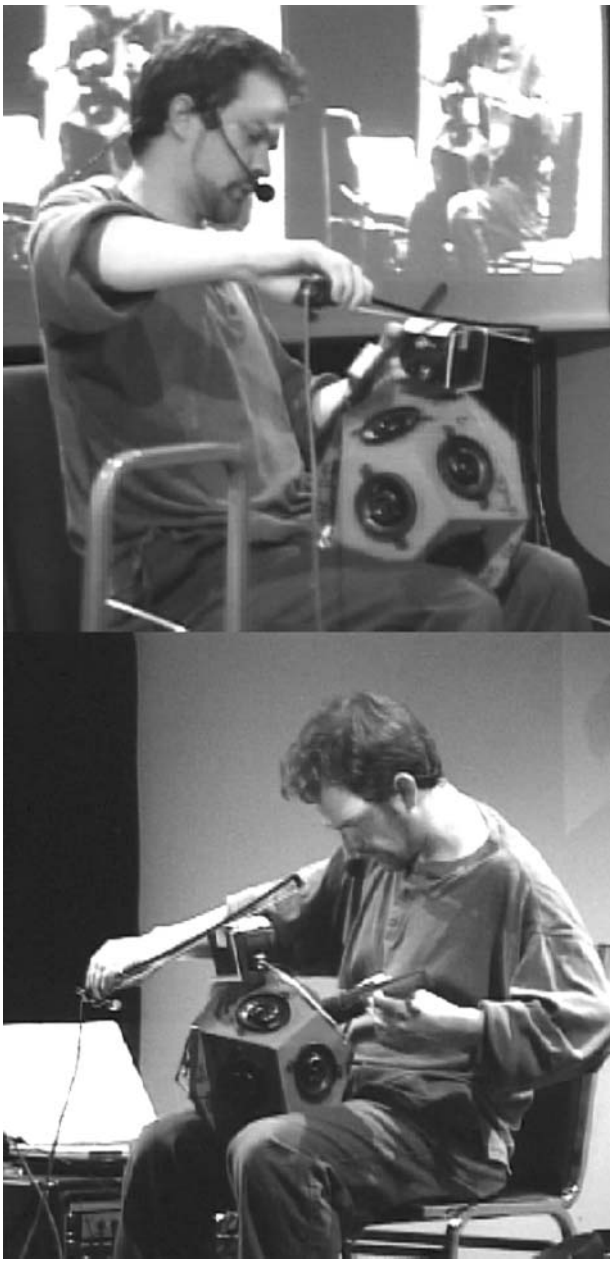

Figure 1. The author with the Bowed-Sensor-Speaker-Array (BoSSA).

- PLOrk has fifteen performance stations, each consisting of:
  - a six-channel hemispherical speaker,[2]
  - a laptop with a variety of software, including Max/MSP, ChucK and SuperCollider,
  - a multi-channel audio interface, with amplification for the speaker,

[2]See (Trueman D., Bahn C., and Cook P. 2000) for a discussion of the merits of outward radiating spherical and hemispherical speakers.

  - a sensor interface for taking in a variety of sensor types, allowing for various idiosyncratic approaches to designing control mechanisms, and
  - a variety of other interface devices, including miniature keyboards, graphics tablets, and drum pads.

- Each player sits on a meditation pillow with the laptop either on the lap or to the side, depending on the nature of the piece.
- A wireless network provides for a variety of conducting paradigms, while also not precluding non-networked and traditional conducting paradigms.
- A wired audio network passes audio directly from station to station.

Figures 2 and 3 illustrate the basic appearance and layout of PLOrk. Complete technical specifications for PLOrk can be found at the PLOrk website (plork.cs.princeton.edu).

Some might object that fifteen is not large enough to be orchestral. A look at the history of the orchestra, however, reveals that the Western orchestra has come in many sizes – as small as ten, and up into the hundreds.

Figure 2. PLOrk in rehearsal.

Figure 3. PLOrk during rehearsal with tabla virtuoso Zakir Hussain.

Throughout the eighteenth century, many orchestras were only twenty-odd strong, and most orchestras were less than fifty (Spitzer and Zaslaw 2005: 316–19). Non-Western orchestras – the gamelan, for instance – are often close in size to PLOrk, and in some ways have more in common with PLOrk than the conventional orchestra. A larger PLOrk is easily imaginable, and might very well come into being, but for the moment PLOrk is quite large enough; it definitely *feels* 'orchestral' in size, and the challenges it presents 'as is' are significant (should a larger laptop orchestra come about, it will be interesting to see how the problems and solutions scale). It is also larger than any of the preceding laptop ensembles mentioned earlier, and while its sheer size distinguishes itself, it is the orchestral-instrument inspired hemispherical speakers, local to each player, that make PLOrk unique and more 'orchestral' than other laptop ensembles.

What must we do before we can begin to make music with this ensemble?

(1) We need to design and construct instruments for each player (or perhaps have them do it themselves, if they are able).[3] Further, we need to teach the players how to play these instruments, and they may need to practise to master them.
(2) We need to decide how these players are coordinated, if at all.

I would like to belabour each of these challenges, challenges which are in some ways inseparable.

3. INSTRUMENT DESIGN: SONIC PRESENCE AND PERFORMATIVE ATTENTION

For anyone who has worked with laptops in a performance situation, one of the first issues that becomes apparent with PLOrk is that our instruments need to be designed from the outset knowing that they will be played simultaneously with many other instruments. This is perhaps *the* central challenge presented by PLOrk, and it highlights the fact that most laptop music is larger-than-life; the laptopist typically generates enormous amounts of sound, with little or no effort or continuing attention. This is not necessarily a bad thing – in fact, I think this is one of its attractions – but when multiplied by fifteen, or even five, and distributed throughout a large acoustic space, we are forced to think carefully about how much sound each player will be capable of making and how responsive they will be able to be to their fellow musicians.[4] And we are not simply concerned with volume – the nature of the sound is crucial as well: is it fairly homogenous like, say, a trumpet, or more heterogeneous, with many different features present, perhaps even a full 'ensemble' texture in and of itself with multiple simultaneous 'voices' (like much laptop music, or perhaps like a substantial percussion setup)? Incisive, clear sound sources will likely be easier to manage in multiples than complex, layered textures, though this does not mean the latter should be avoided.

The very design of PLOrk with its localised hemispheres already frames and limits the sonic nature of each instrument to some extent; we don't have fifteen players sending their signals to a massive centralised PA system. Also, given that each player has a relatively small speaker localised near them, conventional studio approaches to separating voices (panning, reverberation) are unavailable, making layering of multiple voices for a single player challenging, though not impossible. On the other hand, these speakers allow careful attention, since each player can bring her ear within inches of the hemisphere if desired.

This brings us to another crucial issue: how much attention will the instrument require? There may be moments where we simply want a player to initiate a process and revel in its decay (akin to a giant gong strike) and other times when we want him to be maximally involved to quiet effect (a violinist playing a very high note *pianissimo*, for instance). There may also be interesting processes indigenous to the laptop (algorithmically based instruments, for instance) that don't have clear analogies to acoustic situations but nevertheless beg the attention question: how intensely will the player be engaged at any particular moment? Will this engagement be constant, or might it vary radically over the course of a performance? Or will this engagement vary depending on how the body is used (for instance, the left hand might trigger simple switches while the right carefully manipulates a sensitive pressure sensor)? What will the ratio of this attention level be to the quantity and nature of sound produced? How will this sonic presence of the instrument work within the context of the whole ensemble?

Sonic presence and performative attention are relevant issues when designing a digital instrument, regardless of the context, but the laptop orchestra sets them in high relief. While I don't think it essential that players be maximally engaged at all times – this is not the case in traditional ensembles – I do think that in the long run pieces that go beyond simple automation and endeavour to challenge the players in a variety of ways

[3]This is quite different than preceding ensembles like the Hub, where the players each design their instruments individually; the Hub is a specific group of people with their own instruments, whereas PLOrk is a collection of meta-instruments whose players might change from piece to piece.

[4]As Paul Lansky has said: 'To my mind there is no correlation between automation and musical virtue. The music doesn't get better simply because one person can do the work of fifty in a fraction of the time. It probably gets worse' (Lansky 1990). In this context, PLOrk can be seen as an ensemble that forces a rebalancing of the attention/sound ratio, so there are more ears, eyes, and hands attending to contributing aspects of the total sound-world.

are essential if we are to discover the full potential of the laptop orchestra, and laptop music in general. I am not arguing that we should eschew automation (or algorithmic/generative systems) – after all, we should take advantage of the natural strengths of the laptop – but rather that we need to think carefully about how and when to automate, and how the players interface with this automation.[5]

Intertwined with this issue is the notion of virtuosity, in some ways the antithesis of automation. Many people have observed that one of the attractions of the laptop orchestra, or laptop instruments in general, is the ability to set the barrier for entry, in terms of instrumental skill and practice, quite low and provide a context where people can experience making music with others without having to master a traditional instrument. Does it make sense, after all, to create a new large ensemble like the orchestra which requires its players to begin practice at a young age and prevents all but a select few from ever reaching a professional or near-professional level? Probably not, but on the other hand I think we will never discover what is ultimately possible with computational-based performance if we don't see challenge and difficulty as instrumental virtues.[6] I believe we can have it both ways. We have already created pieces for PLOrk that can be taught, learned and performed in an afternoon, and there is no reason not to continue doing so. Many of them are tremendously rewarding to play and hear, and it is likely that, through incremental intuitively motivated changes, some of these simpler instruments will evolve into more refined entities – this may be where the most uniquely 'laptop-orchestra' music will come from. But we are undoubtedly going to continue working with more challenging instruments, inspired by BoSSA and others,[7] and exploring how music on an orchestral scale can be made with them.

Finally, it is important to point out that the goal isn't necessarily to create finished instruments that remain with us for generations, but rather to develop a performance practice where instrument building itself plays a central role. This is one of the great enticements of building digital instruments; we don't have to spend a year carving up several pieces of wood to explore a new acoustical design. Since a significant component of an instrument like BoSSA resides in software, it can be redesigned quickly, in an afternoon, or sometimes even during a performance (as with live-coding). The bulk of the time spent is simply living with the new instrument; with some designs, we can tell within seconds whether it is worth pursuing, whereas other designs will invite hours, months, or years of playing and tinkering. PLOrk provides a highly charged social and musical context for pursuing this kind of instrument-building based performance practice.

[5]See also (Collins 2003) for a discussion of generative systems in laptop performance.

[6]Joel Ryan explores this idea in (Ryan 1991).

[7]See, for instance, Mr. Feely (Armstrong 2006), the Meta-Instrument (Laubier 1998), a variety of instruments by Perry Cook (Cook 2004), and the Beatbugs (Weinberg 2002). Finally, (Jordà 2005) presents a comprehensive theoretical context for developing new digital instruments.

4. CONDUCTING THE LAPTOP ORCHESTRA: EYES, EARS, ETHER

Complaining about an early orchestra, before the word was even used as it is now, Michel de Pure writes:

> I witnessed a shivaree, for I don't know what else to call that huge company assembled a few years ago. Not only did the large number of performers create impossible problems, but sour notes and poor intonation were almost inevitable. And in the end this conflation, which seemed curious and novel at the time, turned out to be nothing but foolishness, and gave rise only to mockery and scorn.[8]

Suppose we have succeeded in building a set of instruments for the laptop orchestra to play – how do we go about playing together? When first trying to make music with PLOrk one is immediately struck by its elephantine inertia; my colleague Paul Lansky describes coordinating PLOrk as akin to 'steering a battleship'. But before we attribute this inertia to the computational component of PLOrk, we should remember that few large ensembles are nimble. The early orchestra was itself often compared to an army; only with military discipline and training could an ensemble of decent size have any chance of playing together (Spitzer and Zaslaw 2004: 514–19). The high school or university orchestra is rarely quick on its feet and even a fine professional orchestra (never as agile as a string quartet) can have difficulty if the acoustics of a particular hall are poor. This sense of inertia is not limited to strict musical parameters like tempo or dynamics; simply getting the attention of an entire ensemble can be a challenge. This, in conjunction with the sonic presence of all the instruments combined, creates a sense of great mass.

By design, PLOrk shares with the orchestra a wide distribution of sound sources, and the very distance between the players factors significantly into the ability of the orchestra to respond quickly; the speed of sound becomes relevant. Regardless of the instrument, the further apart two players are, the more difficult it will be for them to play together. Because of this, I think we have a natural sense of approximately how fast an ensemble of a particular size in a particular space can play and remain together, and also a sense of how quickly they can change tempo together, either suddenly or gradually. The first time we tested PLOrk using the wireless network to control a rapid pulse, this intuitive limit, for me and many others in the room at the time,

[8]From 1668, quoted in (Spitzer et al. 2004: 510).

was violated; somehow PLOrk was playing faster, and changing tempo faster, than seemed reasonably possible for an ensemble of that size. In this experiment, one laptop (the 'conductor' laptop) sent a rapid, constant stream of messages (Max/MSP 'bang' messages) over the network; the players on each machine then controlled qualities of the instrument – timbre, loudness, pitch – but the conductor machine controlled tempo. In effect, we bypassed the speed of sound and the natural latency of our perceptual and cognitive systems, instead relying on the speed of the network to control timing while leaving control of other parameters to the musicians.

So, while the sense of a battleship is real, the laptop orchestra can be in some ways a responsive battleship. This limit violation was both thrilling and a bit disturbing. Being able to capitalise on the capabilities of the network is naturally one of the appeals of PLOrk but, surely, playing together in more traditional ways, relying on the eyes and ears to create ensemble, is still worth pursuing.[9] Again, I think we can have it both ways, and many ways in between. We have done pieces with music notation and a traditional conductor, and also pieces that use timing-insensitive communication via the network. For instance, text messaging can be useful for communicating, from conductor to ensemble, or even from player to player. Sending music notation also opens up interesting possibilities. In some pieces it is useful for players to be able to see the state of their neighbour's performance interface and to borrow information from it; we have done this by setting up various kinds of networking relationships, including linked-list and binary tree structures.[10] And sometimes it is useful for the conductor to control certain non-timed parameters over the network (for instance, volume of particular sections within the orchestra, to manage balance) while the players focus on rhythmic aspects.

The notion of a conductor has proven useful in our initial efforts with PLOrk, though only occasionally has it manifested itself in something that actually looks like a traditional conductor. Rather, it serves as a metaphor for control that is often distributed in various ways, sometimes with multiple people taking on different aspects of control alongside with computational coordination strategies. But, like all metaphors, it is incomplete and we are often left to follow our intuition.

[9]In his study of synchronisation of ensembles, Rasch (Rasch 2000: 81) argues that '[onset] deviations are of primary importance for the ''live'' character of music performed by human beings. The asynchronisation of simultaneous tones should be regarded as one of the vital deviations in the performance of music'. I agree, but I also think that pushing on that intuitive limit is one of the musically intriguing facets of the laptop orchestra.

[10]The work of the Hub is relevant here; their notions of 'network resonance' are particularly compelling. See also (Weinberg, Computer Music Journal 2005 and Organised Sound 2005) for further discussion about network models.

5. THE LAPTOP ORCHESTRA IN PERFORMANCE

'As far as I could tell, they were all just checking their e-mail'. This is a common complaint levelled at laptop performers, PLOrk included. Conventional orchestras are undoubtedly interesting to look at. One can gaze at the players and marvel at their technique (or just their appearance). Some instruments are more visually stimulating than others; the giant hammer in Mahler's 6th Symphony, for instance, is a sight to behold, and simply watching the percussionist prepare to strike creates a sense of tension. The oboe, on the other hand, offers very little for the eye, though some players attempt to compensate for this with grand gestures. The conductor also offers a focal point, providing a visual counterpoint to the sound.

I have always felt, though, that in the end the experience of hearing an orchestra live is primarily aural, and I often simply close my eyes to avoid distractions. This is especially true for experienced orchestral listeners. Audiophiles spend enormous sums of money to recreate the aural sense of being in a hall with a live orchestra; the visual component is blissfully ignored, though we might imagine what the players are doing with our mind's eye.

And this, perhaps, is the rub. Having seen an orchestra play once or twice, we can from then on imagine what the string sections, with their synchronised bow strokes, look like. We can visualise the oboe player's appearance and we associate her sound with that image without even trying. In fact, I subscribe to the view that for most of us the listening process is intimately tied up with our knowledge of these instruments; an oboe sound is not *just* a sound – it is a sound made by a particular instrument which looks a particular way and is played with a particular technique. When we hear, we also see and feel how that sound is made, or how we think it is made.[11] Taking this a step further, not only do we see and imagine how a sound or musical gesture is made, we engage in a kind of 'vicarious performance' (Cone 1968: 21), mentally performing the sound we hear – a kind of imaginary air-guitar. Rolf Inge Godøy identifies this activity as a *motor-mimesis*.[12]

For the laptop performer, this seems to pose a deep problem. If we look like we are simply doing e-mail while generating sounds that provoke the motor-mimetic response of, say, striking an enormous

[11]From an entirely different argument regarding the relationship between music and body, Richard Leppert says: 'For much of Western history, at the most fundamental levels of human perception, the sound *is* the sight, and the sight *is* the sound' (Leppert 1995: xx).

[12]'Motor-mimesis translates from musical sound to visual images by a simulation of sound-producing actions, both of singular sounds and of more complex musical phrases and textures, forming motor programs that re-code and help store musical sounds in our minds' (Godøy 2003). See also (Godøy 2001).

hammer, what will the 'listener' make of it all? What kind of vicarious performance could this possibly inspire? What would the 'air-laptop' dance look like?

But perhaps this is an opportunity instead of a problem, a challenge for which the laptop orchestra is a musically and socially charged gymnasium. On the one hand, we can go at it head-on and endeavour to create challenging instruments that generate sounds which somehow seem tangibly (even acoustically) related to the physicality they demand. A more general approach would be to aim for what Newton Armstrong calls *enactive digital instruments*, instruments that invite exploration and intuitive approaches to performance, and ultimately draw the performer into a kind of performance *flow* (Armstrong 2006). If we succeed in building these kinds of instruments, surely they will be as interesting to watch as conventional orchestral instruments, and as fun to imagine with the eyes closed. On the other hand, this disconnect between body and sound is itself worth pursuing; here we have room for irony, given the right musical context.[13] Perhaps sometimes, because we don't care how the performers look, we ignore the issue, or demand that the audience adjust to a new performance practice.[14] Or we put up a video screen and offer something else to look at; while this last option is possible and has been often suggested, I resist it because it seems like an evasion of responsibility unless the video is closely tied to the basic conception of the piece. Visual stimulus has a way of trumping sound, so simply throwing up some video to distract from the fact that the players are uninteresting to watch can actually ruin what might have been a remarkable sonic experience.[15] My hope is that the laptop orchestra can grow into a wonderfully engaging performance ensemble and I worry that efforts to bootstrap the process via video projection or other theatrical techniques will stunt its growth and obscure other paths that might prove fruitful. In the end, our focus need always remain on the music we make, and everything else should fall into place.

6. SO, WHY A LAPTOP ORCHESTRA?

For much of the history of computer music, the nature of the mainframe computer or, later, computer clusters based around a single sound system encouraged communal experimentation and music making. While these contexts generally didn't allow for real-time music making, they did establish a context where people interacted with one another while creating new work. As computers became less expensive, they migrated both into the home and into the higher end, single-user production studio; the cluster largely became obsolete, and its ephemeral musical community vanished with it. Ironically, this migration occurred at the same time that computers were becoming fast enough to process audio in real time; the studio community, which just might have turned into an actual performance community, instead fragmented into isolated work spaces.[16]

Over the last several years, many of us involved with university-based computer music studios have struggled with how to re-establish their relevance and necessity, mostly with the aim of creating communities where once again experimentation and music making can thrive.[17] While high-speed networking has enabled a certain amount of distance communication and collaboration, there is little doubt that it is a sorely incomplete substitute for the kinds of interaction that occur when musicians are together in one place.[18] One of the most exciting possibilities afforded by the laptop orchestra is its inherent dependence on people making music together in the same space.[19] In this first year, the studios and rehearsal rooms where PLOrk lives have been veritable beehives of activity, busy day and night with students, researchers and composers in various stages of work, sometimes hacking up new code side by side, other times developing new pieces in small groups, or rehearsing nearly finished pieces in larger groups. At any particular time, these spaces are somewhere between laboratory, workshop, or rehearsal studio, often having elements of all three simultaneously.[20] PLOrk is an orchestra, but it is also much more.

[13] I actually experienced a similar but unintentional irony at a performance of Mahler's 6th, where, after a long and clearly strenuous preparation, the large hammer produced nothing more than a pathetic thud, all three times.

[14] See, for instance, (Cascone 2003) and (Stuart 2003).

[15] As Francis Dhomont wrote: 'the eyes block the ears' (Dhomont 1996). Though Dhomont is defending acousmatic music in this article, the issues are similar. See also (Jaeger 2003) and (Monroe 2003) for related discussions pertaining to laptop performance. A wonderful example of a successful integration of a visual element with PLOrk is the piece *In/Still* by Curtis Bahn and Tomie Hahn; see (Smallwood, Trueman, Wang and Cook 2007).

[16] To my knowledge, very little has been written about this decentralisation of the computer music studio. The parallel decentralisation of the recording studio, and its impact on the large recording studio, however, has been described in the popular press (see, for instance, Pareles 2005), and many of the issues are similar.

[17] Many of the ensembles mentioned earlier, particularly those by Moorefield, Wolek, Rush, and the Behaviour Ensemble, were primarily pedagogically motivated.

[18] Though some, including the composer/performer Pauline Oliveros, argue that this is really due simply to a lack of infrastructure, not to limitations in the technology itself (personal correspondence).

[19] While an analysis of the collaborative possibilities presented by laptop ensembles is beyond the scope of this paper, see (Moorefield and Weeter 2004) for an examination of collaborative spaces and laptop ensembles with the Lucid Dream Ensemble, and also the more general theoretical frameworks developed by Leigh Landy and others (Landy 2000) for considering collaborative spaces. We will consider these issues in a future publication.

[20] See (Wang, Trueman, Smallwood, and Cook 2007) for a discussion of the pedagogical structures embedded in PLOrk.

In their wonderful narrative history of the orchestra, Spitzer and Zaslaw detail the 'web of metaphors' that has been constructed to describe the orchestra. They apply the notions of mimetic and normative isomorphisms from the sociology of institutions to reveal how the early orchestra may have borrowed institutional structures from its metaphorical sources like the army, choirs, English gentlemen's clubs, and (eventually) other orchestras. They also show how, over time, orchestras became more or less identical as institutions. Within this context, the challenges of PLOrk are enticing. We can model certain things after the orchestra (mimetic isomorphisms), but, as with the network pulse, some things are simply beyond the orchestral metaphor and we are cut loose, having to discover new ways to think about how to make music with such possibilities. And while we can take advantage of skills and behaviours developed by conventional orchestral musicians (normative isomorphisms), when it comes to exploring how text messaging can serve an organisational musical purpose, we are obviously borrowing skills and assumptions developed in non-musical contexts. The orchestra is undoubtedly an incomplete model for the laptop orchestra, and it is precisely this incompleteness that makes the laptop orchestra worth pursuing.

I think it is remarkable that the orchestra persists in our culture at so many levels, from the middle-school orchestra through the regional amateur and professional orchestras. It speaks to the compelling nature of the music composed for orchestra, but also to the appeal of the large ensemble in general, be it a marching band, choir, drum circle or big band. There is something magical about gathering together and making sound, as any of us who have sung in a choir or played in a good orchestra know; it is, perhaps, a primal urge. In spite of the widespread dissatisfaction reported by many professional orchestral musicians, I believe most still marvel at what they are part of. And, at the risk of overstating the case, we shouldn't ignore the larger context: the modern institution in general. As Spitzer and Zaslaw argue, the story of the orchestra 'is linked to a grander narrative: the creation of modern institutions. Armies, navies, banks, bureaucracies, factories, corporations, secondary schools, scientific societies, and more; all came into being during the seventeenth and eighteenth centuries, in developments that were, if not part of the same process as the birth of the orchestra, at least parallel. If readers choose to make our story a chapter in this grand narrative of modern institutions, we have no objection' (Spitzer and Zaslaw 2004: v). Could the laptop orchestra provide yet another chapter in this story, one that teaches us about the possibilities of the modern institution in the face of digital technologies?[21]

At the end of the day, however, my hopes are more modest if no less difficult to attain. While the orchestra continues to capture the imagination of many composers, it is hardly the centerpiece it once was; as Peter Burkholder argued over twenty years ago, composing for a museum is extraordinarily challenging (Burkholder 1986). This shouldn't be confused with a lack of interest in composing for large ensembles;[22] it is rather the tradition-laden aspects of the orchestra that deter many. On the other hand, the laptop, and laptop music, is without tradition and without much of a performance practice *per se*. The laptop orchestra presents a challenging field of opportunity to both explore the appeals of making music in large numbers – people and their relationships are front and centre in this ensemble – and see what might be possible with new technologies. Neither of these are newfound urges; indeed these were both fundamental to the founding of the first orchestras and, like planets orbiting one another, can restrain and galvanise one another. This is a place to create, explore, learn, and, one hopes, make wonderful music together.

[21](Weinberg, *Computer Music Journal*, 2005) actually uses political terms – democracy, anarchy, monarchy, decentralised organisations – to describe the range of possibilities offered by musical digital networks.

[22]The Grateful Dead drummer and educator Mickey Hart has been organising drum circles with hundreds of participants, and has plans for gatherings in the thousands (personal correspondence).

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