Web-Based Collaboration, Live Musical Performance, and Open-Form Scores

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Biography

Jason Freeman is an assistant professor in the School of Music at Georgia Tech, where he teaches music technology and serves as executive director of the university’s ensemble-in-residence. As a composer, Freeman’s works break down conventional barriers between composers, performers, and listeners. His music has been performed by the American Composers Orchestra, the Rova Saxophone Quartet, the So Percussion Group, and the Nieuw Ensemble, among others.

Keywords

online, web, participatory, music, open form, interactive

Abstract

As Internet-based social listening, composition, and improvisation applications become increasingly important cultural mechanisms through which to experience, create, and share digital music, the author seeks to create comparable systems to engage audiences within the context of live musical performances. Real-time collaboration with audiences during performance can lead to exciting and rewarding musical experiences. But the technical, logistical, and design constraints at live venues, including simultaneous participation and single-stream output, make such live participation systems challenging to create and deploy effectively.

This article instead focuses on linking web-based collaborative experiences with more traditional live musical performances. The article explores the motivations behind such hybrid performance works and the history of them, and it then discusses and evaluates two recent works by the author, Graph Theory (2006) and Piano Etudes (2009), both of which use open-form musical scores as a structural framework for participation.
Introduction

New web services for digital music creation, performance, and consumption increasingly blur the boundaries among composers, performers, and listeners through collaborative paradigms for musical creativity. Yet most live musical concerts remain grounded in more traditional few-to-many models of performance. Audiences may be intimately engaged in listening to live music, but they do not usually have a significant impact on its performance. They are spectators, not collaborators.

New approaches to live musical performance have the potential to forge creative collaborations with audiences, challenging them to become active participants who influence each unique performance of a musical work. Such paradigms not only reflect broader cultural shifts and the pervasiveness of the social web, they also engage audiences in new ways, encouraging them to listen from a different perspective as they focus on the relation of their personal contributions to the work as a whole.

While digital technologies are often integral to the realization of such paradigms, their deployment in live settings presents daunting technical, logistical, and design challenges that can ultimately impose substantial constraints on collaboration. In response to such challenges, two of my recent compositional works — Graph Theory (2006) and Piano Etudes (2009) — utilize a hybrid approach, combining online collaboration with more traditional modes of live musical performance to take advantage of the unique strengths of each medium.

In such hybrid works, web site users participate before the performance and out of real time, with ample opportunities to practice, develop, and edit their creative ideas. Contributed material can be shared online as multiple output streams and is then filtered or condensed into a single stream for each live musical performance. The live event follows more traditional performance paradigms, lacking novel mechanisms for real-time audience contributions. The interaction takes place beforehand, on the web, and without the technical, logistical, and economic constraints of concert-hall deployment. The web serves not as the performance medium itself, but rather as a mechanism through which to link online participation with live performance.

These hybrid approaches are more than just a practical solution to design challenges and logistical hurdles. They are also a powerful way to reach audiences that may have never come to the concert hall at all. In its most recent survey on public participation in the arts, the United States National Endowment for the Arts noted that 18.8% of Americans had attended a musical performance over a twelve-month period, while 47.9% had listened to music on recordings, broadcasts, or over the Internet (Bradshaw and Nichols, 2004: 5). A recent Knight Foundation survey found that “fewer than 5% of those interested [in classical music] actually patronized their local symphonies” (Wolf, 2006: 32). For most of us, live concerts account for only a small portion of the music in our lives. Time, financial, and
geographical constraints often prevent us from attending events, or we may be hesitant to invest our time and money in an unfamiliar artist or genre. The low barrier of entry and direct engagement of an online component, combined with the viral power of social media, can help to reach these audiences. On the web, participants can quickly try something out for just a few minutes and then explore it more deeply if they find the experience compelling.

In this paper, I further explain my motivations for creating these hybrid musical works that combine web-based interactivity and concert performance. I present an overview of previous work in this domain and also explore synergies between this medium and open-form musical scores. I then discuss Graph Theory and Piano Etudes in terms of their design goals, their implementation, and their success at reaching those goals.

**Motivations**

The hybrid approach of *Graph Theory* and *Piano Etudes* was motivated by the success of social music services on the Internet and by the difficulties associated with replicating those experiences in live musical performances.

*On The Web*

Three major classes of social web applications have emerged in recent years to enable creative, collaborative online musical activities: listening, composition, and improvisation.

Social listening applications take advantage of the migration of our music collections from bookshelves to hard drives: personal music libraries, playlists, and listening habits become mechanisms for creative social expression. Sites such as 8tracks (Porter, 2009) enable users to curate and share mp3 playlists, bringing the idea of the mix tape to the social web, while social recommendation services such as Last.fm (CBS, 2009) capture music library and listening data in the background to build social profiles and recommend related tracks.

Collective composition applications enable users to collaboratively create and remix music asynchronously. The NetJam Project (Latta, 1991: 103) facilitated the e-mail-based exchange and remixing of MIDI files among a community of musicians, while more recent projects such as NoteFlight (NoteFlight, 2009) facilitate similar collaborative creation through a browser-based music notation editor. Other services, such as JamGlue (JamGlue, 2009), provide a browser-based editing environment for multi-track audio mixing and enable participants to remix each other’s songs and reuse sound files in new songs.

Collective improvisation applications focus on real-time interaction among simultaneous participants, emulating a jam session using novel music-making interfaces. In Alvaro Barbosa’s Public Sound Objects (Barbosa, 2005: 203) and Chris
Brown’s Eternal Network Music (Traub, 2005: 467), participants control the movement of balls in a virtual space to trigger musical events or modify synthesis parameters. In Auracle (Freeman et al, 2005: 221), a project to which I contributed, the vocal gestures of each participant are analyzed in terms of their pitch, amplitude, and timbre to drive a sound synthesis engine. Barbosa (2003: 57) has dubbed this class of web services “shared sonic environments.”

In Performance

As these Internet-based social listening, composition, and improvisation applications become increasingly important cultural mechanisms through which to experience, create, and share digital music, long-standing paradigms of traditional concert performance — especially of classical music — seem somewhat anachronistic. Audiences sit quietly in their seats in a dark hall, afraid to cough or sneeze lest they disturb the performance, and then politely applaud when each piece is finished. Music flows linearly from composer to performer to listener.

While this framework can indeed lead to powerful musical experiences for all involved, it can also alienate a generation of audiences accustomed to short-form, multitasking listening and continuous social engagement in their entertainment and cultural experiences. The integration of ideas from Internet-based social applications into live concert frameworks can serve as a mechanism for audience engagement, motivating active listening through collaborative creation. If we better understand poetry and poetic form for having written it; if we better understand chemical compounds for having performed mixture experiments; and if we better understand sports strategy for having played games of basketball; then perhaps we can better understand musical structure, gesture, composition, and performance by helping to create music.

Composers and performers necessarily take some risks and give up some control by inviting audiences to help create a live performance, but they also invite the possibility of surprising, novel, and compelling musical results that could not have existed without the audience’s participation.

Unfortunately, the practical realities of live musical performances can make it challenging to incorporate ideas from the social web within the concert hall. From my experiences composing, designing, and deploying two large-scale participative musical performances — Glimmer for chamber orchestra (Freeman, 2008a) and Flock for saxophone quartet (Freeman and Godfrey, 2008) — I have grappled with some key limitations: synchronous audience participation, single-stream musical output, and the technical, economic, and logistical constraints of live performance venues.

At live performances, audiences must usually participate simultaneously. In the context of collaborative composition, participants have no opportunity to edit or revise their contributions, nor can they delve into the structure of participation by exploring the evolution of the music out of real time. In Glimmer, six hundred
audience members participated from their seats in a traditional proscenium concert hall (Figure 1). The environment resembled collaborative composition — participants waved light sticks to influence the music played by orchestra members — but their continuous, simultaneous participation encouraged participants to act strategically to maximally influence the performance rather than musically to create particular sonic results. Amidst a sea of light, simply being noticed and making a difference was the main goal.

In Flock, I addressed this issue by asking different audience members to participate at different times during the performance so that only a small group ever participated simultaneously. But this created new problems: at some performances, audience members complained that they did not get enough of a chance to participate, or that they never had an opportunity to do so at all. Creators of similar participatory works have noted that simply getting audiences “to understand their role so that they can enjoy a participatory experience” is a formidable design challenge in itself (Dannenberg and Fisher, 2001).

[Figure 1. Audience members at a performance of Glimmer wave light sticks to shape the music played by the chamber orchestra.]

Not only do audience members usually participate simultaneously at such live musical performances, they also usually listen to the same music as each other. This places a further constraint on the interaction, as all of these simultaneous contributions must somehow be reflected in a single real-time output stream. As the number of participants grows, the music risks becoming incoherently chaotic in its
reflection of each individual contribution, or else painfully dull in its averaging out of all such contributions into the lowest common denominator. Without the luxury of multiple output streams, as with many web applications, it is difficult for audience members to filter, explore, or manipulate the output to foreground their own preferences or contributions. Balancing individuality and coherence becomes a critical design challenge. In Glimmer, I addressed this by organizing the audience into groups and keeping the nature of their contributions fairly simple; in Flock, I relied on the saxophonists to musically interpret their music notation to address such imbalances. Neither solution was perfect, and both ultimately reduced the depth and transparency of the creative collaboration with the audience. Outside of the domain of music, designers of large-audience participatory experiences have often relied upon competitive games to motivate audiences to work towards collaborative, rather than individual, results (e.g. Maynes-Aminzade et al, 2002).

Beyond these substantial design challenges, live performance venues impose daunting technical, logistical, and economic constraints. Interfaces for interaction must be scalable for large-scale deployment: mobile computing devices, for example, can be too expensive to deploy to even a small audience, while many communications protocols (e.g. Bluetooth) cannot support enough simultaneous connections. While computer vision techniques (Carpenter and Carpenter, 1999: 395) and custom giveaway sensors (Fildmeier and Paradiso, 2007: 50) do scale fairly well, they limit the ways in which audiences can participate. And even these systems can be tricky to deploy, as venues often offer little time in which to set up and test equipment and require the use of expensive stage crews to do much of the work. At the premiere of Glimmer at a major concert venue, for example, setup time was limited to five hours and rehearsal in the hall to twenty minutes. Tod Machover sums up such frustrations: “...everything you need to put on even the simplest piece becomes difficult in current conditions” (Holwin, 2001).

**Background**

*Graph Theory* and *Piano Etudes* are not the first musical works to explore the power of combining Internet-based participation with live musical performance. Previous systems have generally taken two approaches: improvisation systems combine webcast streaming with real-time participation to create a telepresence environment for online users, while composition systems seek online participation in advance of a concert performance. *Graph Theory* and *Piano Etudes* follow directly from the latter approach, and they also draw from the idea of open-form musical scores to structure that participation.

**Improvisation Systems**

In improvisation systems, web users participate in real time during a live musical performance. They typically view a video stream of the concert while using a novel
user interface to create music in collaboration with live musicians and other online participants.

In one section of Tod Machover’s *Brain Opera*, online participants performed along with a trio of live musicians. The online instrument, titled The Palette, enabled users to move their mouse across a two-dimensional box to control generative music parameters such as rhythm, scale, and tempo (Metois and Back, 1996). At the live performance, a large video projection represented each user’s mouse location as a ball in the space, and corresponding audio was generated based on all users’ positions. An audio feed of the live performance was also streamed to online participants.

The PitchWeb (Figure 2), a component of William Duckworth’s *Cathedral Project*, gave online participants and members of the live band “the impression of simultaneously being on stage and online” (Duckworth, 2005: 95). During performances from 2001-2003, web users moved shapes around a two-dimensional window and triggered playback of sound files corresponding to each shape via mouse clicks, key presses, or an automation engine. Players also communicated with each other and with the live band via a text chat, and the sounds they created were mixed into the live performance (Duckworth, 2005: 94).

![Figure 2. The graphical user interface for William Duckworth’s PitchWeb.](image)

At the time of Machover’s *Brain Opera* performances in 1996, few web users had the tools with which to participate; the requirements for bandwidth, processing power, and browser plugins were simply too daunting, and online participation was scarce.
While Duckworth’s 48-hour *Cathedral* webcast event in 2001 drew more widespread participation, attracting the simultaneous critical mass required for these improvisation systems remains a challenge.

**Composition Systems**

In composition systems, web users participate in advance of the live musical performance. They provide individual contributions that are then combined or considered in order to influence live performances of the work. In some cases, this participation takes place over a fixed time period, resulting in a fixed-form product; in other cases, the participation is ongoing, differentially influencing each unique performance.

In *The People’s Choice Music* (Soldier et al, 1997), five hundred participants took a poll on the Dia Center for the Arts web site, indicating their musical preferences for everything from instrumentation and style to lyric subjects and duration. Composer Dave Soldier analyzed the survey results to compose a love ballad he predicted to be “unavoidably and uncontrollably ‘liked’ by 72+/-. 12% of listeners.” He also composed a 25-minute collage featuring an opera singer rapping about Wittgenstein while children sing holiday advertising jingles, which he predicted to be enjoyed by “fewer than 200 individuals of the world’s total population” (Soldier et al, 1997). While Soldier successfully incorporated online contributions into these engaging and humorous works, he simultaneously points at the futility of trying to create music which reflects broad listening preferences and implicitly criticizes the focus group procedures favored by major record labels.

Other recent projects have invited web contributors to write individual musical notes or gestures in order to create an instrumental score for live concert performance. The New York Miniaturist Ensemble’s Collaborative Composition Web Site (2006) invited anyone to add, remove, or change notes on a single musical staff. Snapshots of the site were periodically printed and performed in concert by the chamber ensemble. The Wiki Collaborative Composition Project (Frankel, 2007) invites composers to contribute up to eight measures of music to a work in progress for chorus or band; participants download a music notation file, edit it, and then upload their expanded version.

While these two projects appeal to trained composers comfortable with music notation, Sergi Jordá’s *Faust Music On Line* (FMOL) employs a unique graphical interface (Figure 3) representing sound and processing operations as widgets (Jordá, 1999: 7). Contributors download the software, connect to an online database, and create short electroacoustic compositions. A tree structure encourages them to create variations of each other’s work and to add additional musical layers to existing compositions (Jordá, 1999: 7). The contributed compositions were used during a 1997 theatrical performance at La Fura dels Baus in Barcelona based on Goethe’s *Faust* (Jordá, 1999: 5). No live musicians were necessary, nor was a traditional score: the electroacoustic sound generated through the application directly created the content used in performance.
Open-form Scores

When composition systems seek to engage untrained musicians as online participants, the interface for their participation becomes a core design challenge. Jordá developed a unique and effective interface for electroacoustic music. But in the case of Graph Theory and Piano Etudes, the interfaces must ultimately produce more conventional musical scores to be performed in concert by instrumental musicians. In such situations, open-form scores offer a powerful foundation for interface design.

In open-form scores, the order and/or contents of musical materials may change dramatically from one performance to the next. Composers such as Earle Brown, drawing inspiration from the malleable sculptures of Alexander Calder, sought to capture Calder’s “construction of units and their placement in a flexible situation [...] which subjects the original relationships to constant and virtually unpredictable, but inherent, change” (Brown, 1999:40). In Brown’s malleable scores, such as Available Forms I (Brown, 1961), a conductor determines the order of the fragments and cues the musicians accordingly. In another example of an open-form score,
Stockhausen’s *Klavierstück XI* (Stockhausen, 1957), the pianist plays musical fragments on the printed page in the order in which her eyes wander across them. More recently, open-form scores have served as a conceptual basis for real-time music notation systems, in which notation is rendered on the fly, during the performance, based on live input into the rendering algorithms (Freeman, 2008b: 25). Art Clay’s *GoingPublik*, for example, renders real-time music notation for a trombone trio based on the players’ physical movements through the performance space (Gutnkecht et al, 2005: 149).

While open-form scores, whether conventional or technological in nature, can give musicians tremendous interpretive flexibility in performance, they often leave audiences confused about the unique roles of the composer and performer in the work’s realization; audiences cannot typically see the score. Saariaho’s *Mirrors* addresses this issue by using the open form as a mechanism for audience engagement. On a CD-ROM application (Figure 4), users create their own versions of this piece for cello and flute. They view each musical fragment as standard notation or as a graphical sonogram, and they drag those fragments onto a timeline to create and hear their unique version of the music (Saariaho, 2001). The application, though, exists in isolation from live performances of the work; there is no way to capture versions created through the interface. The published performance score features the linear arrangement of fragments preferred by Saariaho, though she does invite performers to physically cut and paste the score if they wish to create a different version.
Saariaho’s work shows the potential of open-form scores to creatively engage audiences in shaping and “remixing” a musical work, avoiding the potential mystery of open-form scores in performance and providing a foundation for the creation of hybrid web-based and live performance compositions. Scores can be transformed into more abstract, graphical representations of musical structures that enable participants to creatively engage with music regardless of their formal background. And their online interactions with these open-form scores can influence the specific instantiations of the scores performed in concert. Instead of navigating the score on the fly, performers can base their decisions on those made by web-based collaborators. This approach guided the development of *Graph Theory* and *Piano Etudes*.

**Goals**

The broad goals motivating the hybrid design of both *Graph Theory* and *Piano Etudes* can be understood within two thematic areas: individual engagement and social connection.

Both projects aim to reach new audience members and to engage each of them actively with the work’s musical material. Through their interactive web sites, the projects seek out people that might not attend live performances of the works or might not attend classical music concerts at all. They challenge those people to actively and creatively navigate the work’s musical material, to listen to the music from a different perspective than with a conventional recording or performance, and to consider both the music’s sound and its symbolic representation: the (open-form) musical score.

The projects also attempt to create new social connections among audience members and between audiences and performers. By inviting audiences to navigate the work’s musical score, the projects try to help audiences understand and appreciate the unique interpretive role performers play in the piece. By asking audiences to share their creative contributions online, the projects aim to make participants feel a stronger social connection to each other than at traditional classical music performances. And by encouraging performers to incorporate the contributions of web site visitors into their performances, they challenge musicians to collaborate with their audiences.

Though these projects rely upon social web technologies and draw inspiration from the success of social music applications on the Internet, their objectives focus on individual engagement and social connection within the context of traditional classical music performance. They leverage current technological tools in order to facilitate rapid development and broad dissemination, to circumvent some technical, design, and logistical challenges, and to reach new audiences by appropriating culturally pervasive technology. Were these projects to be
implemented in a different generation, they would surely leverage different tools to achieve their goals.

While both projects do seek to create compelling musical experiences — online and in concert — the musical product is secondary to the process by which it is created, the experiences of the people who are involved in creating it, and the connections forged among those people.

The following sections describe how the broad goals — reaching new audiences, engaging those audiences actively with the music, and creating new social connections among audience members and between audiences and performers — informed the design and implementation of each project. I also consider each project’s success at achieving these goals.

**Graph Theory**

*Open-form Score*

The open-form score for *Graph Theory* (Figure 5) includes sixty-one short musical fragments for solo violin; each fragment ranges in length from 0.6 to 4 seconds and includes between one and five pitches. On the score, each fragment is depicted as a node on a graph, and the nodes are connected by undirected edges to indicate possible paths of traversal. Any graph traversal constitutes a potential version of the piece; in any given version, each node may be visited multiple times or may not be visited at all.

[Figure 5. An excerpt of the open-form score for *Graph Theory*.]
To compose the fragments and create the links, I first developed some broad, self-imposed constraints on the musical content and structure, notated my musical ideas on pencil and paper, iteratively revised them using my musical intuition, and finally engraved them as a musical score (Figure 5) using music notation and illustration software. My compositional constraints focused on pitch material and on the relationship between linked fragments. As in much of my music, the minimal pitch material is drawn from only twelve pitches: each of the twelve pitch classes is frozen in a particular octave throughout the composition. Linked fragments share similar pitch content: they always differ by only a single added, removed, or changed pitch. Each node links to either three or four other fragments on the graph. Collectively, these constraints encourage gradual rather than sudden changes in musical material over time. I imposed no constraints on the rhythmic and metrical content of the fragments, but I attempted to avoid a regular sense of pulse and meter between fragments to create a minimal, meditative score.

**Web Interface**

The open-form score for *Graph Theory* is never used in live concert performance; instead, it forms the basis of the web interface (Figure 6). Participants use the web interface to explore the open-form structure and to traverse the graph creatively and uniquely.

![Figure 6. The web interface for *Graph Theory*.]
The top section of the interface displays piano-roll style representations of the current fragment, previous fragment, and possible next fragments. The lower section of the interface features a visual representation of the entire graph structure. Different colors highlight the previous, current, and possible next fragments, and the hues of possible next fragments indicate their relative popularity with other website visitors. The colors of the remaining fragments on the graph indicate whether the user has already visited them during the current session.

Users choose the next fragment by clicking on either the piano-roll representation or the graph nodes themselves; they may move back to the previous fragment if they are unhappy with their decision. A path review button enables users to play through the entire series of fragments they have visited thus far; in this mode, each fragment in the path is played in succession a single time.

The web interface focuses on individual exploration of the open-form structure. The site does explain the role of user decisions in live concert performances, but this aspect of the piece is not core to the site design. I wanted the web experience to be an engaging end to itself, in addition to its connection to live performance.

**Fixed Score Generation**

As web participants traverse the graph of musical fragments, each decision they make is logged to a server-side database. The server also records the number of times a fragment loops before a new decision is made. Each day, the server uses this data to regenerate a downloadable score file for use in future performances.

The score-generation algorithm creates a linear path through the composition. It first assigns weights to the directed edges linking each pair of fragments in the graph; the more “votes” a particular edge has received from participants, the lower its weight. The software then finds the path that visits all fragments at least once but has the lowest total weight. It solves this optimization as a variation of the traveling salesman problem, allowing for a graph that is not fully connected and allowing for the same fragment to be visited multiple times. In this manner, more popular path segments are more likely to appear in performance scores. The decisions of recent website visitors take precedence: a server-side variable configures how far back to look in the decision database when computing weights.

The algorithm also labels each fragment in the score with a suggested number of repetitions, based on the average number of times website visitors let it play before moving on.

Using these techniques, *Graph Theory* is able to merge the activities of website visitors into a constantly changing combined output stream. The most recent score file is always available for download from the web site.
Live Concert Performance

While no technology is required in the performance of the piece, presenters are asked to direct audiences to the web site in advance of the concert, and they are encouraged to place computer kiosks running the web site in the concert hall lobby.

In each 7-10 minute concert performance, the violinist exercises considerable interpretive freedom to modify dynamics, timbre, and tempo, to insert pauses, and to vary fragment repetitions, musically shaping groups of fragments into larger-scale musical phrases. The resulting performances sound markedly different than the web interface, in which audio recordings of each fragment are identical each time they are played.

Recordings of live performances are posted to the web site. This not only enables visitors to hear the collectively generated scores; it also helps them to understand the role of the live performer in interpreting those scores.

Evaluation and Discussion

Graph Theory launched to the public in October 2006, and since then, over 17,000 people have explored the work online, and it has been presented in six live performances.

To assess the project’s success, I solicited feedback in three formats. In July and August 2006, beta testers were asked to provide written feedback about their experiences using the web site. In May 2009, five university students were asked to use the web site, listen to recordings of live performances, and answer questions about their experiences in a verbal interview. Finally, a violinist who had performed the piece three times was also interviewed.

Graph Theory’s interface pushed users to explore the musical fragments on the graph rather than to consciously create a complete individual version of the piece. One beta tester noted: “my overriding desire was to explore the graph thoroughly, and hear fragments I hadn’t heard yet,” while an interviewee stated that “I didn’t try to construct a piece…I just let it happen.” Many users, though, felt frustrated by their inability to create a finished product beyond the limited functionality of the path review. One interviewee thought that his navigation decisions were rather “arbitrary” and that he was unable to “make a song,” which was “what I wanted out of it from the beginning.” A beta tester went further, arguing: “I feel that I cannot really make any aesthetic decision. I am just charting a path geometrically and the sound becomes secondary.” Regardless of their contributions towards a collective score, users clearly wanted more opportunities for individual creation.

The project had mixed success in making web users feel socially connected to each other and to live musical performances of the work. The hue-based visualization of the relative popularity of choices intrigued many of the interviewees. One person “found myself choosing the unpopular [fragment]” and wondered to himself why his decisions always deviated from the norm; another person would “try to figure out
why everyone wanted to go” in a particular direction. Users had more difficulty feeling a connection to live performances through their influence over the collective score, since the process that generated that score was not transparent. One beta tester asked if he could “see my impact on the score, expressed in some sort of easy-to-understand metric,” while an interviewee thought that the connection “is satisfying on a conceptual level but not on an immediate level.”

Originally, I had hoped that violinists performing *Graph Theory* would practice individual fragments in advance but would wait to sight-read the latest score from the web site during each performance. I intended for this process to give the work a degree of spontaneity and excitement as the performer reacted to the collective creation of web users.

In reality, this process proved too difficult and impractical. The violinist with whom I spoke explains: “There were some [versions from the web] that were just extremely awkward and which frightened me...I thought that if that one comes up in the concert I won’t be able to do it well, it will sound clumsy and I will feel embarrassed.” So instead, she “printed out ten [versions from the web]...and kind of played through them and decided on one that felt comfortable and sounded good.”

Because of practical performance challenges and the variability in the quality of scores generated online, violinists have had to take a more active creative and preparatory role than I had anticipated. The performer essentially filters the collective product from the web as she prepares for each concert.

In spite of such unexpected changes to the process, the violinist still felt a strong connection both to web site users and to live audiences. While preparing for one performance of the work, she noticed that all the versions of the score she printed “were pushing to have this one sequence...the same cluster kept on appearing close together...it seemed like everyone wanted this to happen.” She also felt a stronger connection to live audiences: “they’re more concentrated because they know about the uniqueness of the piece...everyone was just so focused,” which gave her increased “energy” and “concentration” as she performed.

As a classically-trained composer, I approached this project with some trepidation. It was important to me that participants be creatively empowered, but it was also important to me that the music be compelling to me in concert performance, independent of the collective process by which it had been developed. While developing the project, I made numerous decisions to retain musical control. For example, variations between linked fragments are minimal, so that musical paths through the score evolve gradually over time rather than suddenly. And the algorithm that merges user contributions into a collective score relies on popularity, eliminating outlier contributions.

Ultimately, I felt an uneasy balance between retaining and distributing control in my role as a composer. While I was invariably happy with the musical content of each performance, the variations in each version of the score were subtle and rested on large-scale structural organization rather than smaller-scale gestures. While I felt an
unusual distance to the music in performance — I never knew exactly what would come next — I was rarely too surprised, for better or for worse, by what did come next. My surprises, in fact, came more from the musical decisions of the violinists than from the order of elements within the score.

**Piano Etudes**

My experience with *Graph Theory* convinced me of the promise of using open-form musical structures to create hybrid works combining web-based participation with more conventional live performance. In *Piano Etudes*, I sought to address some of the key issues that arose with *Graph Theory*; I also adapted the design to a more polyphonic instrument, the piano. The resulting project focused on individual creation rather than collective products, giving web participants more ownership of their work and giving performers more flexibility in deciding how to incorporate that work. *Piano Etudes* also introduced community mechanisms for online participants to share their work more directly with each other.

*Open-form Score*

*Piano Etudes* retains the same open-form score design as *Graph Theory*: a collection of short musical fragments serve as nodes on a graph, with edges connecting them together to indicate possible paths of traversal across that graph.

Unlike *Graph Theory*, the score for *Piano Etudes* (Figure 7) is divided into a series of four short etudes (movements) with one or two graphs for each etude. Graphs contain relatively few nodes — between sixteen and twenty-four — so that each graph can be rendered in its entirety in a single web browser window or on a single sheet of paper.

[Figure 7. The open-form score for the first of the Piano Etudes.]
Because the piano is primarily a polyphonic instrument, with two hands working together to play chords or multiple layers of music, the open-form score needs to accommodate multiple simultaneous sonorities. In two of the work’s four etudes, distinct musical layers are represented by two separate graphs. Traversal of each graph is independent; movement from one node to another need not be synchronized across the graphs. The remaining etudes use a single graph in which each node represents a full polyphonic texture rather than a single layer.

Finally, graph edges are not regulated by similarity rules but solely by my intuition during the compositional process. As a result, each graph has a unique structural character: some are highly symmetrical while others are more irregular; some have few connections among nodes while others have many; and some have directed edges while others use undirected (bidirectional) edges. Some allow fragments to be repeated; some have rests; some have nodes of variable duration. Each graph reflects the musical qualities of a particular etude within the work, allowing different kinds of freedom through traversal and encouraging different kinds of musical structures to emerge. In each of the etudes, I have given up far more control as a composer than with Graph Theory, and each graph makes possible a far greater diversity of musical possibilities on multiple hierarchical levels.

All of these changes combine to create a musical score that is more manageable because of its division into distinct parts; more flexible through its use of independent layers, variable durations, and repetitions; and more varied through the unique structure of each graph.

**Web Interface**

Since the graphs for Piano Etudes easily fit within a single browser window, the web interface (Figure 8) essentially becomes the open-form score. Each node is displayed in piano-roll or musical notation and no scrolling is necessary. The split-screen view of Graph Theory, in which only the content of local nodes was displayed, is no longer necessary.

![Figure 8. The graphical user interface for the first of the Piano Etudes.](image-url)
The website design also focuses more on the conscious creation of individual versions of the work. *Graph Theory* users clicked on nodes to make immediate navigation decisions as the music continuously played, and the functionality of the path-review feature was limited. In *Piano Etudes*, creating, editing, and listening are treated as separate tasks in the interface. Playback is not continuous; users click on nodes in the graph to preview them and then add them to a timeline view of their version. On the timeline, users can view their version, play it back (with random access), and edit or remove individual fragments within the timeline. (Users cannot remove nodes from the timeline when it would break the navigation rules of the graph’s edges.)

The website’s sharing features further emphasize individual creation. In *Graph Theory*, there was no way to save or share an individual version of the work; only the collective composition was saved. In *Piano Etudes*, there is no longer a collective version, but rather many individual versions. Participants may download their versions as audio files or printable musical scores. They may also save them to the server, share them on social networks, e-mail them to friends, or post them to the site’s own gallery so that others can retrieve them and create derivative versions. The music is released under a Creative Commons share-alike license (Lessig, 2004: 282) to facilitate these community mechanisms.

*Fixed Score Generation*

In *Piano Etudes*, performance scores are created directly from individual versions of each etude on the site; there is no collective version that tries to algorithmically merge the activities of recent participants. While that collective aspect of the project was conceptually powerful in *Graph Theory*, it was less effective in practice: the connection between individual contributions and the collective scores was not transparent to participants. By using individual versions directly in performance, I give up far more control as a composer: unusual contributions, even those I do not personally find compelling, may be presented in concert. As a composer, I preferred to take this risk because of the potential it offered to surprise me with creative results I could not have imagined myself.

*Live Concert Performance*

Pianists have three options when presenting the work in live performance. First, they may simply play from the printed open-form score, making navigation decisions on the fly and never looking at the website or at versions created by users. Second, they may use the web interface to create their own fixed version of the piece in advance of the performance, eliminating the risks of real-time navigation but also forgoing its spontaneity. Finally, they may browse the online gallery and choose user-contributed versions to perform in concert. The approach that a pianist chooses ultimately depends on the degree to which she wishes to connect to online participants and on her desire to navigate the open-form score on the fly.
As with *Graph Theory*, recordings of live performances are also posted to the web site.

**Evaluation and Discussion**

*Piano Etudes* builds upon *Graph Theory* to present more compact and varied open-form scores, a streamlined user interface with a focus on individual creation and sharing functionality, and a more flexible approach to incorporating user contributions into performances. Like *Graph Theory*, it has been successful at reaching audiences both online and in performance. Since its launch in February 2009, over 20,000 people have visited the site, the work has been presented in ten live performances, and over 400 people have contributed their versions to the online gallery.

The same techniques were used to evaluate the project’s success as for *Graph Theory*. Beta testers supplied written feedback, an interview was conducted with the pianist who played the work in all seven performances to date, and the same five university students as with *Graph Theory* were asked to use the web site, listen to (or in some cases attend) a live performance, and share their thoughts during an interview.

Beta testers and interviewees noted the shift of focus in *Piano Etudes* from exploration to creation: one noted that it was “more about the finished product,” while another said it was “more of a composition than an improv.” Most people preferred this shift, as it encouraged them to focus more on making creative musical decisions: a beta tester thought that “the overview [timeline] allows the user to kind of plan the whole piece.” This new focus, along with the increased flexibility offered by the compact and varied graph structures, made interviewees feel that they “had more control” and that “there was much more room for creating something interesting that you could kind of feel ownership for.”

Web users often felt a strong connection to other online users. One interviewee was interested in viewing the versions contributed by other users because “there was a lot more room for remixing it” than in *Graph Theory*; he noticed, for example, “things that I had chosen as transitions they would have as the main theme.” But while web users were interested in having their versions performed live, the lack of a collective composition made them skeptical that their work would ever be incorporated into a performance. One interviewee thought: “it feels like a game drawing...I feel pessimistic about my chances of ever being selected.”

That pessimism was mirrored in the pianist’s struggles to perform the versions created on the web. While she did peruse all of the user-contributed versions, she ultimately created her own versions for performance, using those found online “as inspiration.” While she did think that “people came up with combinations that I didn’t think of that were quite successful,” most of the versions, she felt, were too short to use directly in live performance. (Other pianists have chosen to directly perform versions from the web site.) As with *Graph Theory*, the performer became a
filter, combining material from the web site with her own unique interpretation of the piece.

The pianist also felt the same strong connection to live audiences as the violinist had with *Graph Theory*. The work helped her to share the experience of the open-form score with her audiences: “I think they were completely fascinated by the idea and they couldn’t believe that from those boxes out comes this music. Because of that it really got them interested.”

At the same time that the pianist wished the web versions had been longer, web users complained that it was “hard to create a long” etude. They asked for the ability to cut and paste groups of fragments and for an “autogenerate” feature to create such groups. Others wanted to be able to modify the links on the graph or the contents of fragments themselves. These requests collectively suggest a more hierarchical approach to the interface that simultaneously enables quick, broad strokes and low-level tweaking.

As a composer, I gave up much more control in *Piano Etudes* than in *Graph Theory* by creating graphs open to far more diverse musical results and to both large-scale and small-scale gestures; and by encouraging individual rather than collective contributions to be presented in performance. I did still value the quality of the musical performances, independent of the process by which the music was created, and I continued to make design decisions to control that musical output: the graphs are still constrained, and I ask pianists to play a substantial filtering role both in interpreting the music and in deciding which version of the score to perform.

While I have not been happy with every version of the music presented in performance, I have been thrilled and surprised by the diversity of creative contributions, many of which I find both surprising and compelling. For me, these results have made the additional risk and my reduced control worthwhile. I also feel a strong social connection to participants, much more so than in *Graph Theory*, because I can see their individual contributions and understand in detail how they have chosen to work with the musical material.

**Conclusion and Future Work**

Both *Graph Theory* and *Piano Etudes* draw from the tradition of open-form musical scores to create web-based interfaces that creatively engage audiences with musical content and structure while linking their activities to more conventional live concert performance. This hybrid approach helps these works to incorporate ideas into live performance that would otherwise be difficult to do so.

While both works demonstrate the promise of this approach, they struggle with key design challenges in this domain: the balance between individual and collective contributions; the transparency of the link between the web and the performance; and the relative emphasis on the exploratory process and the shared product.
Besides continuing to address these challenges, my future work in this paradigm will explore ways in which to build upon these core designs. A more hierarchical interface, for example, would enable participants to choose the level of musical structure at which to engage. With broad strokes, they could define large-scale trajectories and ask the software to compute the intervening musical gestures, or they could zoom in to control the individual notes within motives. Such an approach would help users quickly develop larger-scale forms while also giving them more control over revisions and low-level details.

I also hope to expand the scope of these works beyond solo performers. The move to a polyphonic instrument with Piano Etudes introduced some new techniques, such as simultaneous graphs, but with a chamber ensemble or large ensemble, questions about the connections and synchronization between graphs arise, and a balance must be struck between limitless possibilities and a coherent musical texture.

Finally, the rapid growth of Internet-enabled smartphones suggests a possible solution to a frustrating problem with these works: live audiences have rarely visited the web site in advance of the concert, and they sometimes understand little about the open-form score when they first hear the piece in concert. Because these performances usually take place in traditional venues, logistical and administrative limitations have frequently prevented a computer kiosk from being installed in concert hall lobbies, and unfortunately, some marketing teams have even omitted the project URL from press materials. By the time live audiences learn of the work’s design, they are already at the venue. Versions of the web site optimized for smartphones or dedicated smartphone applications could easily address this issue, as live audiences could engage with the site just before the concert begins, during the time when they might normally read the program notes.

As technological tools become increasingly sophisticated and as the collaborative cultural landscape continues to evolve, I look forward to continuing this search for ways to creatively engage audiences in making music online and in performance.

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Graph Theory is available at http://turbulence.org/Works/graphtheory/. Piano Etudes is available at http://www.jasonfreeman.net/pianoetudes/.
References


