# Social Composition: Musical Data Systems for Expressive Mobile Music

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**ABSTRACT**

This article explores the role of symbolic score data in the authors' mobile music-making applications, as well as the social sharing and community-based content creation workflows currently in use on their on-line musical network. Web-based notation systems are discussed alongside in-app visual scoring methodologies for the display of pitch, timing and duration data for instrumental and vocal performance. User-generated content and community-driven ecosystems are considered alongside the role of cloud-based services for audio rendering and streaming of performance data.

Music is an inherently social experience. The power of music and musical expression has always served as a conduit for intention, emotion and interpretation connecting composers, performers and audience members alike, often spanning considerable distances of space and time in the process. More recently, a democratization of means within music has taken place, allowing listeners instant access to vast libraries of recorded musical performance as data on physical media or transmitted around the world on high-speed networks. Never before has more music been available to more people in more ways. Yet through the changing technological landscape, traditional tripartite relationships between musical composers, performers and listeners persist—composers still write music, performers still perform and listeners still listen—although the lines that once separated each role have become increasingly blurred as new interactive media formats engage and encourage listeners to take active roles in the creation and generation of sound and music.

With the commercial success of mobile computing devices such as Apple's iPhone and iPad [1], as well as the growing popularity of Google's Android mobile operating system [2], there exists a large and rapidly growing user base of portable computing devices, each connected to a persistent wireless network. As mobile platforms have become more powerful and increasingly ubiquitous, the possibilitie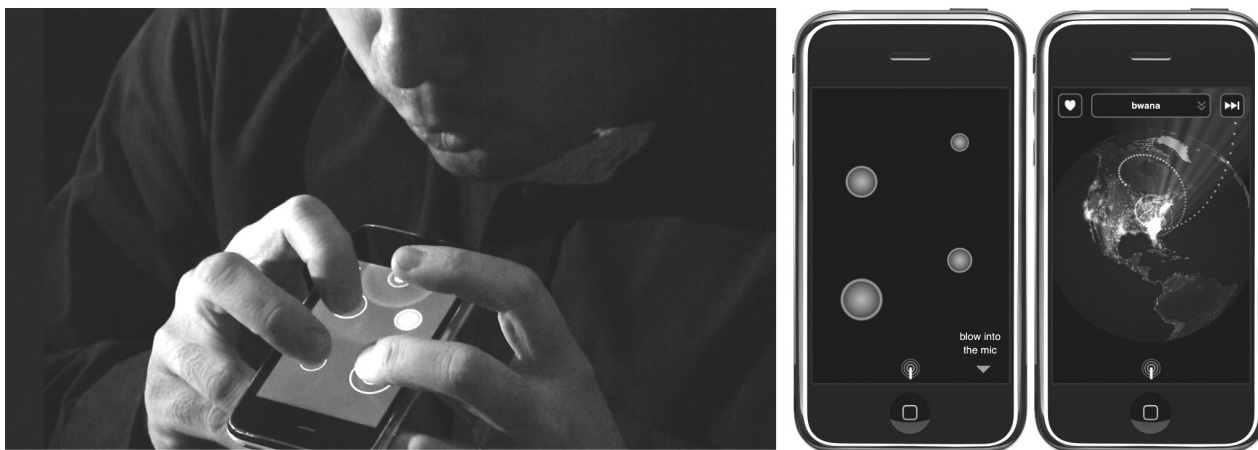s for real-time mobile musical creation have flourished, combining the intimacy of highly personal mobile devices with an unprecedented level of global social connectivity. Sound and image can be recorded at any time and place and be instantly transmitted around the world, proliferated over content-sharing platforms such as YouTube, Twitter and Facebook. Mobile telephones are no longer just telephones, and with the right combination of software and network capabilities, these devices can be and have been repurposed as immensely creative tools for musical expression and social connection by novice and accomplished musicians alike.

Of particular interest in this brave new world of social musical creation is the changing role of the composition itself, specifically the manners in which composed musical intention—as revealed in pitch, timing and expressive gesture—can be notated, distributed and presented for interpretation. In an age of digital creation and distribution that values immediacy and portability above all, melodic and harmonic materi-

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See <mitpressjournals.org/toc/lmj/-/21> for supplemental files (such as audio and video) related to this issue of LMJ and accompanying CD. See also <smule.com> for materials related to this article.

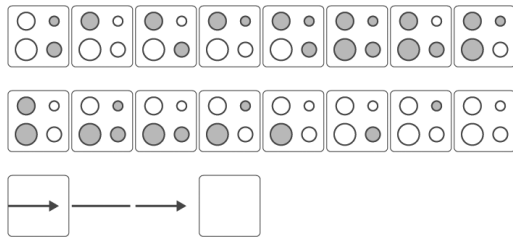**Fig. 1. Ocarina for iPhone. (© Smule, Inc.)**

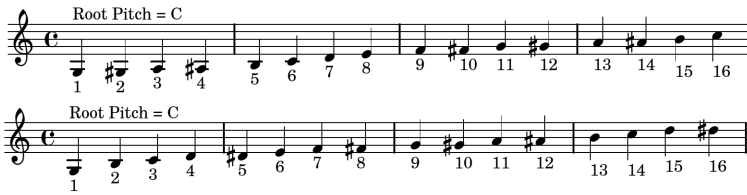Fig. 2. Ocarina tablature symbols. (© Smule, Inc.)



Fig. 3. (top) C Ionian and (bottom) C Zeldarian modes. (© Smule, Inc.)

als composed offline and out of real time engage performers of digital instruments in the same ways they did performers of traditional instruments. In many ways, the core role of notated music has not changed significantly: Performers still can rely on composed material to guide and inform the content and direction of a given musical performance. However, the possible forms of encoding and presenting musical notation itself, and most specifically the manners in which that notation can be distributed to and shared with users, have changed drastically to take advantage of the unique possibilities afforded by digital networked instruments.

## MOBILE MUSIC

In 2006, Gaye et al. defined "mobile music" as "a new field concerned with musical interaction in mobile settings, using portable technology" [3]. Just as the mobile revolution has had a profound effect on the way society in general communicates and interacts, so too has it impacted communities of composers, researchers and performers of new music. Accelerometer-based audio-control paradigms [4], touch-screen control of dynamic synthesis processes [5] and GPS-based locative musical systems [6,7] have been explored with and made possible by the rapidly evolving capabilities of mobile devices. The portability inherent in the mobile form has allowed for the emergence of new performance paradigms, ranging from rapid physical displacement of music-generating devices [8] to ensemble-based mobile-phone orchestras [9,10] capable of exploring a variety of group-based interaction and gestural control schemata. Researchers

leveraging the increasingly powerful processing capabilities of mobile devices have implemented a variety of audio-processing techniques—ranging from physical modeling [11] to parameterized synthesis and real-time full-duplex audio I/O—made available in projects such as the open-source MoMu software development toolkit [12]. Additionally, mobile ports of existing computer-music software languages [13–15] have become viable options for music-making with the marked increase in mobile computing power.

While the use of wired and wireless networks for contemporary musical performance and composition has been explored by an increasing number of artists and researchers over the last three decades [16–19], the majority of approaches explored tend to embrace levels of technological and musical complexity that leave all but the most savvy music technologists unable to partici-

pate. As the wireless mobile revolution continues to unfold, we see such complexities as a significant barrier to entry for a massive pool of potential composers, performers and listeners, each possessing a desire and potential to create, each one a valid participant in a pervasive view of music itself that Tanaka dubs a "living form of cultural expression" [20].

## SMULE

Following the launch of the Apple App Store in July 2008, we and our colleagues have created a series of social musical applications for the iOS platform at Smule, Inc. [21], including Ocarina [22], Leaf Trombone: World Stage [23], Magic Piano and Magic Fiddle [24]. We founded Smule with the ethos of democratization not only of music but of *music-making*. The influence of the recorded medium on the past century of music performance and consumption has to some extent pushed music away from its roots as a social, interactive medium. We believe we have encountered its first true inflection point with the proliferation of the mobile Internet. The new democratization of music, including the notation, performance and interactive consumption of the medium, seems a natural response.

In contrast to musical games such as Guitar Hero [25], our apps are designed to give users expressive control over the shape and articulation of sound yet at the same time use game-like mechanics and user interfaces to lower user inhibition, particularly in users who are not accomplished musicians, enhancing both the accessibility as well as the potential engagement for such novice users. Put another way, if Guitar Hero could be characterized as a *game masquerading as a musical instrument*, then Smule's products

Fig. 4. Leaf Trombone: World Stage instrument interface and judging view. (© Smule, Inc.)
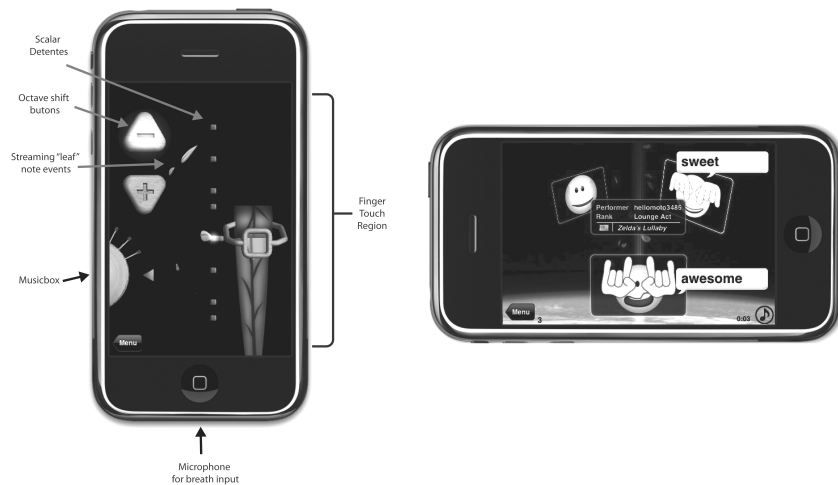
might be described as *musical instruments masquerading as games*. The distinction, perhaps subtle if not trivial, is that the output of such experiences is unique and expressive; in short, users create music.

## INSTRUMENTAL DESIGN AND MUSICAL ABSTRACTIONS

Our design principals seek to exploit the potential of mobile devices, both as physically interactive tools and as networked, connective agents between participants, facilitating novel musical social intercourses. Smule's products are not attempts to "port" traditional instruments to mobile devices but are meant to reimagine their expressive potential. Ocarina re-purposes commodity iOS device interfaces to control an abstraction of an ancient clay ocarina. Taking advantage of mobile-device connectivity and locative tracking technologies, the instruments interface with social networks in real time, from any location, allowing new social relationships to be forged through the sharing of expressive audio. To date, users have experienced over 100 million user-generated musical performances through cloud-based integrated services currently powered by 50 servers running on Amazon Web Services (AWS), managing interactions by over 13 million unique users.

By combining real-time sound synthesis, multitouch gestural data, microphone-based breath control and dual-axis accelerometer motion to create novel-yet-familiar musical performance interfaces, mobile musical instruments afford users nuanced control over a subset of key experiential components of instrumental performance practice while simplifying or automating others. In this manner, an abstraction of a given instrument—a four-hole pendant ocarina or a violin—and its performance schema is created, with a goal of enabling musically expressive experiences for all users, regardless of musical training.

## INTRODUCING OCARINA

In November 2008, we introduced Ocarina, a monophonic iPhone instrument that enables users to play music through a combination of multi-touch gesture, breath control and accelerometer motion and share their performances by uploading data to the cloud (Fig. 1). Ocarina was designed with four "finger-holes," in a configuration similar to that of a traditional four-hole pendant ocarina, with a configurable "mode" setting, allowing users to change the instru-
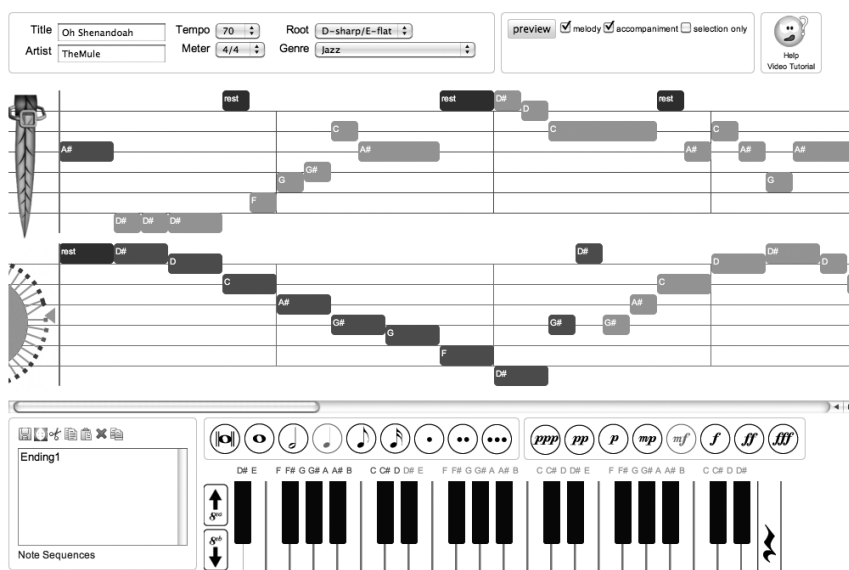


Fig. 5. Leaf Trombone Composer melody and accompaniment tracks. (© Smule, Inc.)

Fig. 6. JSON representation of *Oh Shenandoah*, for Leaf Trombone. (© Smule, Inc.)

"header":{
    "name":"Oh Shenandoah",
    "parts":2,
    "mode":"Ionian",
    "root":63,
    "bpm":75,
    "beats per measure":4,
    "beat unit":4, },
"body":[{
    "polyphony":1,
    "auto":false,
    "frames":[
        {"po":-5, "fto":0, "d":0.25, "i":4},
        {"po":0, "fto":0.25, "d":0.125, "i":4},
        {"po":0, "fto":0.125, "d":0.125, "i":4},

ment's tuning system among a series of modes. Sixteen notes are available to be played at any given time and can be transposed into any diatonic key. As such, the Ocarina-as-abstraction offers features no traditional ocarina could while forgoing complex control parameters such as harmonics generated by half-hole finger placements or more subtle pitch and timbre inflection as controlled by variable breath rates.

## OCARINA COMPOSER

At launch, Ocarina reached the top-selling spot in the iTunes App Store, going on to sell more than 1 million copies in its first 6 months. To encourage and educate the rapidly growing Ocarina user base, we introduced a web-based composition tool for creating and viewing user-generated score content. Based on traditional ocarina fingering tablatures, the Ocarina Composer [26] allows users to compose monophonic melodies and render and post a viewable tablature online. To facilitate user access, we cre-

ated an on-line forum within which users could post URLs of their compositions. More recently, the forums were replaced with a database-driven on-line Ocarina Songbook [27], where users share compositions, add comment threads and post modified versions of any score, a practice that has fostered a communal culture of updating and improving user content.

By storing score data as parameter strings to be rendered through a web-based display, the original Ocarina notation ecosystem was designed to be lightweight and flexible, encoding integer parameters representing fingering tablature images into a valid URL [28]. When links were processed by the web server, each fingering image was displayed by a client's browser, as well as song meta-data including title, root-pitch and mode. The score could then be read and performed by users with little or no formal musical training. The more recently updated Ocarina Songbook visually re-creates the same fingering tablature images but extracts its data from a database.

Figure 2 shows a rendered Ocarina tablature score of a 16-note Ionian scale as "open" or "closed" finger-hole images, followed by three non-specific duration markers and a space marker, representing extended note durations and rests. Within the instrument and on the composer page itself, each of the seven traditional "church" modes (Ionian, Dorian, Phrygian, Lydian, Mixolydian, Aeolian and Locrian) are made available, as well as a customized "Zeldarian" mode, designed to play a specific melody from the Legend of Zelda video game [29] (Fig. 3).

Usage statistics tracked by Google Analytics show that the Ocarina Composer, the updated Ocarina Songbook and the archive of user-generated score content posted on the smule.com forums have been popular and continue to be so more than 2 years after the instrument's introduction. The Ocarina song forums alone currently garner approximately 55% of all the site's page views [30].



**Fig. 7. Magic Piano spiral keyboard and Globe. (© Smule, Inc.)**
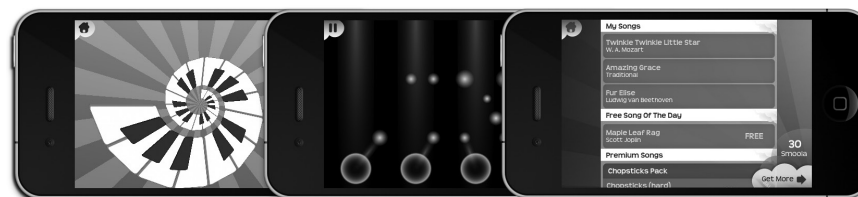


**Fig. 8. Magic Piano for iPhone: spiral keyboard, performance score and Songbook. (© Smule, Inc.)**

## LEAF TROMBONE: WORLD STAGE

In April 2009, we released Leaf Trombone: World Stage (Fig. 4), a monophonic breath-controlled mobile trombone-style instrument featuring a "music-box" accompaniment, on-line real-time judging and a feature-rich on-line composition tool built using the Java-based Google Web Toolkit (GWT) [31]. Like Ocarina, Leaf Trombone was designed as an abstraction of a traditional instrument utilizing breath control for note onset and amplitude enveloping and a single continuous touch input to function as the trombone's "slide" pitch-control. Leaf Trombone tracks continuous pitch data, allowing for smooth glissandi and semi-tones that lie in between diatonic scale pitches. Visual détentes or position-markers displayed along the length of the touch path measure discrete steps in a diatonic major scale. The instrument's range presents 1 octave on the screen, with buttons capable of shifting the instrument's pitch range up or down an octave.

To integrate access to musical scores within the application itself, we designed Leaf Trombone with the ability to download and present community-created score content onscreen. Using a visual note streaming paradigm in which colored leaf-shaped markers move across the screen of the app, each note of a melody is presented as a position along the touch path. Dynamic and phrasing choices are left to the performer's discre-

tion, simplifying the visual scoring display. A rotating music-box displays note "tines" being plucked as a monophonic accompaniment track, stored in the same score as the melodic information, is rendered.

## LEAF TROMBONE COMPOSER

For Leaf Trombone we felt a more robust composition system was needed that could support composition for two simultaneous tracks. As composed songs were designed to be downloaded and presented to users on the instrument itself, the score format used for Leaf Trombone did not need to be human-readable.

Figure 5 shows the introduction of the traditional song "Oh Shenandoah," scored for Leaf Trombone and monophonic accompaniment. Note durations are depicted by the width of each note object, from double whole-note to 16th-note duration, scaled to fit within the width of measure lines. Note and rest objects are entered into the score by first selecting a note duration, dynamic marking and optional single, double or triple dot, then by clicking on the desired pitch in the three-octave keyboard; notes for the accompaniment can be chosen from a five-octave range. The colors for each note object represent specific octaves to which a given note belongs. In this manner, the display of the score staff remains a constant height and the potentially confusing use of additional ledger lines is avoided.

When a score is composed and saved

it is published to the Smule servers, sharing that score with every Leaf Trombone device as well as posting that score to the Leaf Trombone on-line forums for discussion. Modifications can be made by any user, although derivative works created from one user's score are tracked in the database as such.

Leaf Trombone composer scores are saved using JSON (JavaScript Object Notation) [32], a lightweight data-interchange format that encapsulates notation and song-level meta-data into a human-readable packet. JSON score-data is analyzed with a C/Objective-C parser and used to drive both the OpenGL ES rendered streaming note sequences and the ChiP (ChucK on iPhone)–generated music-box accompaniment.

Figure 6 shows the introduction to "Oh Shenandoah" in JSON format. Each note is described by four parameters: "d" (duration), "fto" (fractional time-offset, or time since the end of the previous note), "po" (pitch offset from root) and "i" (intensity). Leaf Trombone timing information is described relative to whole notes. Thus, "d = 0.25" would be a quarter note and the elapsed clock time for each note is calculated from "d" combined with the "bpm" (beats per minutes) header parameter.

## IN CONCERT: *DICHOTOMOUS HARMONIES* (2010)

In September 2010, we extracted Leaf Trombone performance data from Smule's database and put it on display

**Fig. 9. Magic Fiddle for iPad, played by members of the St. Lawrence Quartet. (© Smule, Inc.)**

in the multimedia composition *Dichotomous Harmonies* [33], featuring 1,000 synthesized trombones, live networked trombone and real-time iPad controller. Premiered at the 2010 MiTo Settembre Musica Festival in Milan, Italy, *Dichotomous Harmonies* spatialized 1,000 Leaf Trombone performances of the Leonard Cohen song "Hallelujah" across an eight-channel soundscape. A visualization of each Leaf Trombone performance in the data set was projected in the concert hall, displaying performance-specific meta-data: date and time of performance, location and performer name. To compose the piece, JSON representations of each performance were extracted from Smule's databases and rendered into monophonic .wav files with ChucK. These audio files were used in the composition of the soundscape as well as source material transformed and processed in real time by a ChucK script controlled by a custom iPad control application. *Dichotomous Harmonies* thus stands as a musical representation of numerous facets of the Leaf Trombone community, including a user-generated score composed on the Leaf Trombone composer and performances by 1,000 Leaf Trombonists uploaded to the cloud.

**Fig. 10. Glee Karaoke for iPhone. (© Smule, Inc.)**



Karaoke-Style Song Lyrics

Vocal Pitch Marker

Pitch Accuracy "Starbursts"

Harmony and Melody guidelines

## MAGIC PIANO

The introduction of the Apple iPad in April 2010 brought an enhanced touch and visual experience for users, enabling the tracking of 11 multi-touch inputs on a larger display than previously offered on existing iOS devices. Taking advantage of the new form factor and feature set, we created Magic Piano (Fig. 7), a whimsical take on a virtual piano, allowing users to play circular, spiral or invisible keyboards, shifting octave ranges and relative position along the pitch access using pinch and swipe gestures. The greater physical size of the iPad itself supports the device-as-abstraction metaphor for a virtual piano, as the ability to control piano keyboards with two hands is an idiomatic feature of piano performance practice.

Magic Piano features a Songbook mode, within which users control score-driven piano performances by following a stream of descending note objects and tapping the touchscreen to play the next highlighted note or chord. In a manner similar to a player-piano note roll format, pitches in the diatonic scale are arranged from lower pitches on the left side of the screen to higher pitches on the right. Screen taps struck to the left or right of each note position are synthesized an audible number of cents respectively flat or sharp, a feature that can be disabled, leaving users free to strike the screen at any location, simply controlling score playback with timing and Y-axis–mapped dynamics.

At the heart of Magic Piano's Songbook mode is a MIDI-based scoring system that drives both the visual rendering of note objects as well as the SoundFont-based Piano note emulation, using the RtMidi API for parsing MIDI files [34].
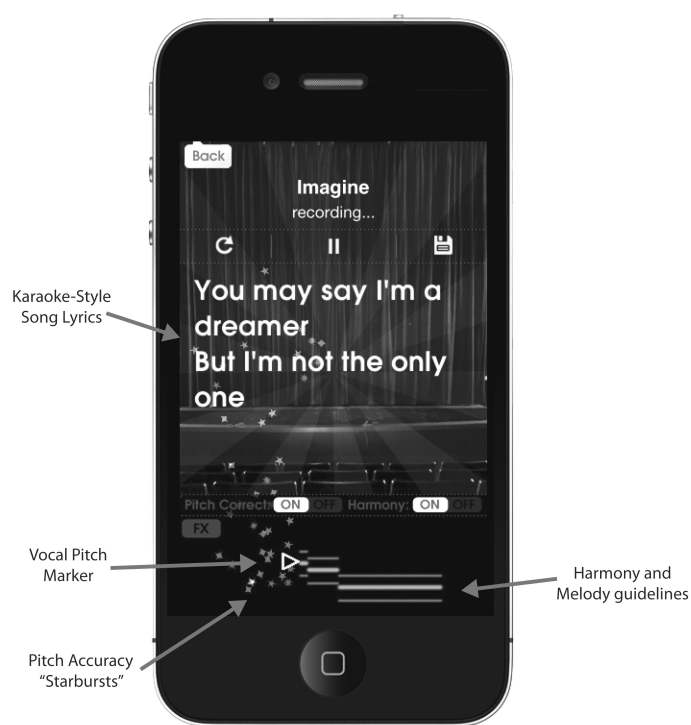
Only a subset of MIDI data is used for note display and rendering, as dynamic levels, note-onset timing and note durations are all generated dynamically by a user's interaction with the touch interface. In this manner the striking of actual keyboard notes has been abstracted away, while the user still can expressively perform a given musical score by controlling timing and dynamic level.

Scores prepared for the Songbook in Sibelius [35] or Finale [36] are exported as Type 1 MIDI files and dynamically downloaded to devices from our servers. Scores are manipulated to optimize presentation on the iPad's display; limiting scores to five registers ensures every note in a score will display. A JSON file specifies parameters including the speed with which descending notes appear, sustain, single-versus-chord pitch groupings and a global volume.

In May 2011, we reintroduced the Magic Piano with a smaller form factor for the iPhone and iPod Touch and a greatly expanded songbook featuring purchasable piano arrangements of classical and popular works alike. Released as a free application, the iPhone Magic Piano (Fig. 8) recorded over 1 million users in its first week in the App Store. In the first month of release alone, over 15 million performances had been created and uploaded to the cloud.

## Magic Fiddle

Magic Fiddle, launched in November 2010, is a virtual violin built upon both the scoring methodologies introduced in Leaf Trombone and the MIDI-based notation formats used in Magic Piano but significantly expanding on both instruments, with an interface and notation format allowing for polyphonic playability and use of articulation figures. Magic Fiddle is a three-stringed virtual violin, coupled to a bowing circle that acts as a note trigger as well as a control for bowing dynamics (Fig. 9). Multiple notes can be played simultaneously, with a rapid multi-touch response allowing for idiomatic performance techniques including smooth glissandi, pizzicato (via a plucking touch-point), trills and vibrato. Control data representing notes along the continuous string lengths as well as bowing data are used as input to a commuted synthesis algorithm [37], within which a bank of fiddle body impulse response samples are triggered at a desired frequency.

Magic Fiddle presents score information to users in two manners: in a Songbook equipped with polyphonic piano accompaniment and a Storybook of interactive tutorials that lead users through exercises in performance practice (posture, hand positioning, bowing) and musical articulations (glissandi, vibrato and arpeggios).

Scores for Magic Fiddle exist as multi-part (piano and violin) Type 1 MIDI files. We repurposed lesser-used MIDI General Purpose Controller messages to represent specific violin articulations (pizzicato, vibrato, glissandi and trill note-pairs), as tools such as Finale and Sibelius support the representation of control change MIDI data using customized text dictionaries or manual insertion techniques. To associate a given control message with a given MIDI note event, control messages are inserted between NOTE ON and NOTE OFF MIDI messages (see Table 1).

## Sing and the World Sings with You: Glee Karaoke

Released in April 2010 in partnership with Fox Media, Glee Karaoke for iPhone, iPad and iPod Touch combines audio recordings of pop songs from Fox's musical television show "Glee" [38] with real-time pitch correction algorithms and a harmony engine that generates layered harmony vocals in real time from a user's own voice. Visually, the pitch of a user's singing voice is tracked as a floating marker over target pitch and harmonies lines with star-shaped dynamic visual feedback as users sing the correct pitches (see Fig. 10). Users are able to broadcast recordings of their songs over the network as well as to add their voices to recordings made by other singers. In an A Capella mode, automatic four-part harmonies are generated from a user's voice without accompaniment.

The preparation of audio and semantic content for Glee Karaoke requires the remixing of instrumental and vocal audio tracks from a song's studio recording, the composing and encoding of harmony vocal lines, and the tracking of song lyrics for karaoke-style display (Table 2). Each Glee Karaoke song track is built as a Logic [39] session combining multi-track audio tracks and individual MIDI tracks for the scoring of lead and harmony vo-

**Table 1. MIDI Controller Change messages and their re-mappings for Magic Fiddle.**

| CONTROLLER NAME | Ctrl # | ARTICULATION | VALUE |
|---|---|---|---|
| GENERAL_PURPOSE_CONTROLLER_5 | (0x50) | VIBRATO (Single Note) | (0x01) |
| | | PIZZICATO (Single Note) | (0x02) |
| | | PIZZICATO (Mode Switch) | (0x03) |
| | | ARCO (Mode Switch) | (0x04) |
| | | VIBRATO (Mode Switch ON) | (0x05) |
| | | VIBRATO (Mode Switch OFF) | (0x06) |
| GENERAL_PURPOSE_CONTROLLER_7 | (0x52) | GLISSANDO (Target Note Pitch) | [MIDI PITCH] |
| GENERAL_PURPOSE_CONTROLLER_8 | (0x53) | TRILL (Target Note Pitch) | [MIDI PITCH] |

**Table 2. JSON data representing (a) global track data, (b) melody pitch events and (c) song lyrics for the Glee Karaoke track "Bad Romance."**

| (a) | (b) | (c) |
|---|---|---|
| { "visuals": [], "header": { "scale": "minor", "max_harmony_voices": 3, "key": "a", "pitch_correction": true, "version": 1, "delay_max": 5.0}, "tunings": [ "duration": 0, "time": 0.0, "scale": "minor", "detune": 0.0, "key": "a", "pitch_correction": true, "chord": "A min7", "track_volume": 1.0, "swap_harmony": true | "noteEvents": [ { "duration": 0.499999325, "voiceNum": 0, "time": 0.0, "midiNote": 57, "isOn": true, "isRelative": false }, { "duration": 0.0, "voiceNum": 0, "time": 0.499999325, "midiNote": 57, "isOn": false, "isRelative": false | "lyrics": { "duration": 7.878140625, "time": 0.0, "rap": false, "lyrics": "Rah rah, ah-ah-ah\nRo-ma, ro-ma-mah\nGaga, ooh-la-lah\nWant your bad romance\n"}, {"duration": 0.37815075, "time": 0.063025125, "length": 4, "start": 0} |
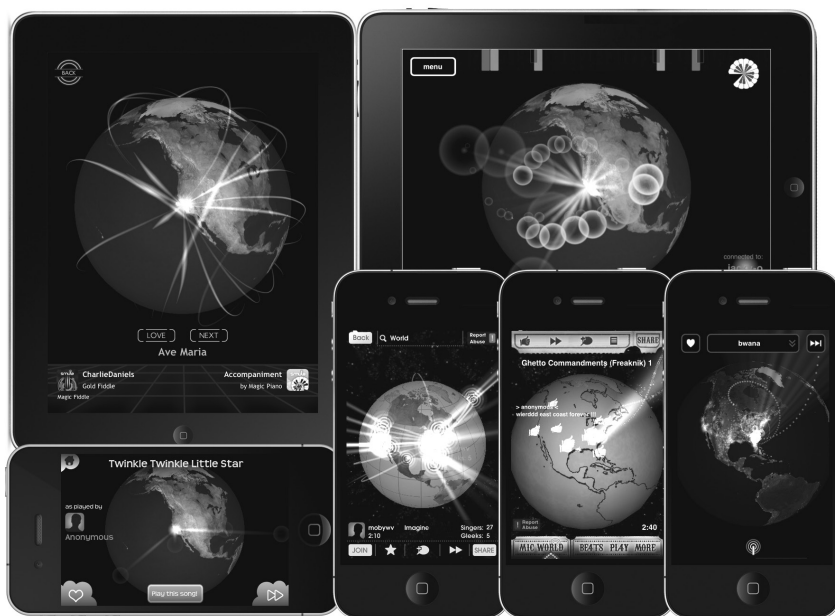
**Fig. 11. Clockwise from top left: iPad and iPhone Globes for Magic Fiddle, Magic Piano HD, Ocarina, I Am T-Pain, Glee Karaoke and Magic Piano. (© Smule, Inc.)**

cal parts, lyric events, global volume and key-change data and the chord progressions of the song itself (see Table 2).

## GLOBAL CONNECTIONS

At the heart of each of our applications is a network connection to a suite of cloud-based services enabling users to share musical performances with listeners around the world. Recordings of control data (Ocarina, Leaf Trombone, Magic Piano and Magic Fiddle) and audio (Glee Karaoke) are tagged with GPS data and uploaded. Within each application and on smule.com, users can view and listen to performances on a rendered Globe or World Listener interface (Fig. 11), displaying user locations as beams of light. Links to recordings are shareable on social-networking sites such as Facebook and Twitter or can be e-mailed from the iOS Mail application.

While the same basic sharing paradigm holds true across the entire family of applications, there exist variations in networking and sharing capabilities that deserve mention. In Ocarina, users can manually record and upload their performances or simply allow the application to record snippets as they play, streaming impromptu highlights to the globe. In Leaf Trombone, a real-time judging session presents performances made on the "World Stage" to a panel of user "judges," able to type text commentary and award a score for the performance. Magic Piano takes the idea of real-time networked interaction one step further, connecting "duet" performers in real-time, stream-

ing bi-directional control data rendered into audio on both devices. In Glee Karaoke, the community that has developed around the application's out-of-real-time ensemble performance and the social connections formed through shared recordings connects on Facebook and in the real world, with users meeting and singing together in real life.

## SOCIAL PERFORMANCE: "LEAN ON ME" FOR JAPAN

On 11 March 2011, Japan was devastated by a massive earthquake and subsequent tsunami. Two days later "Mayo57" posted her Glee Karaoke performance of Ben E. King's "Lean on Me" to the Smule Facebook page, with a request for singers to join her:

> Hi everyone, it's from Japan. In Japan, there are still earthquakes and people are really scared. So, I'm trying to cheer them up by the song "Lean on me." Please join, sing and pray for Japan. If you'd like to join, comment here or on my songs, I'll send you request. Thanks!!

More than 3,600 users of the application responded, creating a group song viewable within the application or on the web at <glee.smule.com/song/group/369888>. The rendering of so many vocal tracks required special modifications to the server rendering engine.

## FUTURE DIRECTIONS

Addressing the future of musical performance experiences, Tanaka stresses the importance of interactivity and the role

of the web itself as a creative medium: "Leveraging the human potential of network interaction to create new musical experiences would be the ultimate" [40]. The role of listeners in the already-unfurling future of music already has blurred the lines between composer, listener and performer to an extent that ecosystems such as Smule's are not only possible but rapidly expanding.

## OPEN ARCHITECTURE AND PLATFORM

Our servers maintain a growing body of user-generated musical data. We are working to document and publish application programming interfaces (APIs) to these servers, allowing researchers as well as third-party developers open access to this content. This significant corpus of actual user content will, we hope, facilitate research in such areas as Music Information Retrieval. Moreover, we anticipate that third-party developers will benefit from not having to spend capital and time building such infrastructures for their own inventions, thereby enabling their products more readily to explore the social potential of mobile music.

## COMMUNITY DEVELOPMENT

We believe social interactions within online communities that have embraced sharing technologies and methodologies can now drive entire commercial and artistic ecosystems. Our app users act as agents of social communication, creating and promulgating content across the world. In a 2-year span, this community has created more than 9,500 scores in various tablature and notation formats, in genres ranging from traditional folk songs such as "Auld Lang Syne" to non-conventional songs such as one user's interpretation of the H1N1 virus. Using our I Am T-Pain app, a pitch-correcting musical karaoke app, users have created and shared over 6,500 music videos over e-mail and YouTube, captured and recorded directly from their iPhone cameras and microphones. Ocarina users have listened to one another play over 40 million times. Clearly the attention to and generation of user-generated content within the mobile-phone app network is a huge motivational force behind the social interactions of the user base.

## TOWARD A VISION OF "UBIQUITOUS MUSIC"

Computing pioneer and father of ubiquitous computing Mark Weiser, in his

landmark paper "Computers in the 21st Century," described a world where computing evolves from the "personal" to the "pervasive," where technology "disappears into the fabric of everyday life" [41]. Computing technology, Weiser envisioned, will evolve to "calm technology" that recedes into the background of our daily world, empowering people without being noticed. In keeping with Weiser's predictions, the mobile devices that more and more feel like (un)natural extensions of ourselves are shrinking not only in size but in our awareness of them as technology. They increasingly transport us into a world where we do not have to immerse ourselves in computers, but instead take computing into our physical world and nearly every part of our daily life. And if this fabric of "invisible" technology becomes increasingly connected, available, infused and invisible, what new potential does it hold for music and music-making?

## References and Notes

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