

# Open Band: A Platform for Collective Sound Dialogues

**Ariane Stolfi\***  
University of São Paulo  
São Paulo, Brazil  
arianestolfi@gmail.com

**Fábio Goródscy†**  
Instituto de Matemática e Estatística  
University of São Paulo  
São Paulo, Brazil  
fabio@ime.usp.br

**Mathieu Barthet**  
Centre for Digital Music  
Queen Mary University of London  
London, UK  
m.barthet@qmul.ac.uk

**Antonio Deusany de Carvalho Junior**  
Instituto de Matemática e Estatística  
University of São Paulo  
São Paulo, Brazil  
dj@ime.usp.br

## ABSTRACT

Open Band is a web-based platform for collective “sound dialogues” designed to provide audiences with empowering experiences through music. The system draws on interactive participatory art and networked music performance by engaging participants in a sonic web “agora” in collocated and/or remote gatherings, regardless of musical level. In this paper, we present our artistic intent grounded in Eco’s concept of Open Works and the initial design of a web-based open environment that supports social musical interactions. Interaction operates by means of a multi-user live chat system that renders textual messages into sounds. Feedback gathered across several public participatory performances was overall positive and we identified further design challenges around personalization, crowd dynamic and rhythmic aspects.

## CCS CONCEPTS

• **Human-centered computing** → *Mobile devices*; Interaction design theory, concepts and paradigms; • **Applied**

\*Also composer of the pieces.

†Main programmer of the software.

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than the author(s) must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from [permissions@acm.org](mailto:permissions@acm.org).  
AM ’17, August 23–26, 2017, London, United Kingdom

© 2017 Copyright held by the owner/author(s). Publication rights licensed to Association for Computing Machinery.

ACM ISBN 978-1-4503-5373-1/17/08...\$15.00

<https://doi.org/10.1145/3123514.3123526>

**computing** → **Performing arts**; **Media arts**; **Sound and music computing**; Language translation;

## KEYWORDS

audience participation, interactive music, web audio, performance, participatory experiences

## ACM Reference Format:

Ariane Stolfi, Mathieu Barthet, Fábio Goródscy, and Antonio Deusany de Carvalho Junior. 2017. Open Band: A Platform for Collective Sound Dialogues. In *Proceedings of AM ’17, London, United Kingdom, August 23–26, 2017*, 8 pages.

<https://doi.org/10.1145/3123514.3123526>

## 1 INTRODUCTION

Amongst the factors that can keep people away from playing music, are to be noted the poor access to musical instruments due to cost and the time and complexity required to learn an instrument. A growing number of works point to web audio technologies as a basis for developing more accessible interfaces for sonic or musical expression [24], since they are ubiquitous on modern computers and mobile devices and easy to distribute [17]. Furthermore, such technologies can be used to design interactive systems, independent of any extra software installation [30].

This work is part of a larger project that aims to use interactive web audio technologies to build an “open” artistic work following some of the principles advanced by Umberto Eco [7], an art work in motion, that can be shaped by each audience participant who interacts with it. We apply these principles to design a web-based multi-user musical instrument for experimental collective music improvisations. The system facilitates participatory performances which are opened to any willing person regardless of musical level or background, yet requiring devices with access to a web browser and internal loudspeakers (such as smartphones,

tablets or laptops). Musical interaction is operated through the production of text messages, a technique users of modern communication devices are usually familiar with.

The remainder of this paper is organized as follows. In Section 2, we present related works on digital participatory art and networked music performance. Section 3 describes the design of our initial prototype from the artistic intent to the technological requirements. The web-based client/server architecture of the system is detailed in Section 4. In Section 5, we describe a use case and associated performances making use of pre-established sample packs. We provide our conclusions and outline the future work we envision in Section 6.

## 2 RELATED WORKS

### Participatory Art and Eco's Open Works

This work inscribes itself within participatory art and Eco's vision of Open Works which we introduce in this section. Western performing arts (music, dance, theatre, etc.) practices have traditionally restricted creative interventions from audiences. Contemporary Western performances are predominantly presentational, with performers preparing and providing music for another group, the audience [26].

In contrast to presentational performances, which intrinsically create a divide between audience and performers, participatory performances [14] seek to blur the boundaries between audiences and performers by giving equal role to participants, building up on the notion of "communitas" (unstructured communities in which all members are equal allowing them to share a common experience). Such aspiration from participatory art corroborates Eco's conceptions of "open works", which, according to Robey in [5], require of the public *"a much greater degree of collaboration and personal involvement than was ever required by the traditional art of the past"*.

In Open Works, it is *"the artist's decision to leave the arrangement of some of their constituents either to the public or to chance, thus giving them not a single definitive order but a multiplicity of possible orders"*. These motivations interestingly resonate with the contemporary perception of audience's role changing from primarily passive to one "co-creating values" [23], with audiences who increasingly want to "shape" their own experiences. Another important rationale of participatory art is to improve audience cognitive engagement in performance through an active form spectatorship involving a physical engagement in the performance [14].

### Participatory Music Performance Using Web Technologies

Human-computer interaction (HCI) and communication technologies provide great potential to facilitate participatory art

forms in our digital age as they can be used to mediate and transform creative information remotely, in (quasi) real-time and scalable ways. Within the field of digital participatory art, several authors investigated how to create participatory music performances using web technologies (see [29] for a review of some of them). Web applications for participatory performances have been proposed e.g. in [3, 8, 16, 28, 31], each of these studies manifesting specific artistic and audience creative agency models.

The massMobile framework [28] was used to let audiences control stage lighting effects or create musical loops from instructions provided through a graphical user interface (GUI) on their smartphones. Mood Conductor [8] also relies on the use of smartphones to enable audience members to conduct performers in terms of emotional directions. In Open Symphony [29, 31], audience members can generate live graphic scores interpreted by performers by voting for music playing modes on their smartphones. In this work and others, such as A.bel [3] and the CoSiMa framework [16], smartphones are employed both as a sound control and diffusion interface leveraging the loudspeakers embedded in the devices.

## 3 DESIGN OF THE OPEN BAND SYSTEM

### Artistic Intent

*A Web "Agora"*. This project grew out from the discernment of an implicit contradiction with contemporary social media. Although social media provide ways for people to be highly connected, they may also induce a form of isolation, inciting to be frequently absorbed in one's own individual device. In this work, we are attempting to build a collective experience that could break that isolation and put every members of an audience in a web "agora".

*Eco's Framework*. We are framing our work within Eco's conception of "open work" [6]. Being "in movement", open works can be changed by every participant, providing freedom to the performer to change it or to the audience to interpret. In Open Band, we are inviting the audience to join as performers, since everything typed in gets converted into sounds that are played back to everyone. Eco's vision of open work includes systems with a certain degree of indeterminacy, ambiguity and even deliberate "dis-ordering". Such principles occur in Open Band, especially when a large number of users interact. The project involves an anonymous multi-user chat, where everyone can be free to express themselves without risk of being pointed at or judged.

*Mapping Language to Sounds*. As pointed by Koelsch [15], music is a social activity that puts people into contact with one another, and that can lead to "increased social cohesion of a group" and promote cooperation between individuals. As the author says, making music collectively generally involves

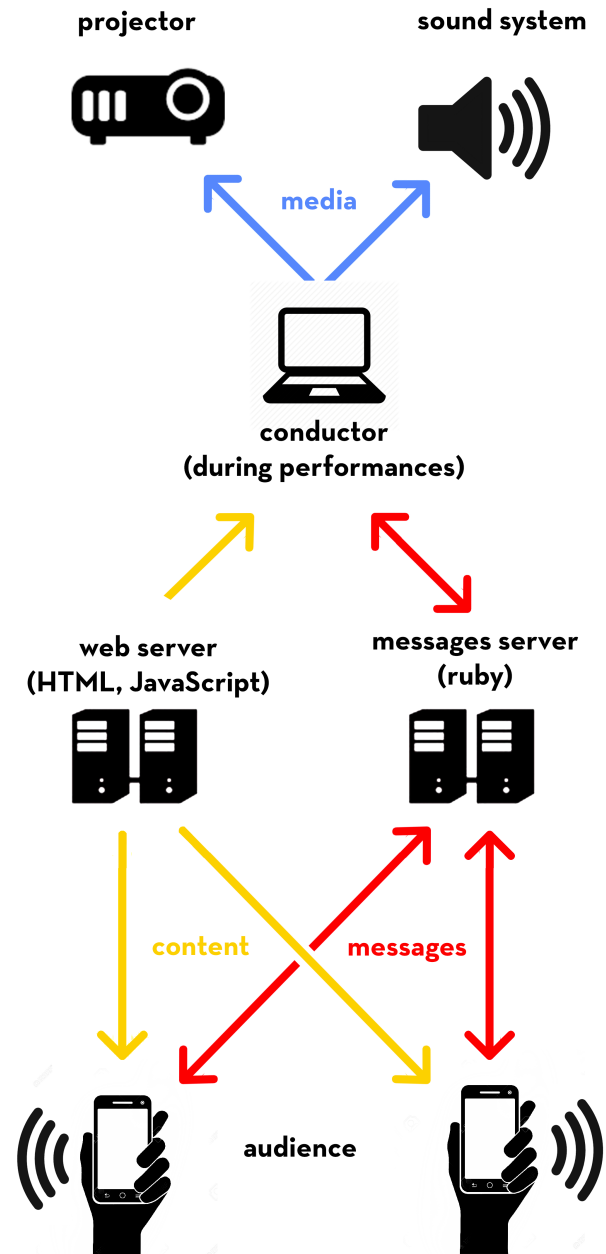
a high degree of coordination of actions, e.g. to synchronize to musical beats. In this project, we are proposing a system where participants don't need to have previous musical skills. The act of writing, seen as a "technology" in McLuhan and McLuhan [19], can be used as a way to crystallize verbal sounds into the visual space. Unlike speech recognition systems that convert speech into text, we are atomizing texts to trigger sounds one after the other, to generate music. Taken as separated letters, words are played as musical phrases, which thus give non musicians access to simple musical experiences. When participants start to talk one after the other using the chat, messages get superimposed. The rhythm becomes mores frenetic and it becomes more difficult to recognize how specific messages are sounding, like when several people talk at the same time.

*Participatory Music Performance.* Being hosted in a web chat, the system can be easily accessible to anyone having access to a device with a web browser (e.g. computer, laptop, tablet or smartphone) compatible with web audio technologies, and an Internet connection. Once in the chat, everything that is typed in can be heard by anyone connected to the same message server. For participatory performance, we deploy a version of the server on a local host, to create a closed network of people and to lower the bandwidth requirements for the audience and reduce delay time in playing the messages. We usually connect one of the devices to a PA sound system to increase the volume and thus the musical perception. A performance can have a conductor who uses special commands to change the samples and to change the overall dynamics of the piece. The conductor can also completely turn off the sound which may be used at times. There is no hierarchy amongst audience participants, and everything which is typed in is played with no distinction.

In another use case, the system can act as an instrument, in solo performances or within free improvisation contexts, for musicians who know the samples and the commands to change sounds. Currently, the system is closed with some musical choices previously defined by composers, that we will discuss in Section 5, but the samples are easily changeable by replacing files in folders on the server side.

### Technological Design

To ease audience participation, the project is presented as a website, with no login and with open access. During performances, a person also acting as conductor typically runs the site on a local host, and provides a private WiFi network for the audience. The website can be projected on a screen using a projector to provide visual feedback and a PA can be used to provide aural feedback, which also allows to share the performance to those not joining the chat.



**Figure 1: Overview of the Open Band system.** The audience interacts with the system through a website. During performances, a participant can act as conductor to change dynamics and sound packs. The website can be projected on a screen and sounds diffused using a PA.

Since text messages are probably the main form of communication on smartphones nowadays, we chose to experiment with this type of communication as input to produce interactive music. Many kinds of interfaces use typing as input,

such as those used in live coding [4], in audience participation pieces to receive feedback from the audience [21], to get user data as source for algorithmic compositions, or using keyboard as music controllers [9].

We addressed these requirements by developing a client/server web-based architecture which is described in the next section. The project was developed following an Agile methodology called Lean Ux [18], that consists in having always a working version of the project since its start, and to perform gradual changes for each performance as we receive feedback of the audience and the composer.

#### 4 OPEN BAND SYSTEM WEB ARCHITECTURE

The project was built having two server-side components that are independent: one of them is a typical web server that serves web content such as HTML, JavaScript and audio files and is based on the Web Audio API [27]; the other server component is responsible for making messages deliverable (see Figure 1). This is a desirable feature, just as it makes possible to change the messaging technology at any moment, as well as allows different front-ends to receive or send messages.

##### Front-end

The front end was designed to be as minimalist as possible, with only a text input for the messages. The idea was to use minimal design elements to avoid distraction from the main content of the messages sent and the sounds generated from them in real time. There is no register nor login windows, and the site is totally open for every user.

*Interface and Interaction.* The interaction process happens through an open chat interface, where there is no distinction between users. Hence it is not possible to identify who is playing what. Each message sent to the chat is loaded into a chat room and played as a sequence of samples with no hierarchy. In an inter-semiotic translation [22] between text and sound, we decode the text messages as musical information, through concatenation of samples. Messages can be played again by touching or clicking them on screen. Unlike speech synthesis mechanisms, our sound chat does not concatenate syllables, so words cannot be understood as words, but only as sound rhythmic sequences. Besides the sounds generated from the textual inputs of participants, there are also commands that can be live coded. Those commands are hidden from the public to create some degree of surprise when used by a participant acting as conductor. Participant-conductors can change the audio samples pack, change the global volume or turn the sound off.

*Open Source Project.* A second project is maintained [12] as an alternative for people who would like to reuse the project

without having to amend the server component. It is possible to change the audio files and play one's own performances.

The current implementation treat all provided sounds as samples, and each ASCII character is associated to a sample (mp3 audio files used by the system are named after the given ASCII number they relate to). When a user enters the chat, the audio samples are loaded into a buffer, and they are played when messages are sent. In the version used in performances so far, samples are played one after another, as indicated by the sequence of the letters on the messages.

##### Back-end

The current implementation of the messaging server is written in Ruby, making use of the Puma, Sinatra and Faye frameworks, as well as the WebSocket technology for server/browser communication. The code has been developed with the aim of reproducibility on Linux platforms and is released as open source [13]. The messaging technology plays a main role in such application and early versions of the project frameworks like PubNub and Peer.js have been tested. However the Ruby server was eventually kept to enable performances even without any Internet access, what could not be achieved with the other frameworks.

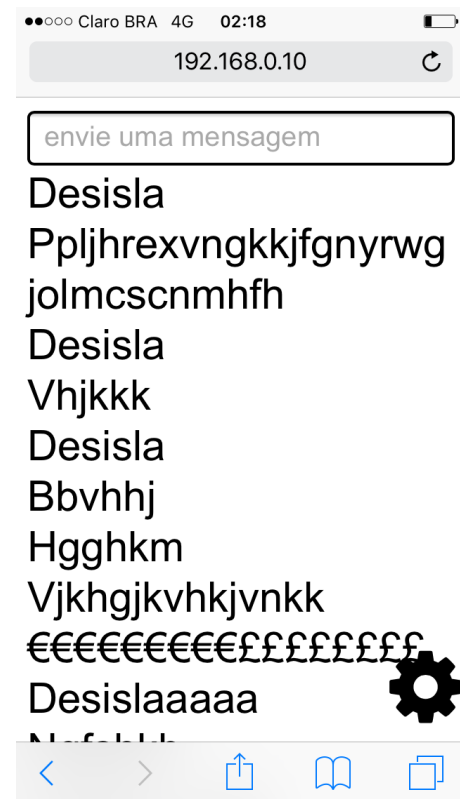


Figure 2: Interface of the Open Band chat on mobile device.

## 5 PARTICIPATORY PERFORMANCE USE CASES

### Sample Design

In the version of the project presented in this paper, all the sounds are played as samples, and each sample pack works as an interactive music composition by itself. As the order and nature of the sounds played by the audience is not known in advance, we cut and produced samples so that they could either be played alone or combined with one another. To this end, we cut the samples based on James Tenney's concept of clang, or aural gestalts, a minimum unity of a sound object, that is similar to Pierre Schaeffer's concept of "cellule" sound-objects, short or redundant objects [20]. Being simple sound units, we believe that such sounds can be more suited to random combinations than complex sounds, with less risk of rhythmic or tonal inconsistencies.

We are also making an analogy with the phonetic alphabet "technology" itself based on the idea of atomization of the spoken language [19]. To leave room for chance, we tried to cover high degree of variation of sound clangs, and made four different compositions of packs of samples, with different sonorities, that can be changed in real time by typing in special commands during the chat (see the description of "samples3/" below). To maintain a certain rhythm, the samples were cut in fixed and multiple formats, in order to enable them to fit within a time grid.

*Galaxies (samples0/)*. The default pack was sought to maintain some phonetic relation with original letters, to introduce public to the system. Most of "lowercase letter sounds" were cut from Haroldo de Campos readings of his long poem *Galáxias* [2]. This was achieved to also pay tribute to concrete poetry defined in Campos et al. [1] as a "tension of thing-words in time space. Dynamic structure: multiplicity of concomitant movements". For special characters, we implemented in this pack symbolic semantic-sound relationships such as the use of a cash machine sound for the dollar sign. We also use other more iconic analogies, such as using subtractive graphic synthesis made by spectral visuals, as illustrated in Figure 3. This sample pack is the default one and is generally used for introductory parts in the performances to make the audience familiar with the sound-to-letter associations on the website and during the performance.

*Percussion and Chords (samples1/)*. The second pack of samples deals more with materials in the realm of pop electronic music, such as elements of traditional electronic samplers, chords and guitar samples. We associated percussion material to consonants, trying to identify sounds that resemble the original phonetic of the letters, such as bass kicks for the "B" and cymbal for the "S". For vowels, we used synthesized sound made from additive samples in a C major scale.

For some special characters, we took samples from Velimir Khlebnikov's *Radio of The Future* [25].

*Collaborative Samples Set (samples2/)*. This sample set was put together by Viktor Kisil, professor of Music Production at Anhembi Morumbi University (São Paulo, Brazil), who asked his students to make some short samples for a performance. This pack results from a collaboration in mapping the samples with the ASCII table. It contains samples from different kinds of sources, concrete and synthetic sounds, and also includes a lot of special sound effects. Relations between sounds and letters are more arbitrary than in the other sample packs.

*Orquestra Errante (samples3/)*. These samples were cut from recordings of free improvisation group Orquestra Errante, conducted by Rogerio Costa at University of São Paulo, mostly produced on traditional acoustic instruments, such as saxophone, flute, clarinet, trombone, guitar, percussion and voice. The instruments were often played with extended performance techniques during rehearsals or in studio. We searched an archive of several past free improvisations of the ensemble, to find sounds evoking letters, or repetitions

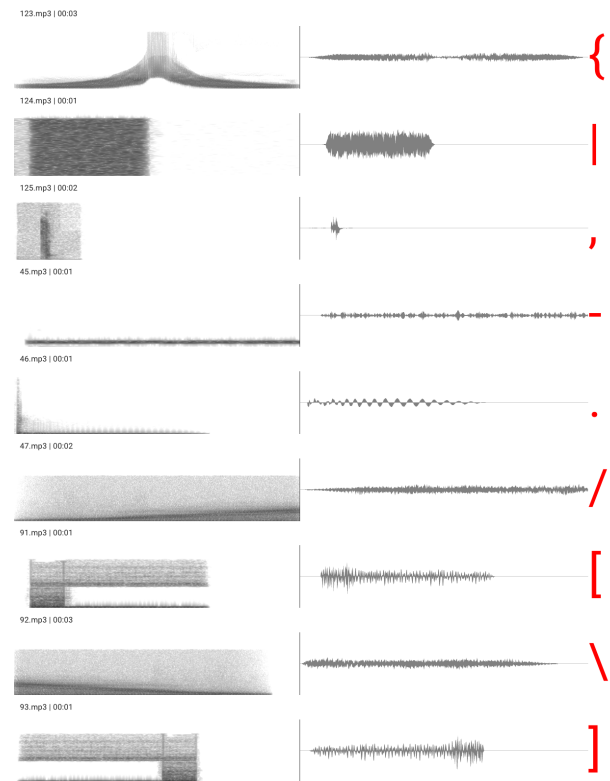


Figure 3: Spectrographs and waveshapes of some of the samples from the first sample pack. These were obtained by subtractive graphic synthesis.



for numbers or that evoked the shape of the characters for some special ones.

### Overall Performance Apparatus

The performances are designed to be made in any space that can fit a laptop and a network hub. All interested participant are invited to join the network with their device and connect to the the application in a web browser. As web browsers are now ubiquitous, the only limitation for connecting to the application is the device being able to join the network through WiFi. A regular laptop should be able to run the application without any issues. The last performances were made on a laptop with AMD A4-5000 processor and 4GB memory. Any devices that can install Ruby gems should be able to host the server. The source code is hosted on Github as open source software and there is a shell script with the application to easily start the server. In most performances held so far, we used a projection of the chat on a screen.

### Performance Procedure

Audiences were first asked to join a specific Wifi network running the server, and then enter an IP address that was provided to them (e.g. in the projection). As users enter the web page, they start to write messages trough the chat. At some point, a participant acting as conductor (one of the facilitators can hold this role) change the samples to cause some degree of surprise. The performances usually last for about 20 minutes and finish when the conductor types the command “stop!”, witch brings the system to silence.

### Settings and Participants

To date, Open Band has been performed at five occasions, namely at the Bigorna Festival, at a public square (see Figure 4), at various concerts and in private spaces. During the first performance at the Bigorna Festival (see Figure 4), the audience included about 70 people, 30 of whom were able to connect to the chat (due to restrictions of our current router we could not support more connections). The audience was formed mostly by students of Music Production that had collaborated on the third sample packs.

During the second performance at the ABRAPEN conference, the audience mostly comprised traditional musicians who were conference attendees. There was about 25 participants in the audience who demonstrated their interest by asking information about the system and about the sounds chosen through the chat. There was more interest by the audience in trying sound combinations together than by just exchanging textual messages anonymously<sup>1</sup>.

<sup>1</sup>A recording of the performance at ABRAPEN is available at: <https://www.youtube.com/watch?v=NOWapLq6eiU>



**Figure 4: People interacting during an Open Band performance at a public square.**

The third performance was held on a web radio. 10 participants actively joined the chat and 20 participants listened to the performance through the radio<sup>2</sup>.

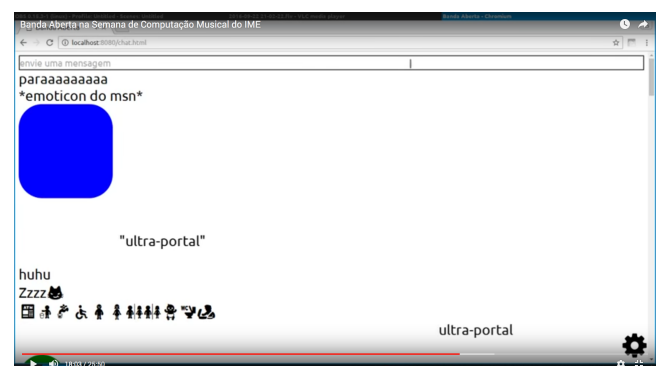
The fourth performance was held at a concert of experimental music in a bar, where there was about 40 participants<sup>3</sup>. The audience was formed by experimental musicians and enthusiasts, who kept experiencing with sound combinations, more than with discourse.

The last performance held to date was conducted as part of a Computer Music Concert at the *Instituto de Matemática e Estatística* (IME), with an audience composed mostly of programmers and computer scientists<sup>4</sup>. During this performance, some of the participants discovered a flaw on our site's security that made possible to send JavaScript and CSS

<sup>2</sup>A recording of the radio session can be heard at: <https://soundcloud.com/asss/banda-aberta-na-radiograve-reset-do-universo>

<sup>3</sup>A video of the screen recording of the performance at the bar is available at: <https://www.youtube.com/watch?v=DpCuU41tWM8>

<sup>4</sup>A video of the screen at IME's performance is available at: <https://www.youtube.com/watch?v=xs23z1IfPfY>



**Figure 5: Screenshot during the performance at IME, with people inserting CSS data on the chat.**

commands through the chat interface, as shown in Figure 5. Participants kept trying to make things move on the screen and change visual aspects of the site, despite the sounds that were been played. This illustrated a surprising example of use of our system with audiences using their creative agency in a collaborative way.

### Qualitative Evaluation

We discuss here several aspects that emerged across the five performances presented in the previous section. The system was used in different ways depending on the profile of the audiences. We could see that in musical contexts, the audiences spend more time experiencing with the samples and rhythm, typing phrases without meaning. However with a younger public, the participants tended more to play by discussing in anonymous ways. As conversations got more intense, layers of sounds overlapped, creating more frenetic rhythms.

Noticeably, in all instances, we received a lot of feedback from the public through the chat, showing interest from the participant who supported the project. The engagement of active participants was generally high, but some users complained that it was difficult at times to identify which sounds corresponded to which message, diminishing their sense of creative agency. Specifically when there were more people that our router could support, like during the Bigorna Festival, there was some frustration from users who could not join the chat.

The anonymity of the chat is also a disputable point, as sometimes the users used the platform to make political discourse and wanted to have their messages associated to them. At the Festival Bigorna where the audience was very young, there was unfortunately some case of homophobic and misogynist discourse employed by the participants. Our current systems does not have a straightforward way to prevent such messages to be sent. However, besides such issues, we believe that the anonymity benefits a high engagement, since people do not get ashamed of saying things and therefore producing sounds through the chat.

After the concert at IME, five people from the audience completed an online survey about the project. No user found it difficult to use the application, two of them felt musically limited by the resources of the system, and everyone felt that they were collaborating in the process during the performance.

## 6 CONCLUSIONS AND FUTURE WORK

We presented in this paper Open Band, a novel system to create participatory music performances by sonifying participants' textual messages in a live chat platform. The free interaction and ease of use has shown to provide a high degree of fun for some participants during five performances

which were held in various settings. The system fosters a sense of play that resembles that of games, but also affords socio-political standpoints as expressed by free speech in a chat system. Messages decoded into music also give the possibility of communicating beyond symbolic written language sharing of phrases purely at the sonic level, without expected literal sense.

To date, Open Band has been developed mainly as a performance project and creative coding experiment, with fixed collections of samples. We seek in the future to expand it to be a framework to be used in different musical contexts. Also it is quite simple for any enthusiast to change the sample packs in the open-source software.

In future work, we wish to use the Audio Commons API<sup>5</sup> and/or the Freesound API [11] that grants access to a collection of more than 300k sound samples released under Creative Commons licenses [10], enabling interesting media re-purposing. We are also interested in developing more complex text-to-audio mappings, to use gestural controls from users, and real-time analysis of the overall dynamics in the text flow produced by the crowd (mapping textual dynamics to musical dynamics).

## ACKNOWLEDGMENTS

We acknowledge support from the NuSom Research group at University of São Paulo and the CAPES grant awarded to Ariane Stolfi. Mathieu Barthet acknowledges support from the EU H2020 Audio Commons grant (688382).

## REFERENCES

- [1] Augusto de Campos, Haroldo de Campos, and Decio Pignatari. 2014. *Teoria Da Poesia Concreta. Textos Criticos E Manifestos 1950-1960* (literatura brasileira edition ed.). Atelie.
- [2] Haroldo de Campos. 2004. *Galáxias: Inclui o CD Isto Não é um Livro de Viagem* (1 edition ed.). Editora 34, São Paulo, SP.
- [3] A. Clément, F. Ribeiro, R. Rodrigues, and R. Penha. 2016. Bridging the gap between performers and the audience using networked smart-phones: the a.bel system. In *Proceedings of International Conference on Live Interfaces*.
- [4] Nick Collins, Alex. McLean, Julian. Rohrerhuber, and Adrian. Ward. 2003. Live coding in laptop performance. *Organised Sound* 8, 03 (2003), 321–330.
- [5] Umberto Eco. 1989. *The Open Work* (Translated by Anna Cancogni With an Introduction by David Robey). Harvard University Press, Cambridge, Massachusetts, USA.
- [6] Umberto Eco. 2006. The Poetics of the Open Work. 1962. *Participation: Documents of Contemporary Art* (2006), 20–40.
- [7] Umberto Eco. 2015. *Obra Aberta*. Perspectiva.
- [8] G. Fazekas, M. Barthet, and Mark B. Sandler. 2013. The Mood Conductor System: Audience and Performer Interaction using Mobile Technology and Emotion Cues. In *Proc. of the Int. Symposium on Computer Music Multidisciplinary Research (CMMR)*. <http://www.cmmr2013.cnrs-mrs.fr/Docs/CMMR2013Proceedings.pdf>

<sup>5</sup><http://www.audiocommons.org>

- [9] Rebecca Fiebrink, Ge Wang, and Perry R. Cook. 2007. Don't Forget the Laptop: Using Native Input Capabilities for Expressive Musical Control. In *Proceedings of the 7th International Conference on New Interfaces for Musical Expression (NIME '07)*. ACM, New York, NY, USA, 164–167. <https://doi.org/10.1145/1279740.1279771>
- [10] Frederic Font, Gerard Roma, and Xavier Serra. 2013. Freesound Technical Demo. In *Proceedings of the 21st ACM International Conference on Multimedia (MM '13)*. ACM, New York, NY, USA, 411–412. <https://doi.org/10.1145/2502081.2502245>
- [11] Freesound. 2014. APIv2 Overview - Freesound API documentation. (2014). <https://www.freesound.org/docs/api/overview.html>
- [12] Fabio Gorodcy. 2016. fabiogoro/banda. (2016). <https://github.com/fabiogoro/banda>
- [13] Fabio Gorodscy. 2016. fabiogoro/bandaserver. (2016). <https://github.com/fabiogoro/bandaserver>
- [14] Susan Kattwinkel. 2003. *Audience participation: Essays on inclusion in performance*. Number 101. Greenwood Publishing Group.
- [15] Stefan Koelsch. 2014. Brain correlates of music-evoked emotions. *Nat Rev Neurosci* 15, 3 (03 2014), 170–180. <http://dx.doi.org/10.1038/nrn3666>
- [16] J.-P. Lambert, S. Robaszkiewicz, and N. Schnell. 2016. Synchronisation for Distributed Audio Rendering over Heterogeneous Devices, in HTML5. In *Proc. of Web Audio Conference (WAC)*. Atlanta, USA.
- [17] Sang Won Lee and Georg Essl. 2015. Web-Based Temporal Typography for Musical Expression and Performance. In *Proceedings of the International Conference on New Interfaces for Musical Expression (NIME 2015)*. The School of Music and the Center for Computation and Technology (CCT), Louisiana State University, Baton Rouge, Louisiana, USA, 65–69. <http://dl.acm.org/citation.cfm?id=2993778.2993798>
- [18] Lassi A. Liikkanen, Harri Kilpiö, Lauri Svan, and Miko Hiltunen. 2014. Lean UX: The Next Generation of User-centered Agile Development?. In *Proceedings of the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational (NordiCHI '14)*. ACM, New York, NY, USA, 1095–1100. <https://doi.org/10.1145/2639189.2670285>
- [19] Eric McLuhan and Marshall McLuhan. 1992. *Laws of Media: The New Science* (edição: 2nd revised ed. ed.). University of Toronto Press, Scholarly Publishing Division, Toronto.
- [20] Michel Chion. 2009. *Guide to Sound Objects: Pierre Schaeffer and Musica Research*. London.
- [21] Female Laptop Orchestra. 2016. In Transglasophone. CMMR. (2016). <http://www.crisap.org/event/in-transglasophone/>
- [22] Julio Plaza. 1987. *Tradução intersemiótica*. Vol. 93. Editora Perspectiva.
- [23] Jennifer Radbourne, Katya Johanson, Hilary Glow, and Tabitha White. 2009. The audience experience: measuring quality in the performing arts. *International Journal of Arts Management* 11, 3 (2009), 16–29. <http://www.jstor.org/stable/41064995>
- [24] Charles Roberts, Graham Wakefield, and Matthew Wright. 2013. The Web Browser As Synthesizer And Interface. In *Proceedings of the International Conference on New Interfaces for Musical Expression*. Graduate School of Culture Technology, KAIST, Daejeon, Republic of Korea, 313–318. [http://nime.org/proceedings/2013/nime2013\\_282.pdf](http://nime.org/proceedings/2013/nime2013_282.pdf)
- [25] UbuWeb Sound. 2017. Sound Experiments in The Russian Avant-Garde (1908-1942). (2017). [http://www.ubu.com/sound/russian\\_avant.html](http://www.ubu.com/sound/russian_avant.html)
- [26] T. Turino. 2008. *Music as Social Life: The Politics Of Participation*. University of Chicago Press.
- [27] W3C. 2014. Web Audio API. (2014). <https://webaudio.github.io/web-audio-api/>
- [28] Nathan Weitzner, Jason Freeman, Stephen Garrett, and Yan-Ling Chen. 2012. massMobile – an Audience Participation Framework. In *Proc. of the International Conference on New Interfaces for Musical Expression*. 92–95.
- [29] Y. Wu, L. Zhang, N. Bryan-Kinns, and M. Barthet. 2017. Open Symphony: Creative Participation for Audiences of Live Music Performances. *IEEE Multimedia Magazine* 48-62 (2017). <http://ieeexplore.ieee.org/document/7849101/>
- [30] Lonce Wyse and Srikumar Subramanian. 2013. The viability of the web browser as a computer music platform. *Computer Music Journal* 37, 4 (2013), 10–23.
- [31] Leshao Zhang, Yongmeng Wu, and Mathieu Barthet. 2016. A Web Application for Audience Participation in Live Music Performance: The Open Symphony Use Case. In *Proc. of International Conference on New Interfaces for Musical Expression (NIME)*.