Bridging the gap between performers and the audience using networked smartphones: the *a.bel* system

Alexandre Resende Clément [1,2], Filipe Ribeiro [1], Rui Rodrigues [1,2], and Rui Penha [1,2]

[1] INESC TEC, Porto, Portugal
[2] FEUP, Porto, Portugal
alexandre.clement@fe.up.pt

Abstract. The *a.bel* project aims to provide artists with a way to easily interact with their audience, making use of their participation to effectively craft unique performances. This paper gives an overview of the *a.bel* system and details the development of a suite of tools (as well as its integration into mobile applications) with which multimedia artists can easily create and distribute interactive content unto mobile devices.

Keywords: music, interaction, interactive art, collaborative system, smartphones, audience participation

Introduction

The use of smartphones has been steadily increasing during the last decade and 2015 marked the year when most Western European countries surpassed 50% smartphone penetration among the total population (Google 2016). These devices combine a growing cluster of sensors, networking technologies and high quality multimedia capabilities. Yet, we still mostly use these devices as personal computing devices, using them to communicate as we did with 2G mobile phones (i.e. voice calls and SMS), to play or work individually (e.g. reading the news, playing single user games, listening to music, editing documents), and to access services through the web (e.g. social networks, internet browsing, video calls). We believe that smartphones can also be used to foster real-time interaction between users sharing the same physical location, and thus we propose a solution to explore the large scale use of smartphones in a music concert setting to bridge the gap between performers and the audience.

Background

Digital orchestras

Even though the use of laptops and mobile phones in networked live musical performance systems is not new, these devices' role has mostly remained as that of an instrument dedicated to performer use. Stanford and Princeton universities, for example, have both implemented networked systems for live performance using laptop computers, which became the staple for most laptop-orchestra implementations (Trueman and Cook 2006; Wang et al. 2009). Each of the laptops is connected to a common network, communicating with a central computer server, and is operated by a performer to execute a given musical piece. Mobile phones also have been used in a similar way, taking the place of laptops in similarly organized mobile phone orchestras (Wang, Essl, and Penttinen 2008; Oh, Herrera, and Bryan 2010). Elements interact with each other to create a performance where the individual composer/performer is responsible for the establishment of the rules, much like a composer would go about creating a musical piece for a conventional orchestra.

Audience participation using portable devices

Golan Levin's 2001 *Dialtones (A Telesymphony)* made use of the audience's cellphone ringtones as an instrument (Levin 2001), namely by uploading ringtones to the cellphones and calling each one at a given time. This approach is closely related to the one we propose, as it makes the audience a part of the performance, even if in a rather passive role. Since 2012 the British band Coldplay has been using a device called Xylobands to "engage audiences and make them part of the show" (Xylobands 2016). A similar technology is used by PixMob to create "interactive, immersive and unforgettable crowd experiences" (PixMob 2016). These are some examples of the growing willingness of popular music acts to adopt novel ways to increase interaction with their audience. In fact, the responsiveness, precision, reliability, and timing requirements of a musical performance provide an interesting and demanding testing environment for both novel interfaces and computer networks in the context of musical interaction.

a.bel

It is nowadays increasingly safe to assume that a significant part of the audience in a concert setting will be carrying a smartphone in their pocket. The *bridging the gap between performers and the audience using networked smartphones* project, henceforth referenced in this document by its working name *a.bel*, aims to provide a solution to the use of networked smartphones to promote interaction in musical concerts, proposing a framework that enables the bidirectional interaction between performers and audience, in a *performer-system-audience* interactive system (Bongers 2000). Some examples of the creative potential of this novel framework are: the distribution of sound emanating from the audience, enabling the creation of large diffuse sound fields, sound paths and musical responses that emerge from the audience; the distribution of video signals amongst the devices, using their screens as a small part of a larger screen; the network control over some musical parameters of each device (e.g. current harmony or timbre), thus facilitating the musical integration of each person's contribution. All of this as part of "a situation [...] where the audience and performer meet, each influencing the other, as if conversing, while maintaining the quality of the performance at a high level." (Bongers 2000, 49). The potential of this system, however, is not limited to music or concert settings: the same framework could also contribute to the development of location-based and time-sensitive networked intelligent systems using smartphones, such as location-based multi-user games.

Since the main objective of this project was to allow multimedia artists, in particular musical composers, to make use of audience members' mobile devices as part of their performance, two main issues were addressed:

- The development of a multi-platform (iOS and Android) mobile application that provides, to the artists and front-end developers, an easy way to develop, test and distribute content built with a standard development environment for interactive media; and to the user, a transparent way to participate in live performance settings.
- The development of a solution to connect hundreds of mobile devices to a network in a concert environment that is reliable, cost-effective, and easy to deploy and operate.

This paper focuses on the first issue and describes the implementation of the *a.bel* app, available for iOS and Android, with the network implementation details going beyond its particular scope.

Proposed Framework

The *a.bel* framework can be separated in 3 distinct operative blocks (as illustrated in figure 1). The main application consists of the performance material, developed by the composer using Pure Data (Puckette 1997), and the networking management application, which uses the implemented network infrastructure to send data to the mobile application. The data is sent from the Main Application to the Mobile Application, where it triggers a specific event or creates and controls an opportunity for user interaction. The return of the audience interaction is thus solely based on their sonic and visual contribution, as the communication from mobile devices to the server is not currently implemented. This intrinsic limitation of the framework proved to be, however, a very interesting challenge for the composers, as they were forced to build self-contained musical/sonic instruments for the audience, even if their behaviour can be altered via the network. This way, each audience member has a local feedback, and thus increased awareness, of his or her contribution.

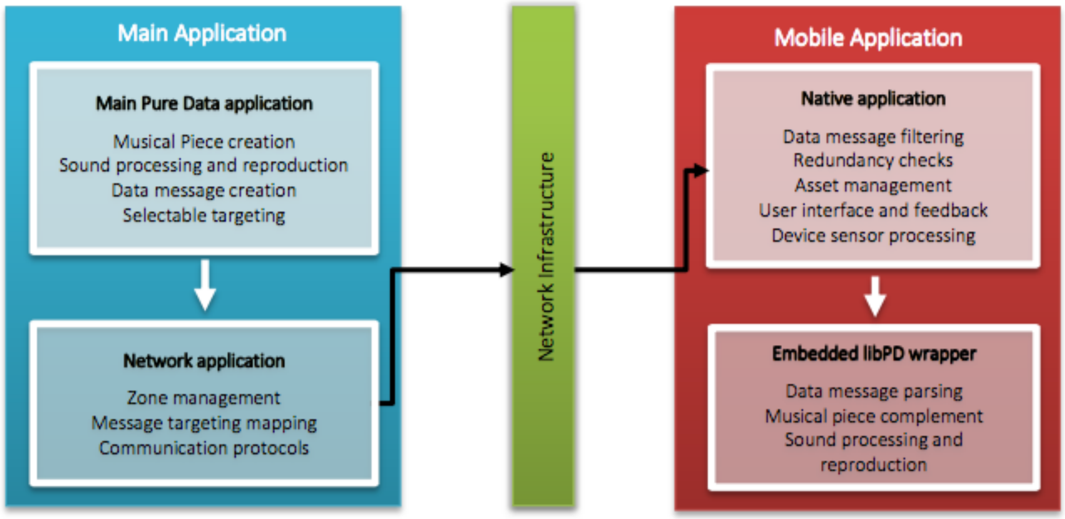

Figure 1. Global system structure

Audience-side assets for the mobile application can also be developed using Pure Data, as the mobile applications carry the libPD wrapper library (Brinkmann et al. 2011), and are distributed using simple QR-code scanning. Schiemer's Pocket Gamelan (Schiemer and Havryliv 2005) implements a tool allowing for musical performance on mobile phones using Pure Data as well, although it makes use of PD2j2me in order to convert Pure Data patches into java code, allowing developed assets to run on the phones. By using libPD, we bypass the need of this conversion, making it so the mobile applications can load and run the PD patches directly. A toolset of external objects was developed, in order to give composers easy access to the system's data communication, to the functionalities of the audience members' devices (sensor data or user interface feedback, such as touching or waving the device), and all other system functionalities. The application was designed to operate seamlessly, with the embedded patches taking care of all audiovisual content associated with the performance, using the information gathered both from composer/performance provided data (through network communication) and from the device's own sensors to promote interactivity.[1] We decided early on that, in order to take the device out of its ordinary role as a personal device destined for individual use, the screen should be completely filled by a single, patch-controllable colour when in performance mode, showing no user interface elements other than an optional text message. This decision proved to be an effective way of transfiguring the very personal device as a musical instrument during the performance, and audience members were often seen waving the devices in the air, sometimes performing *impromptu* group choreographies. These interactions might be achieved by means of OSC controller mobile applications, but these aren't, by themselves, tools for musical expression or collaboration tools, but merely a way of controlling remote systems.

Pure Data library

LibPD is based on Pd-Vanilla (Brinkmann et al. 2011), which means that it only features a limited set of objects that lack functionalities that were critical to achieve our goals. Whilst some of these needs were already covered via third-party objects, the need to have fine control over some of the network settings and an easy to use platform for the development of mobile assets led us to the development of a suite of Pure Data objects. This toolkit is embedded in the mobile *a.bel* app, being also available for development using Mac OsX, Windows and Linux. Table 1 gives an overview of the created toolkit.

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[1] Examples of user control of musical features using the *a.bel* app can be seen at http://vimeo.com/142726571 and http://vimeo.com/142726073.

Category	Description	Function
Data communication	One-way data transmission using Wi-Fi and/or *data over sound*	8-bit value transmission, performance control messages
Device input	Device sensor reading based on user input	Accelerometer, touch, swipe
Device output	Device visual output	Screen colour change, text messages on-screen output
Auxiliary	Process standardization and system-specific functionalities	Scale remapping, data message targeting

Table 1. a.bel toolkit components

Data communication

To cope with the particular features of the network model, a particular communication protocol between main and mobile application was developed. Our first approach was to use a Wi-Fi network, which proved a reliable way of connecting hundreds of devices with low latency but required a considerable network infrastructure to guarantee the system's stability. At the time of this writing, we have developed and are currently testing an additional solution based on ultrasound communication.

When using Wi-Fi, data is sent and received through a series of up to 40 data slots. These data slots correspond to a series of user-definable variables, which are responsible for storing the data values to be sent via network to the mobile devices. The data communication objects accept 8-bit integer values, which are grouped, converted and sent over network in the form of a string block, and read back by the application upon reception. This string is composed of 2 different characters for each data slot value, the first corresponding to the data slot index (for correct parsing and output in the embedded patch) and the second corresponding to that slot's sent value.

When using ultrasound communication, data is sent using amplitude modulation of a given frequency and received by demodulating on the client side. This frequency can be chosen by the composer, but it has to take into account the frequency range of both the emitting loudspeakers and the receiving smartphones. This mode of communication only allows for two 8-bit integer values and is noticeably slower and less reliable than Wi-Fi. It has, however, the potential of enabling the control over a bigger number of devices and of unlocking local communication between devices. It can use the concert venue's existing sound reinforcement infrastructure and can be used for real-time localization of devices, using time difference of arrival techniques, something we plan to implement in the near future.

Input methods

The touchscreen is the most ubiquitous sensor in modern smartphones. It allows for multiple input types, from simple touch-coordinate reading to complex gesture recognition. For the *a.bel* tool set, 2 interaction modes are considered:

1. **touch:** touch/tap event coordinates are made available in a normalised form as screen dimension percentages (e.g. a tap at centre screen corresponds to a 50 / 50 coordinate);

2. **swipe:** 4 different swipe gestures are made available (up, down, left, right) as action triggers (trigger upon gesture detection);

Another very common sensor in smartphones is the accelerometer. The developed object gives the composer access to raw acceleration values, as well as calculated roll and tilt values, overall acceleration magnitude and a device shake action trigger.

Output methods

A colour object provides simple background colour change functionality, allowing for individual manipulation of the Red, Green and Blue components of the colour. A text object allows the artist to pass a text message from the patch to the application, showing it on-screen. These objects can be used together to show, e.g. a splash screen showing relevant information at the onset of each piece.

Auxiliary components

In addition to the main objects, some additional auxiliary objects were created, so as to provide standardization of some processes and system-specific functionalities. These objects are not as relevant as the aforementioned ones and will not be discussed in this paper. The toolkit download[2] includes standard Pure Data help files to demonstrate the functionality of all of the objects.

Testing the system

a.bel - nova música interactiva was the event which served the purpose of both presenting and testing the proposed system. It took place on October 26th, 2015 at Casa da Música's Sala Suggia, the main concert hall at Porto, Portugal. It featured pieces by Carlos Guedes, José Alberto Gomes, Neil Leonard and Rui Penha, using acoustic instruments, electroacoustic devices and the *a.bel* system.[3]

One of the pieces — *cellular*, for soprano saxophone, vibraphone and live electroacoustics, in addition to the audience members' smartphones — was composed by one of the authors (Rui Penha). The piece started with only the audience's smartphones waking up from black screens to different shades of evolving greens while producing various synthesized animal and water sounds, producing a diffuse rainforest soundscape. The fact that each smartphone produced an unique, isolated and easily locatable sound — and, in the case of the water drops, changed colour while doing so — made the contribution of each smartphone very easy to pinpoint. This section helped the audience to be aware of the individual impact of their smartphone to the whole experience and to build a serene starting point to the subsequent shift towards a more frenetic interactive experience.

The second section of the piece introduced user interaction to accompany fast-paced articulations of the saxophone and vibraphone. Audience members could interact with the musicians and with each other by using two musical gestures:

- by waving the smartphone in the air to produce slowly evolving drones[4];
- by tapping the screen to produce short notes from a given harmonic series, which were then automatically repeated with variable delays[5];

The harmony, timing and delay behaviours of these gestures were automatically synchronized with the output from the musicians on stage via the a.bel system.

More than 700 people attended the event and logs show that roughly 70% were able to connect their smartphone to the system and successfully made use of it. The remaining 30% include people that did not carry a smartphone to the concert, users of other operating systems (e.g. Windows Phone or Blackberry), users of incompatible Android versions (below version 4.0), users of incompatible iOS versions (below version 6.0) and a small number of users that could not connect to the system for other reasons, mainly due to incompatible Android ROMs. During the event no disruptions were observed, either in the network data streaming or from the audience engagement.

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[2] To be made freely available in time for the conference.
[3] An integral video of the concert can be seen at http://youtu.be/X_YeO3Qi3H4.
[4] An example of this interaction mode can be seen at https://vimeo.com/142726571.
[5] An example of this interaction mode can be seen at https://vimeo.com/142726073.

Conclusions and future work

We have described the initial development of *a.bel*, a system for the development of interactive performer-system-audience experiences, and we have shown how it can be used to bridge the gap between performers and audiences in musical concerts. The audience response at the systems' première event was very enthusiastic.[6] The system was proven to work as intended and, given the observed results, has shown room for concrete improvement, scalability and further development.

With the emphasis being placed on the ability to reliably connect hundreds of smartphones and trigger behaviours with very low latency, it was early on decided to postpone to a later stage the capability of sending data from the smartphones to the network. The cycle that starts with the information being sent from the stage to the smartphones is, thus, completed solely by an audiovisual return that is partially dependent on the audience's willingness to interact. Whilst we still intend to enable the upload of data from the smartphones to the network in the future, we believe that the exclusively local audiovisual feedback — akin to the one of a traditional musical instrument — is in fact a characteristic that helps end users to be more aware of their own contribution than what would be possible if, e.g., the data generated by their interaction was to be mingled with hundreds of other sources and used to drive an audiovisual feedback coming from stage.

We have only begun to scratch the surface of how this system can be used to enable audience participation in musical concerts. One issue that we need to address is the fact that the audience has no rehearsal time with the musicians before the concert, which can limit the quality of the more complex interactions. A solution that we plan to test is to have the concert divided into two sections: an informal rehearsal of all intended interaction modes followed by the main performance. Another issue is the fact that most concert venues were designed with the audience facing the stage and, consequently, the audience members do not see each other easily. At the *a.bel* concert, this meant that audience members occupying the front rows were somewhat excluded from the collective experience. Inspired by Golan Levin's *Dialtones (A Telesymphony)* (Levin 2001), we displayed the view from the stage over the audience on a big projection above the stage, but this solution encouraged some of the audience members' to find ways to identify themselves on the projection, leading to a momentary detachment from the performance. We aim to explore a disposition of the audience around the musicians, thus with audience members facing each other, akin to the disposition used by Iannis Xenakis in *Terretektorth* (Xenakis 1966). Finally, we aim to explore ways to promote the direct musical interaction between audience members, namely by composing pieces that rely solely on the audience.

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[6] Media coverage of the concert can be seen at http://youtu.be/fkCrtEPFTN4, http://youtu.be/07XwuHrHgW4, http://youtu.be/aEalgQez28M, http://youtu.be/p2iGkpZZXN0 and http://youtu.be/JofTAb2OIDU.

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