# Designing a shareable musical TUI

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## ABSTRACT
This paper proposes a design concept for a tangible interface for collaborative performances that incorporates two social factors present during performance, the individual creation and adaptation of technology and the sharing of it within a community. These factors are identified using the example of a laptop ensemble and then applied to three existing collaborative performance paradigms. Finally relevant technology, challenges and the current state of our implementation are discussed.

## Keywords
Tangible User Interfaces, collaborative performances, social factors

## 1. INTRODUCTION
Collaboration in music creation does not necessarily only refer to musicians playing together, it also includes their mutual influence, the sharing of their ideas in various forms inspiring them and causing a continuous progression in the development of their art. The flexibility of electronic and digital technology today not only shapes new formats to encode and distribute these ideas, but it also allows for the reconfiguration and customization of the instruments in ways that were not previously possible. Computer musicians utilize this flexibility to express their ideas in the creation and adaptation of their music technology as well as through their actual musical expression.

Programming environments such as MAX/MSP [3] and SuperCollider [15] are good examples of systems that provide this flexibility. They also simplify the distribution and sharing of the artists' patches, so that the fruits of their creativity can be found in forums, mailing lists and internet blogs. It is not just highly customizable software that reflects and promotes this thriving exchange of creativity. Even much less sophisticated music software such as Propellerhead Reason [12] has this practice integrated within its design. An individually created rack setup of instruments and effect devices can be shared, included in a tiny song file, ready for distribution and inspiration within a web community. Hardware devices such as synthesizers also allow for the creation or modification of individual patches and presets. This creation, customizing, sharing and reworking of musical technologies and material appears to be a driving force in the development of electronic music, as it can be found in the design of many modern music systems. In addition to GUI software systems and 'knob & fader' hardware devices the past decade has seen the development of a new musical interaction paradigm namely the Tangible User Interface (TUI). This paradigm promises many interaction-related benefits, and has the potential to allow the integration of creative customization, sharing and reworking of musical material in an entirely new context. But this design opportunity has yet not been fully explored or implemented by musical TUI designers. Therefore, we began this exploration by studying the practice of individual members of the BLISS laptop ensemble in order to develop an understanding of how these individual music systems are formed and how they could be shared in a live performance context. The results of this exploration were then applied to musical TUIs to identify the requirements for a collaborative tangible system that encompasses this creative practice.


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## 2. BACKGROUND
The disembodied and indirect interaction with virtual performance systems through business oriented user interfaces like the mouse and the keyboard causes a disconnection between the performer and the instrument as well as between the performer and the audience [14, 1]. The physical nature of tangible user interfaces (TUIs) appears to be a promising solution to overcome these problems. Not only do these interfaces provide a higher transparency to the audience, as the musician is no longer hidden behind the glare of a laptop screen, they also allow interfacing with data and logic embodied in physical form. Furthermore, the hidden coupling of virtual worlds through a network is not required to enable collaboration on a tangible system; the physicality grants access to everyone nearby. These could be the reasons why TUIs for musical applications have become increasingly popular. This trend started with projects such as Musicbottles [6] and Audiopad [11] and evolved to include sophisticated products like the Reactable [7] and AudioCubes [13] which are now commercially available. Most of these projects are prototypes aimed at a very specific application domain, yet some like the Reactable show potential to compete with the versatility of the laptop in a musical context. However, in order to fully address this musical context the design should also be concerned with social factors relevant to electronic music creation. This is why we take the creative process of the community into account.

In his discussion of embodied interaction Dourish points to the importance of social factors in designing interactive systems so that the users way of working becomes an integral part of the design [4]. According to Benson music develops in a community where the way of working involves artists borrowing ideas from other artists and bringing them into a new context [2]. DJ Spooky [5] describes this process more specifically as follows:

*"Electronic music is, in a way, the folk music of the 21st century. Instead of, say, the '20s, where you had everyone who knew a blues riff playing a guitar, you now have everyone who knows certain beats and things like that putting them together and then circulating them - this scene is about mixing and mix tapes. Technology is making the creative process democratic."*

As we will later discuss in more detail, the design and implementation of a TUI that allows this sharing and mixing of personal material presents several challenges. Personal TUI elements have to be customizable yet compatible with each other in order to allow mixing. Furthermore, they have to be data containers, not just references, in order to promote sharing. Therefore, we suggest the utilization of embedded computing technology. Projects like AudioCubes, the Tangible Sequencer [16], BlockJam [10] and the Siftables [8] are good examples of TUIs based on integrated micro-controllers. However, we have yet not seen an embedded computing TUI that strongly emphasizes customization and sharing within a community.

We started this development by working with the BLISS laptop ensemble to gain insight into such a community.

# 3. DEVELOPING THE CONCEPT

## 3.1 The BLISS Ensemble

BLISS stands for “Belfast Legion for Improvised Sights and Sounds” and is a laptop ensemble at SARC. Its members use a variety of software including MAX/MSP, SuperCollider and Ableton Live. In addition to using different software, the way in which members also approach their performances varies greatly. Some start with a blank patch and improvise with what is available on their hard-drive, others continuously develop and improve the same performance system, while still others create a specific setup prior to every performance. But BLISS is not a strict laptop ensemble that only allows the use of the computer as it is, the performers also use different hardware controllers of their choice. This selection of hardware and software, as well as their personal style in adapting and using it, gives both form and expression to their ideas. When asked how they build their patches and were they get their ideas from, they typically pointed to a range of sources including a mailing list, documentation files and patches of friends and colleagues. This indicates that a lot of the ideas and technology implemented in their systems is shared and developed within their community. In short this community is not about mixing mix tapes, it is about mixing technology.

Summarily as an outcome of discussions with the ensemble two relevant social factors were observed on which we will base our design:

- The individual artists have very different approaches to their performances including the preparation, creation, selection or adaptation of their own performance systems.
- Personalized technology, techniques and ideas are shared and reworked within their community

## 3.2 Abstracting the differences

In order to create our concept of a TUI based collaborative performance system we compare three different collaborative performance paradigms, now including aspects of these social factors in collaborative music making. We then introduce our tangible ensemble concept. Figure 1 shows the relationship between the different performers and their performance systems as well as the relationships between the systems themselves. These are canonical paradigms and actual systems may reflect different or hybridized topologies.

### *3.2.1 Laptop ensemble*

Every performer uses their own system, consisting of an interface connected to the logic of their setup. The interface in this case usually consists of a Laptop with a MIDI controller. The logic is defined by the inner workings of the individual performance system. The selection and adaptation of the software, sound material and control devices embodies the performers' ideas and personal sound. There is no interaction between the individual systems during performance nor can the performers access the interface of the other performers' systems. This paradigm integrates the first social factor; the performers can integrate their own personalized technology. However, the second factor, the sharing and mixing of their technology, is not present during the ensemble's performance.

### *3.2.2 Network performance*

Network performance environments like netpd for PureData [9] allow the performers to prepare, create and bring their own performance elements, each having their own interface and logic. The interface is not represented as one specific instance (one laptop setup) and is therefore purely virtual. This grants all performers access to it over a network, hence creations can be accessed, modified and combined with other elements, by everyone. This paradigm actually embeds both of the social factors identified, the integration of personalized technology, as well as the sharing and reworking of it. However, this freedom comes at a cost. As the representation of their systems resides completely in the virtual domain, problems like the indirect interaction and lack of transparency for the audience arise.

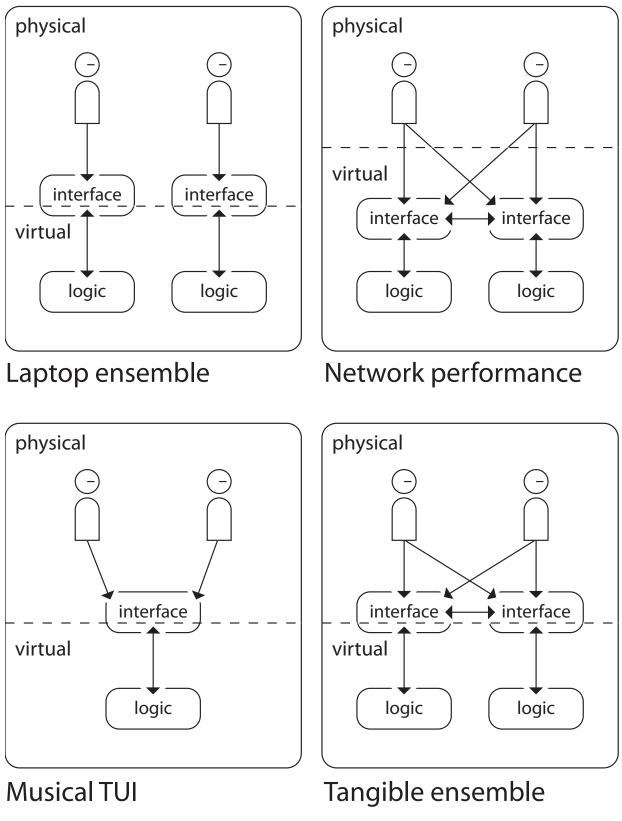


**Figure 1. The different performance paradigms**

### *3.2.3 Musical TUI*

In the musical TUI paradigm all performers use the same physical interface with the same logic. In the case of the Reactable the interface consists of acrylic pucks which because of their physical nature and confined space (the table) can be accessed by every performer. This also increases the transparency of the performance for the audience. However, the customizability is limited and performers can not easily prepare and integrate their own technology, such as their customized patches. Therefore, ideas and techniques based on the systems model might be shared and reworked on the table, but the ability to provide and mix personalized technology is missing.

## 3.3 The tangible ensemble

Our design concept, the tangible ensemble, would allow the performer to create and bring their own personal performance elements as tangible pieces of a system. However, unlike the laptop ensemble it enables them to access, share and mix all their personal technology; and unlike a network performance the sharing and mixing happens in the physical world. This physicality and the embedding of individual technology into their tangible representations provides many opportunities for performers to exchange material before and during performance. Problems such as multiple users clicking on the same GUI widget [18] or the lack of performance transparency can be reduced. Also, these tangible elements can become the format for sharing and distribution of the performers ideas and technology, even outside the performance context. No virtual system is required to share a file because the 'file' exists in the world that we all live in as it is embodied and embedded in the tangible object itself. Moreover, if the physical objects contain their functionality no additional system is required (except for an amplifier and speakers). This is unlike the computer, projection table and the camera setup of the Reactable and other musical camera-based TUIs. The individual objects actually form the performance system in the same way as the individual performance setups of the BLISS members form their ensemble. Furthermore, this performance system will constantly change depending on who the performers are and what they contribute.

# 4. CHALLENGES

In order to realize a system such as the tangible ensemble several obstacles have to be overcome. Firstly, there is the problem of data and logic containment. Most tangible systems are based on physical objects that are referenced to data or parts of the logic. The Reactable uses optical recognition of fiducial markers while systems like Mediablocks [17] are based on ID tags. These systems might be very effective interaction-wise but the problems of their underlying technology become clear if taken out of the pure performance context. Portability instantly crystallizes as an issue. More precisely, a physical object that has meaning in one instance of such a system has no meaning in another one if the referenced data associated with the object was not also transferred from one system to the other. A performer attaching data to an object during preparation at home will not necessarily have the data available at the performance location even though they brought the object with them. Solutions to this problem could be centralized data storage on a web-server requiring an internet connection to access the data of the system; accompanying data storage and handling, for example on a USB stick; or storing the data directly in the actual object. The last solution proposed, containment, is the most preferable as it does not involve unnecessary additional technology – the transfer format is the actual object. But data containment alone does not already allow a performance system to be formed by simply combining independent modules, as the tangible ensemble suggests. The objects have to be equipped with processing units in order to also include the logic and provide digital functionality. This suggests using embedded computing devices.

Secondly, there is the problem of standardization. All the individual modules have to speak the same language in order to allow the interconnection between their interfaces. Even though expression of the performer's creativity in the module's content is desired it has to be restricted in order to conform to a standard communication and exchange protocol. As an initial solution we propose the exchange of a variable signal level per connection, much like traditional analogue synthesizer modules. This level could for example be a slowly changing control signal, or a very fast value change representing an audio signal. A more sophisticated solution would be based on two different signal types, the variable signal level and additionally a note information protocol like MIDI. To distinguish between these two the advantages of physical representation can be applied, either by having different types of sockets and cables, or even by having different types of modules with different input and output socket configurations. However, the performers have to communicate what their modules actually take, process, and transmit. Nevertheless, eventual errors might lead to unexpected and possibly inspiring results. This issue will be studied as soon as our first prototype is ready to be used in a performance.

Thirdly, the performers have to be equipped with a tool to express and embed their ideas into the objects, most likely a patching editor or programming language that allows them to program their content.

# 5. IMPLEMENTATION

We are currently developing an initial design prototype based on an ARM based micro-controller. One of the key design criteria was to keep the cost per token-module as low as possible. This would allow us to produce a large number of modules and might also further promote sharing, as the tokens themselves are less valuable. We have chosen the LPC1343 from NXP for several reasons:

- It is very low-cost.
- It provides an on-chip USB Mass Storage Device driver to update the user-customized logic via USB.
- A clock frequency up to 72MHz ensures enough cycles for DSP.
- Low-cost development with the LPCXpresso board

The PWM outputs can be used to encode and send a variable signal level between the modules (as the pulse width). Furthermore, when the PWM cycle is oversampling the digital audio signal and routed through a low-pass RC filter within the module it even produces an analog audio signal of, for our purposes, acceptable quality. This technique allows us to further reduce the cost per module as no additional DAC chip is required, while still providing the option of analog audio output per module. In a network of these it is a requirement that at least one module can send an audio signal to an amplifier. As interface cables between the modules we have chosen ordinary 3.5mm TRS cables. Currently we use a sampling rate of 25KHz and 4 times PWM oversampling.

A visual programming editor to customize the logic inside these mini sound-modules is also under development. We believe that visually connecting DSP blocks can be easier to understand for beginners because of its less abstract presentation compared to textual programing. The editor also allows performers to map the limited number of knobs and buttons on the module to elements of the DSP logic. Currently the prototype supports only customization of the module's internal logic, but because this information is flashed as firmware, the module can not be used to transfer the open patch-file. In order to fully integrate our tangible ensemble concept this has to be altered because the modules should also function as shareable information containers. We need to investigate further to discover how this can be achieved without increasing production costs significantly.

Figure 2 demonstrates a simple workflow scenario with only two modules and performers.

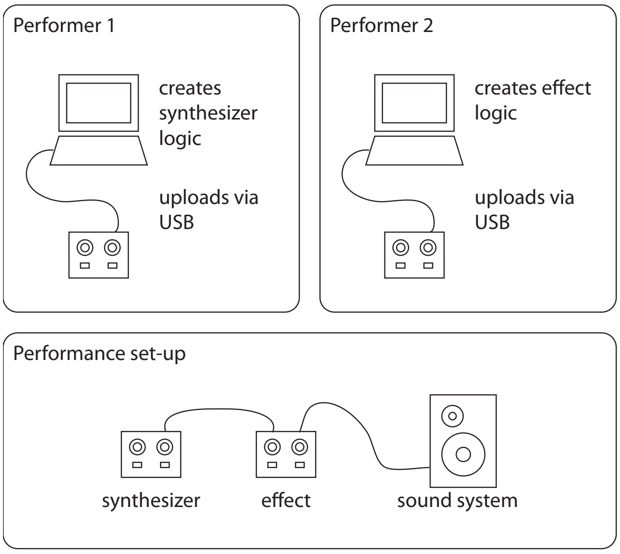


**Figure 2. A workflow example**

# 6. CONCLUSION

In this paper we have shown how social factors in collaborative music performance, such as the creation and adaptation of personal performance setups, the sharing of the involved technology and ideas within a community, are relevant for laptop artists. Therefore, we compared existing performance paradigms and proposed a new concept of musical TUIs, the tangible ensemble, which would support both the integration of individual artistry as well as the sharing of ideas within a collaborative music performance. We suggested and discussed that this could be achieved by creating embedded computing based objects that can be interconnected and programmed by the performers. Even though the implementation of this concept presents a number of technical challenges, as our work progresses we might soon be able to explore a new generation of shareable musical TUIs.

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