Multi-user Instruments: Models, Examples and Promises

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ABSTRACT
In this paper we study the potential and the challenges posed by multi-user instruments, as tools that can facilitate interaction and responsiveness not only between performers and their instrument but also between performers as well. Several previous studies and taxonomies are mentioned, after what different paradigms exposed with examples based on traditional mechanical acoustic instruments. In the final part, several existing systems and implementations, now in the digital domain, are described and identified according to the models and paradigms previously introduced.

Keywords
Multi-user instruments, collaborative music, new instruments design guidelines.

1. INTRODUCTION
Music performance typically is a group activity. For Bischoff, one of the founders of the League of Automatic Composers, there seems to be no substitute "to bring into play the full bandwidth of communication, than the playing of music live" [3]. However, most of the traditional musical instruments have been mostly designed for an individual use. Even if some of them, as the piano or the drum kit can be easily used collectively, acoustic models do not really favor for the actual manipulation and control of each other's explicit musical voice (such as one performer on 'side' of the instrument, directly affecting the other performer's output). It is by designing and constructing electronic communication channels among players, that performers can take an active role in determining and influencing, not only their own musical output, but also their peers' [21]. Besides, if one of the best assets of new digital instruments is the possibility to run several multiple and parallel musical processes in a shared control between the instrument and the performer [14], the possibility to have multiple performers seems as a logical and promising extension.

2. NET MUSIC AND DISTRIBUTED INSTRUMENTS
Thanks to the Internet, the study of network or distributed musical systems is a hot area nowadays and much research is being carried on. For an overview of the field, the reader can refer to [1 or 21], which address from different perspectives topics such as the goals and the motivations, the technical constraints, as well as the perspectives, the topologies or the social implications of both online and local musical networks, proposing also taxonomies and describing many examples of implementations. Still logically, these and other authors tend to concentrate their studies in the peculiarities brought by the net medium, such as time latency or physical displacement and disembodiment.

2.1 Studies and Taxonomies
In 1991, Wessel [22] already introduces several of the principles and paradigms further developed in the present article. More recently, Barbosa [1] proposes a classification space for computer-supported collaborative music mainly based on two axes: synchronous and asynchronous for the time dimension; remote and co-located for the space dimension. Weinberg's taxonomy [21] also distinguishes between on-line and local networks (and, in the last case, between small and large scale systems depending on the typical number of participants) and describes possible topologies depending on the social organization of these networks and on the nature (centralized-decentralized) of their connections. Blaine and Fels [5] study collaborative musical experiences for novices, concentrating on interactive, instrumental and playability aspects. My own work, FMOL [12] has often been referenced and studied as a model for different net-distributed musical paradigms [10, 19, 21], but in this article I want to concentrate in the aspects of shareable multi-user instruments, which, as a result of playing myself in shared environments, currently interest me more as a luthier. What follows should not be necessarily understood in the context of net-music or distributed musical systems; imagine instead a hypothetical acoustic instrument that would invite many simultaneous performers.

3. SHARED COLLECTIVE CONTROL

3.1 Some Multi-User Instruments Considerations and Properties

3.1.1 User-number and user-number flexibility
Some multi-user instrument can be played by a variable number of performers (some can even be naturally played by only one person). Others require fixed number of performers.

3.1.2 User-role flexibility
In some multi-user instruments, each performer is assigned a different role. Instruments with a very strict role assignment tend to be also stricter with its number of users (i.e. one performer/role). Some instruments offer different roles in a more flexible fashion, allowing for example performers to switch roles dynamically, to play several simultaneous roles, or even to

temporally 'duplicate' roles while leaving some other 'unattended'.

3.1.3 Interdependencies / hierarchies

What possibilities performers have in determining and influencing, not only their own musical output, but also their peers'? If no mutual interaction is allowed, the concept of multi-user instrument is definitely debatable. Are all these interdepencies equilibrated? I.e. is the system a democratic system, with balanced rights and duties, or a hierarchical one?

3.2 Some Multi-User Paradigms Based On Acoustic Instruments

Although most of the aforementioned authors consider only digitally connected instruments, claiming that electronic communication channels among players are needed in order to achieve 'real interconnected interactive multi-user instruments, we will illustrate the above properties with acoustic instruments examples. Mechanical communication channels may also permit, as we will show, the development of these concepts, and because we all have a better idea of what traditional instruments are and how they work, examples can be much clarifying.

Let us consider a keyboard instrument such as a piano. The number of hands that can access a piano keyboard is quite flexible. The mutual interaction two or more player can exert on each other is however not that important, if we omit two facts: (a) while a key is taken it cannot be played by someone else; (b) the oscillation modes of each piano string are slightly dependent on the state of the other strings, which theoretically allows each performer to affect the timbre of the notes being played by other performers. When one performer plays the pedals, this timbre modification effect is stronger. In this case, the roles are also clearly differentiated, but the mutual interaction is not balanced: the pedal player affects the keyboard player much more than the inverse. Besides, the pedal player can do 'much less' than the keyboard peer.

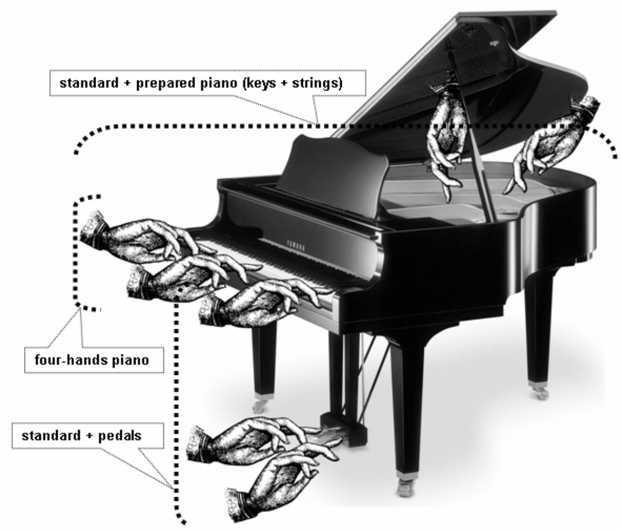

Figure 1. The piano: three multi-user paradigms

But even a traditional instrument such as the piano allows for quite advanced interplay. Imagine a situation in which player A plays the keyboard while player B plays with the strings, in a harp fashion and/or dynamically 'preparing' the piano. This context is suitable for 2 to N performers. It shows two clear and well-defined distinct roles, none of them being essential (each role is individually allowed to make sound). The interplay can thus become extremely intense. This example surely illustrates a quite desirable and inspiring situation. In my opinion, almost an ideal for multi-user instruments designers. Figure 1 illustrates the aforementioned three approaches to 'multi-user pianos'.

Let us pick another keyboard: an old-fashion humanly fuelled organ in which player A plays the keyboard, player B plays the register keys and player C 'plays' the pump. Both A and C are essential roles, although being essential seems not necessarily something enviable, especially when we consider player's C potential expressivity.

3.3 Multi-user instruments simple arithmetic

- If there is strictly no mutual interaction, the output result of the multi-user instrument can be considered as the sum of all the individual contributions.
- If some roles are essential, these roles multiply the previous contributions.
- If all roles are essential, the result is the product of all the individual contributions.

The more interplay and flexibility are allowed in a multi-user system, the more complex will the final expression - in terms of the individual contributions - turn to be, and the more exciting the collective interplay may result.

4. MULTI-USER INSTRUMENTS EXAMPLES

The list of true multi-user instruments that seek to explore different aspects of collective interplay is growing faster. In this section we will only briefly mention seven implementations we consider specially paradigmatical. They are presented in rough chronological order.

4.1.1 Imaginary Landscapes No. 4 (1951)

John Cage's Imaginary Landscape No. 4 is a piece for twelve radios and twenty-four performers. Every radio set had its own frequency-dial player and its volume-dial player who manipulates the final output gain. Although there can be no prior knowledge of what might be broadcast at any specific time of the performance, or whether a station even exists at any given dial setting, all the performers' actions are carefully notated in a composition score that indicates the exact tuning and volume settings for each. As radical as this piece might have been, Cage makes no doubt about the role of the composer and that of the performers; using randomness for removing his sense of choice he was not allowing the musician to have any personal choice either.

4.1.2 Mikrophonie I (1964)

Stockhausen's *Mikrophonie I* depicts a comparable model. It is a work for six performers scored for tam-tam, two microphones, two filters, and potentiometers, in which the tam-tam provides all the basic sound material. Two performers play the tam-tam, two others operate the two microphones on either side of it, and the two remaining performers operate the filters. The sounds of the tam-tam are passed through filters, manipulated, and then amplified. The process of performance and composition are thus wed, as the sounds of the tam-tam are altered in real-time. Pitch and texture may be changed, extraneous sounds may be turned into pitched sound, and similarities and differences between musical gestures may be emphasized or de-emphasized by the electronic processes. The resulting sound world is not just the additive combination of sounds generated by the individual players [22].

4.1.3 The League of Automatic Composers (1978)

The *League of Automatic Composers*, formed in 1978 by John Bischoff, Rich Gold, Jim Horton and later Tim Perkis, can be considered the first microcomputer band and also the first network band of history [4]. Each member of the group owned a microcomputer with its own sound output, either by means of a digital-to-analog converter (DAC) or through digitally controlled external electronic devices. All members programmed their own computers with music programs that should be able to produce music by themselves, but also able to receive data that would affect their musical behavior, and to output data that would affect other computers' programs. They performed connecting their computers in different configurations. The *League* kept playing extensively until they disbanded in 1983. Two years later the former members Tim Perkis and John Bischoff, joined by Scot Gresham-Lancaster, Phil Stone, Chris Brown and Mark Trayle, formed a new computer-network band, *The Hub*, embracing this time the new technology that made all connections much easier, MIDI [7, 11, 17].

The *League*'s importance cannot be overestimated. Not only it constituted the first microcomputer band, predating by a quarter of a century today's plethora of improvising laptop groups, they also established many of the basic principles and models of network music in use nowadays. The *League* itself understood their musical net both as a net of instruments and as a collective instrument that is indeed much more than the sum of its parts. When computers start sharing data between themselves, human performers are not anymore the only ones allowed to 'listen' to each other, which opens to a multiplicity of interaction and complexity networks.

4.1.4 Sensorband's SoundNet (1995)

The *Soundnet* is a large scale multi-user sensor instrument constructed by Bert Bongers for Sensorband (Atau Tanaka, Zbigniew Karkowski, and Edwin van der Heide). It is a musical instrument that takes on an architectural dimension and monumental proportions. As shown in figure 2, it is a giant web measuring 11 meters x 11 meters, strung with thick shipping rope. At the end of the ropes are eleven sensors that detect stretching and movement and the three musicians of Sensorband perform on the instrument by climbing it. All the ropes are interconnected, making it impossible to isolate the movement of one sensor. Limitations of the *Soundnet* are related to its physical scale and interconnected nature. Isolating individual sensor movement is nearly impossible, and one performer's movements take place in relation to the position and actions of the others. These effects combine to give the instrument its qualities of structural resonance and create a dynamic where pure control in the strict sense is put in question; the instrument is too large and complex for humans to thoroughly master [6, 18]. The *SoundNet* proposes no distinctive roles and admits a variable number of users. Performers interconnectivity is extremely high.

4.1.5 The Squeezables (2001)

Developed by Weinberg and Gan [20], the *Squeezables* are comprised of six squeezable and retractable gel balls that are played usually by three performers by holding the balls in their hands and using a set of squeezing and pulling gestures. Each of the five accompaniment balls shows a particular behavior. Three of them mainly control timbre-oriented parameters while the two remaining, offer higher-level accompaniment control. Some additional parameters are also controlled by average actions on all the balls. Like in traditional ensembles, each of the *Squeezables* shows a particular behavior and musical role. Unlike traditional instruments, these roles only make sense in a global context. The *Squeezables* constitute a highly organized and hierarchical distributed instrument that needs all of its components to work properly.

4.1.6 The Tooka (2002)

Exploration of intimate communication and attentive interplay between two performers are epitomised in the *Tooka* [8, 9]. The *Tooka* is a hollow flexible tube with three buttons at each end and with a pressure sensor in the center, which measures the air pressure on the tube. To play the *Tooka*, two players put their mouths over opposite ends forming a sealed tube, so that they both collectively modulate the tube pressure to control sound. The *Tooka* has clearly a fixed number of performers (2) and both share the same responsibility and role. It also represents a very special case, as possibly one of the few (if not the only) multi-user instruments which cannot be considered multithreaded. The team developing the *Tooka* is specially concerned by the physical communication channels and the intimacy new instruments can bring and has also designed several other two-player instruments that further explore this area.

4.1.7 The reacTable*

The *reacTable** is a table-top instrument[1], which allows performers to share complete access to all the musical threads by moving physical wooden objects (representing generators, filters, etc.) on a table surface and constructing different audio topologies in a sort of tangible modular synthesizer or graspable flow-controlled programming *Max-like* language (see figure 6) [13, 14, 15]. The *reacTable** supports a flexible number of users (from one to around half a dozen), with no preconfigured roles, and allows simultaneously additive (performers working on independent audio threads) as well as multiplicative behaviors (performers sharing threads). Because of the way physical objects are visually and virtually augmented (see figure 7), the *reacTable** also constitutes a perfect example of the off-line and on-line all-at-once multi-user instrument. When two or more *reacTables** are connected through the net, thus sharing the same virtual space, performers can only move the wooden objects on their corresponding table, but these movements may modify the shared audio threads, thus provoking interactions between displaced objects, so that one filter in Barcelona may process the output of a generator in Berlin.

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[1] Other musical instruments exist that fall into this table-top category such as the The *Jam-O-Drum* [4], the *Audiopad* [16] or the *Music Table* [2]. Equally, "walls" or "carpets" could be also considered as variations of the table concept.

Figure 2. Two performers playing with the *reacTable**

5. SUMMARY

Multi-user instruments seem a logical and promising extension of the multiprocess behavior of many digital instruments [14]. They offer many interesting possibilities while posing new design challenges; the goal now is not only to facilitate interaction and responsiveness between each performer and the instrument but also between the performers as well. The more interplay and flexibility are allowed in a multi-user system, the more complex will the final expression - in terms of the individual contributions - turn to be, and the more exciting the collective interplay may result. We have introduced different possible models and described several implementation examples which definitely bring new interplay promises to the scene.

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