Faust Music On Line (FMOL): An approach to Real-time Collective Composition on the Internet

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ABSTRACT

Collective creation and the production of open and continuously evolving works are, according to the author, two of the major and more appealing artistic breakthroughs the Internet can offer to composers and creators in general. In this context, concepts like *authorship* and *copyright* will necessarily have to evolve and adapt to a new reality. The author discusses an Internet project for real-time collective composition commissioned by *La Fura dels Baus*, which has been used for the soundtrack of La Fura's play *F@ust 3.0*.

During the spring of 1997, La Fura dels Baus, the Catalan theater and performance group famous for its aggressive shows and performances that frequently involve audiences in an unpredictable manner, was beginning to prepare what would be its new show, *F@ust 3.0*, freely inspired in Goethe's work. Carlos Padrissa, director of the project (together with Alex Ollé), contacted me for an unusual demand: "*Given the important role symbolized by the Internet in our play* [1] *, we would like part of its music to be composed by cybercomposers around the world*". Having worked on interactive systems and virtual musical instruments since 1989, I was at that time haunted by the idea of using the Internet for a wide musical project, so the proposal cropped up at the right moment.

Padrissa and I did not have a clear idea of what we wanted, but we knew what we did not want: to allow people to compose tempered music on the keyboard and send us attached MIDI files via E-mail. Besides, although we felt that the project should have a fairly "popular" approach, we were not looking for a dull General MIDI sound, but for a rich, strange, sometimes noisy electronic sound. How were we to get it without being too demanding and restrictive about the participants' gear (a regular PC with an Internet connection and a [U.S.] $50 multimedia soundcard) in order to bring the project to a wider audience? We found the answer in real-time synthesis, which, we knew was going to considerably complicate all the software design and programming. Our collaboration with Toni Aguilar, one of my former computer programming students - who although not a musician was quite well versed in computer games programming- was to become absolutely invaluable in the project.

COLLECTIVE CREATION - THE FULL-DUPLEX CHAT MODEL VS. THE HALF-DUPLEX E-MAIL MODEL

The Internet not only favors the omnidirectional distribution of information, but also promotes the dialog among its users with services like E-mail and chat. If we imagine some kind of chats or E-mails that would use music instead of written words, then both

collective creation and the production of open and continuously evolving works, would doubtlessly be two of their major and more appealing artistic consequences. My first idea (even prior to La Fura's proposal) was to design an Internet jam-session program, that, following the chat paradigm, would allow musicians from around the world to play together and participate in the real-time creation of musical pieces.

The idea of musical computer networks is by no means original; earlier implementations (on a local area scale) date back to the late 1970s with performances by the League of Automatic Music Composers [2] . But twenty years later, real-time collective improvisation keeps posing serious timing difficulties at a global scale, and the sites that have appeared lately, such as *Res Rocket Surfer* [3], still have many limitations. To experience the *Res Rocket* proposal, one only needs to download the program from the Res Rocket website (both Mac and PC versions exist) and start playing one's MIDI controller, while waiting for someone to surface. Nevertheless, maybe because it is hard to go beyond General MIDI, these jams do generally favor a fusion or "new-agish" flavor, exactly what Padrissa and I wanted to avoid.

We finally decided to follow the E-mail model, which, like old walkie-talkies, uses a half-duplex communication paradigm: first read/listen and then respond. Moreover, instead of choosing the horizontal-*cadavre exquis* approach (allowing pasting of sonic fragments one after the other), we aimed for a vertical-multitrack model, which also fitted better with La Fura's prime condition regarding the duration of the pieces (they wanted to include in the play, many very small compositions - i.e. 20 seconds each). Another important decision was to organize the server's scorefiles database not as a simple list, but rather as a tree. This would allow germinal compositions -musical ideas brought by one composer- to grow and evolve, through the participation of new authors, in many different ways, while still permitting, at the same time, access to all the existing pieces/nodes.

FAUST'S DILEMMA

While developing the show's concept, La *Fura dels Baus* decided that many of FMOL's brief musical fragments would be used as a leitmotif, whenever Faust, distraught and tormented, felt in the depths of his spirit the fierce battle taking place between the chaotic forces of life and the efforts of his intelligence to understand and dominate them. This dichotomy even had two avatars, the Bamboo and the Medusa -both of which played an important role in the stage design- which were represented by two large, automated sculptures created by Roland Olbeter. Bamboo (symbolizing human intelligence), and Medusa (symbolizing the intuition, the strength of life or *élan vital*) [4], were supposed to move alternatingly, each with its corresponding Internet music, reinforcing Faust's dilemma.

This need for two music families led me to my own dilemma: should we use two synthesis engines, two ways of composing, or would two different front-ends be enough? After discarding the idea of designing the "intelligent" Bamboo as a non-real-time compositional tool and leaving the real-time interaction for the "intuitive" Medusa; Aguilar and I chose the simpler alternative of two front-ends, with real-time manipulation applying to both instruments.

I have conceived several virtual instruments and interactive music systems since 1989. Some of them, like PITEL [5] or the QWERTYCaster [6] were conceived for trained musicians, while others like EPIZOO [7] had to be controlled by members of an audience in public performances. The demands for the two genres are obviously different. Complicated tools, which offer great freedom, can be built for the first group, while the second group demands simple but appealing tools that -while giving their users the feeling of control and interaction- produce satisfactory outputs. These two classes are often mutually exclusive. Musicians become easily bored with the "popular" tool, while the casual user may get lost with the sophisticated one.

With these previous experiences in mind, I tried to conceive two graphical interfaces in order to appeal to both sectors -tools that would not dishearten hobbyist musicians, but that would still be able to produce completely different musics, allowing a rich and intricate control, and offering various stages of training and different learning curves. But these interfaces could not develop far without a precise knowledge of how the synthesis engine [8] would work.

FMOL SYNTHESIS ENGINE

One idea was clear when conceiving and designing the engine: performance and creative possibilities were more important than top quality algorithms. The main goal was to build a basic sound-generation kernel that could be flexible enough for real-time manipulation and appealing and enriching for different users, possibly including many who are "MIDI minded" but not acquainted of software synthesis. Since it would have to deal with polyphonic real-time synthesis on standard computers, Aguilar and I discarded the Java applet solution for reasons of speed, and chose instead the stand-alone C++ program. The short developing time available forced us to betray the Internet's platform-independent nature focus on only one operating system: a 16-MB Pentium 100 MHz computer running Windows 95 (plus the Microsoft DirectX libraries) and fitted with any 16-bit multimedia sound card, was targeted as the minimum configuration required.

Here are some of FMOL's specifications and features (for more detailed information regarding the synthesis kernel, please refer to Appendix A or to my previous publications [9]).

- FMOL 1.0, is a stand-alone program, written in C++ for Windows 95 that can be downloaded from the Internet. Once installed, it transparently manages all the http connections with the database server, with whom it interchanges small scorefiles rather than audio.
- Its current synthesis engine supports eight stereo audio channels (real-time synthesized at 16 bit and 22,050 Hz). It is freely based on analogue subtractive synthesizers, but allows for many possibilities that are available only on digital systems.
- The program has been designed not only for real-time synthesis, but also for real-time composition and control, which means scorefiles are generated on the fly and sequenced (at 25 frames/second), while composers interact with its interface and produce sound.
- Each composer is given two channels (of the eight available); therefore, any piece can be made by up to four composers. FMOL "vertical" collective composition approach allows new composers to add new tracks to one composition, but the duration of one composition remains the same for all its composers.

- Each channel or track consists of a sound generator (sine, square, sample player, Karplus-Strong, etc.) and up to three serial processors (filters, reverbs, resonators, etc.), which can be chosen by each composer between more than 100 different synthesis methods, algorithms or variations.
- Generators can also behave as serial processors (i.e. they can take their input from the output of previous tracks, e.g. a ring modulator-), which allows new composers not only to add new sound layers to existing compositions, but also to reprocess/distort any of the previous tracks.
- A non-real-time render-to-wave option is available, which converts its real-time recorded scorefiles to 22,050 Hz 16-bit stereo wave files. To avoid saturation, this audio rendering is temporarily stored at 32 bits, then the result is normalized and finally re-quantized at 16 bits.

THE COMPOSITIONS' TREE PARADIGM

The tree structure that stores all scorefiles allows up to four composers per piece to add two audio tracks each and completely reprocess any previous track as well. Each time a user accesses the database, the program receives and updates one of the two compositions' independent trees (Bamboo or Medusa), allowing the user to see all the compositions' genealogies, with some particular information on each node (e.g. the author's alias and date of creation) as shown in Fig. 1. This user is then able to download and listen to any of these composition (the selected scorefile, with a typical size from 10-30 KB, is downloaded and synthesized). The user can decide to enrich/modify/distort/deconstruct any of them (as long as its four layers are not filled) and send them back to the server. This new node will then take its place in the tree as an offspring of the downloaded piece.

Although the maximum number of users (or layers) per piece is reduced to four, there is no limit to the number of variations that each layer may generate. This means that the tree has a maximum depth of four generations but unlimited offspring at each one of them (a four-layer pieces can be listened to but not "augmented", though its parents can keep engendering). That way, a musical idea brought by one composer can develop in multiple and unexpected directions; pieces become entities with lives of their own, capable of evolving out of the control of their original creators. The number of initial themes is not limited either, and any participant can initiate one at any time.
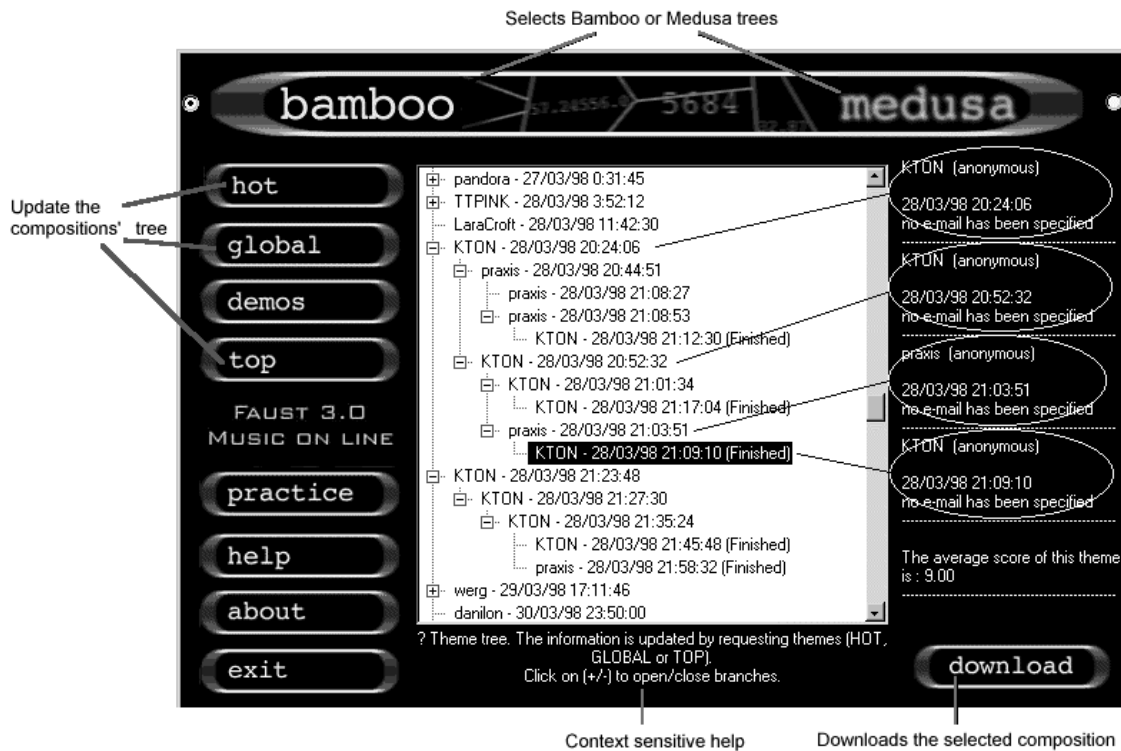
Fig. 1. FMOL main screen, showing Bamboo's composition tree. Each line of the tree corresponds to a composition layer and shows its author's alias and the time and date of creation. The term *(Finished)*, applies to all 4 layer compositions (i.e. compositions which cannot be expanded). The right of the screen shows the information for each one of the layers of the selected composition.

Imagine various composers connected to FMOL and working simultaneously on the same branch: as pieces are composed/played in real time (although multiple takes can be done before submitting material to the server), the delay between the time an author sends a composition and the time he or she checks the composition's descendants can be of only a few minutes, and this process can be repeated infinitely. As an example, the screenshot in Fig. 1 illustrates a 1 1/2-hour musical chat between two users (KTON and praxis) composing and interchanging discoveries on 28 March 1998, between 08:24 PM and 9:58 PM.

BENDING BAMBOO - FMOL GRAPHIC INTERFACES

The design of this graphic interface - long, straight and flexible lines- took its inspiration both from the idea of rational control and from the shape of the plant. Though the interface is not simple, its control can be fully mastered, and the instrument almost succeeds in extracting all of the synthesis kernel potential.

The Bamboo, as shown in Figs. 2.1 and 2.2, is a lattice in which vertical lines are associated with the synthesis generators and horizontal lines with the synthesis processors. Like a virtual guitar, these vertical lines/strings can be plucked or fretted with the mouse while they continuously draw the sound they generate like a multichannel oscilloscope. When the user clicks on a string with the left mouse button, the string gets captured and starts to sound, changing its two primary synthesis parameters according to the mouse movements (vertical movement of the mouse

controls the string's primary parameter, normally the pitch, while its horizontal movement - i.e. the distance from the vertical rest line - controls the secondary parameter). Whenever a string sounds, its waveform is immediately drawn across its line, and while it is being pulled, the line breaks in two segments. This graphical interface runs at 25 frames/second (as the synthesis engine), simplifying synchronization. At every frame, the mouse position and state are captured and converted to MIDI messages [10] that are recorded and sent to the synthesis engine.

Each horizontal segment, on the other hand, does control the synthesizer's serial processors of the string situated on its right. These segments do not bend like strings do, but can be dragged and oscillate up and down. Although a complete Bamboo-user's description cannot be included here, I will just say that the combination of both mouse buttons and the computer keyboard allows for an intricate control, including sustaining sounds, modifying secondary parameters, recording gestures loops, applying low-frequency oscillators (LFOs) with frequency and amplitude control, creating arpeggios or even processing custom MIDI sequences defined by each composer [11].
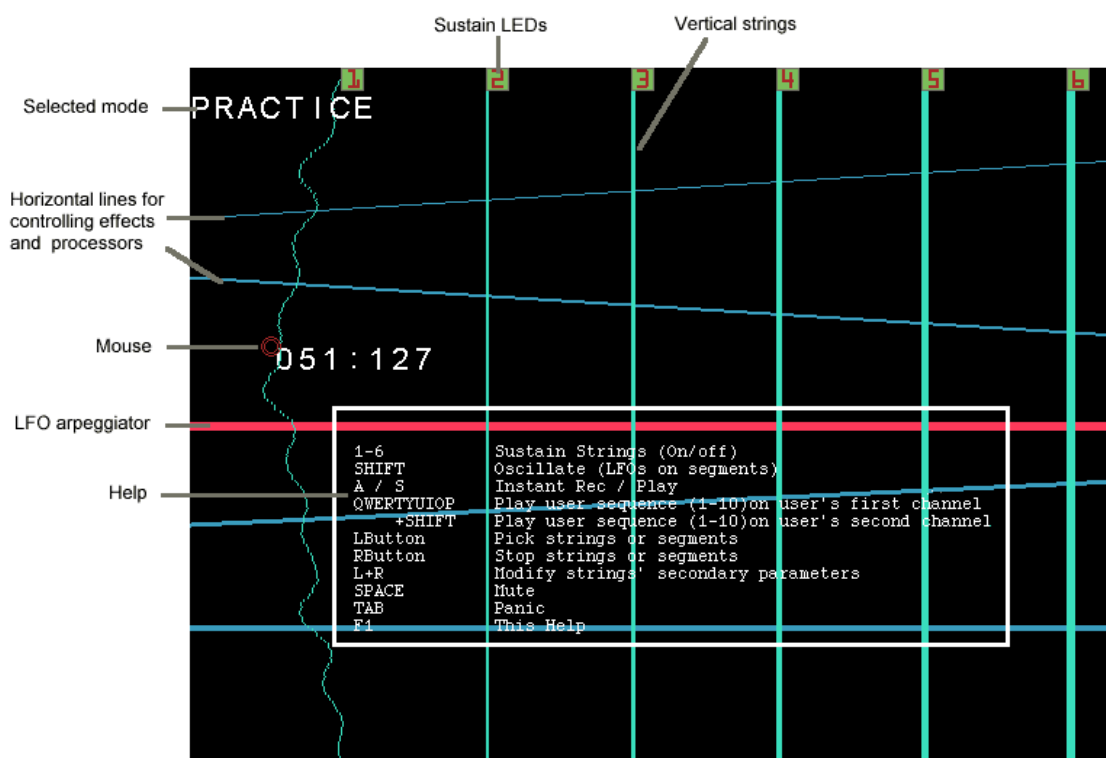

Fig. 2.1. Bamboo snapshot: plucking leftmost string with the mouse while pressing HELP (F1). The circle shows the mouse position, and next to it, its instant values that are being applied to the string two primary parameters.
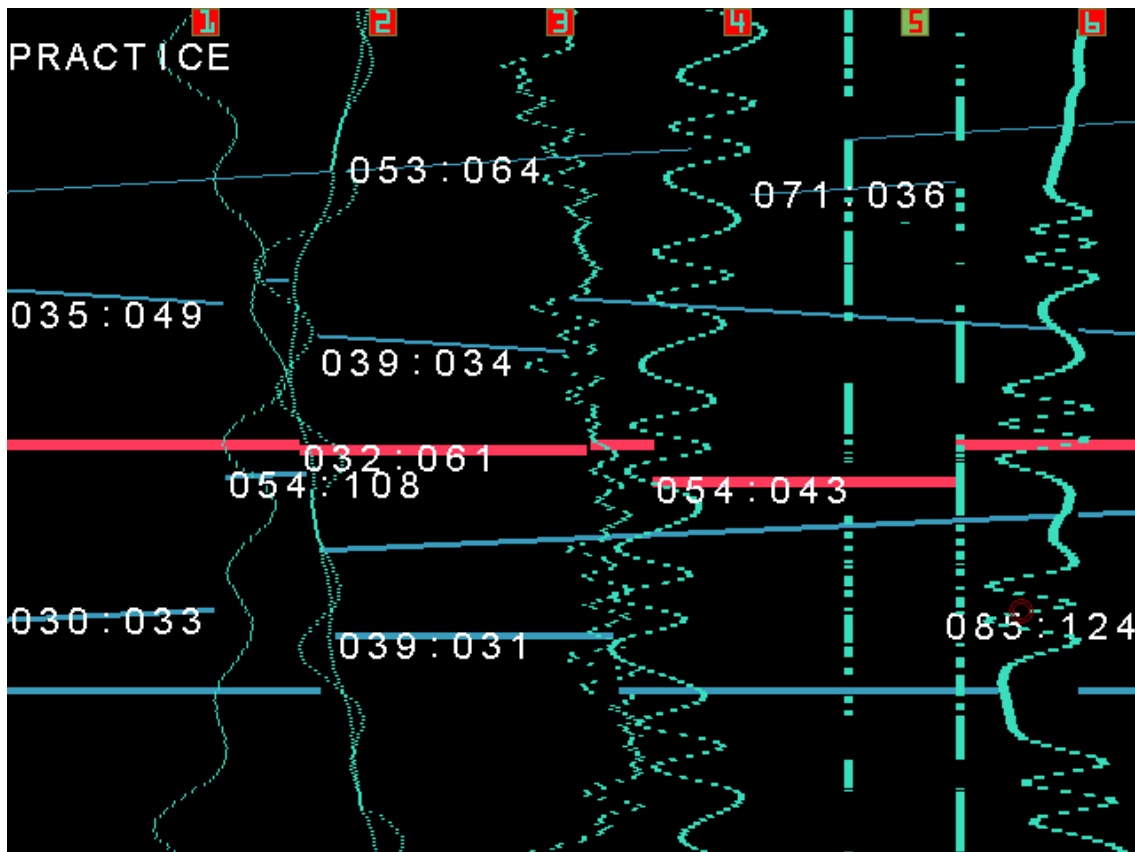
Fig. 2.2. Bamboo in full action: all the strings and processors keep moving and printing their values.

Medusa, the remaining graphical controller interface (shown in Fig.3), is more mysterious and difficult to control. Although it uses the same synthesis kernel, its available presets are more complex (they are more like orchestras or "performances", to borrow a popular MIDI keyboard term). The graphics are magmatic, and the resulting music tends to be thicker, heavier and more continuous, permanently modulating all the synthesis parameters, according to the mouse position, and also to its velocity, acceleration, gestures and trajectories; users cannot know for sure what consequences his/her actions will bring. Whether or not this uncertainty cause Medusa to finally registering less than 12% of the submissions, this imbalance will at least justify why, for the sake of brevity, the next paragraph, which describes the participants' approach to composition focuses mainly in Bamboo.

Fig. 3. Medusa's snapshot: little creatures inhabit a moonlike landscape.

FMOL's Collective Composition Approach

When a composer selects and downloads a piece from the tree, he or she can play it back several times while watching Bamboo's animations. One-layer pieces will activate only the first two strings, while two-layer ones will use the first four and so on. If the piece is not completed the composer can decide to add a new layer, configure the two corresponding strings and effects and assigning instruments from a list of more than 100 presets selectable in a configuration window (see Fig. 4).

Some instruments may have a peculiar string behavior. For instance, strings using *processors* (e.g. Ring or Amplitude Modulators, Pitch Shift, etc.) have to be connected to a previous master string, and will sound and move only when their master does. These kind of instruments allow the reprocessing of previous layers. Also, modifying the pitch or the amplitude may cause different effects depending on the instrument preset. For instance, the Karplus Guitar preset triggers new attacks only when higher amplitudes are received, producing glissandi when moving the mouse vertically. On the contrary, the Karplus Mandolin [12], triggers a new note on every amplitude change.

Once everything is configured, the composer can rehearse for a limitless time or record several takes in real time until he or she feels satisfied and decides to send the expanded piece; sending is as simple as filling in an edit box with one's alias and clicking the SEND button. While fourth-layer composers cannot add new sounds (the Bamboo-

guitar has only six strings), they can mix and balance the previous tracks and add some new effects.
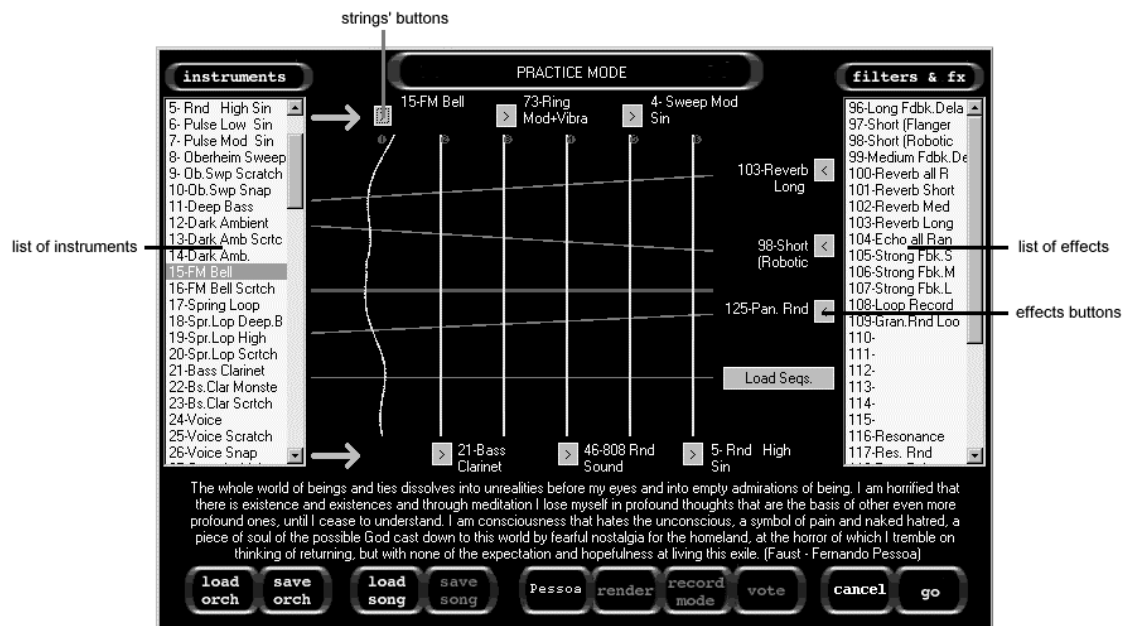

Fig. 4. Snapshot of Bamboo's Configuration Window. The instruments (either generators or parallel processors) available from the leftmost list can be applied to any of the six vertical strings, selecting an item from the list and clicking the corresponding string button. Similarly, the effects (serial processors) from the rightmost list can be applied to any of the three horizontal lines. The text from the bottom is an extract from Fernando Pessoa's Faust. Alternatively, this zone is used for showing context sensitive help. The bottom buttons allow to load and save orchestras and songs, render to audio, etc.

Fig.5. shows Medusa's configuration window. Its approach is quite similar in concept and will not be exposed here. Participants are free to choose between the two graphical interfaces, although -given the two separate trees- themes can only be expanded while keeping the same interface (i.e. hybrid pieces are not allowed). The metaphorical resonances of both are briefly explained in the software's Help information, but apart from these considerations, no specific information about the play is given; composers are not asked to compose for any specific part or scene, as it is La Fura's responsibility to select some of the pieces and allocate them in the soundtrack.
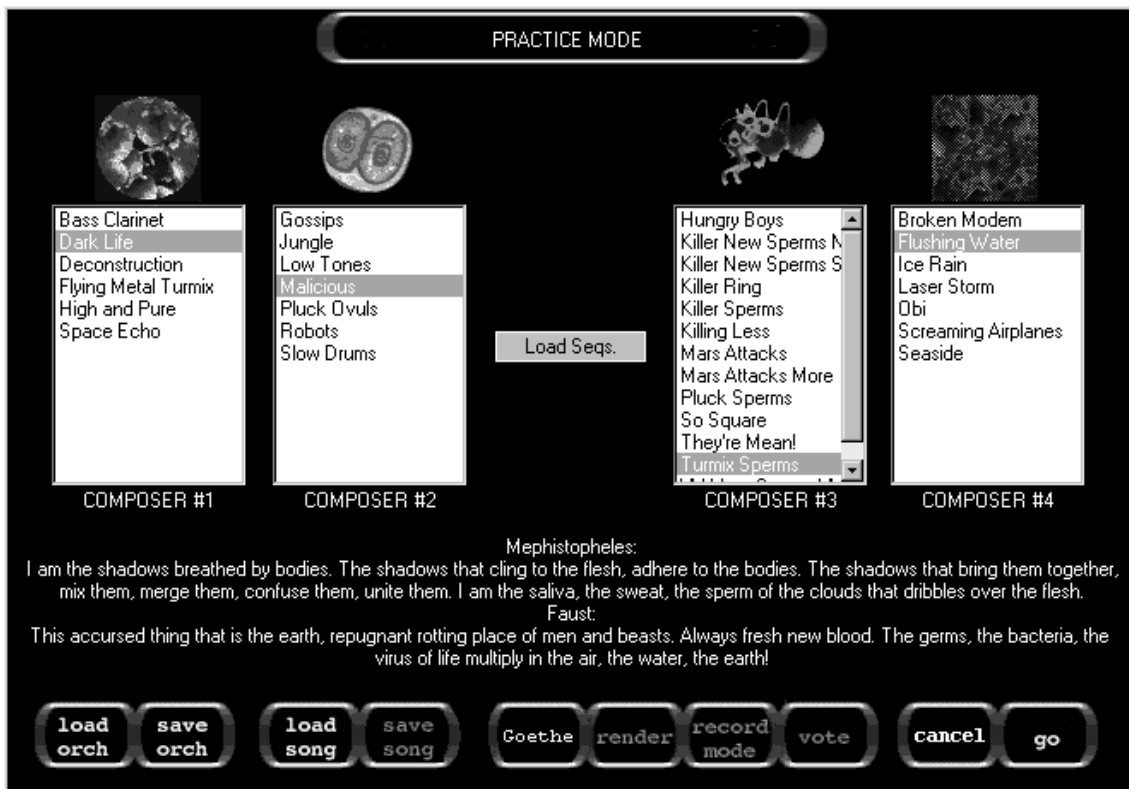
Fig. 5. Snapshot of Medusa's Configuration Window. The four lists show the instruments available at each layer, which means that only one of the four columns can be enabled at any time. Each instrument of these lists uses two audio channels (two generators and six processors); their names try to be only vaguely evocative. The context sensitive help zone displays a fragment from Goethe's Faust.

IS AUTHORSHIP STILL A VALID CONCEPT?

The prevalent use of digital tools and the Internet's communication facilities may be changing the rigid authorship concept that still prevails in music and other arts. As pointed out by both music theorist Kevin Holm-Hudson [13] and British drummer Cris Cutler [14], the use of sampling technology has boosted an appropriationist approach in music (although related possibilities have always been available) that carries both legal and aesthetic ramifications.

Digital data is clonable, which leads to piracy, but it is also manipulable to any degree; and if this data is thrown into a public and easily accessible medium such as the Internet, its chances of development expand, allowing any kind of structural, formal or content redefinitions. When this inevitable process is unwanted by its original creator, the secret evolution of any piece may be hard to follow; but on the occasions when it is desired or encouraged, the resultant collective creations exhibit an artistic expressivity that comprises both the sum of all the participants' work and an expression of all the social interchanges that took place during this interactive process. In this context, copyrights become difficult to define and control, if not questionable, as suggested by cultural reviewer and social critic Crosley Bendix [15] and composer John Oswald [16].

THE AUTHORS' ASSOCIATIONS ARE HERE TO ENLIGHTEN ANY SHADOW OF A DOUBT

My beliefs concerning the copyright question are close to Bendix's position, and this topic was, in fact, one of my major interests when accepting La Fura's initial project. Ironically enough, things took a perverse gloss when La Fura, who was looking for FMOL sponsors, convinced the Sociedad General de Autores y Editores (SGAE-the Spanish authors' association) to produce it. Not only did the SGAE finance and promote it, but they also worked on the database server programming, which they hosted (together with the downloadable program) on their website for more than one year. In FMOL's main page they also clearly exposed their position and interests:

> The question of intellectual property rights in the new communication media, such as the Internet, CD-ROMs or other formats, is arousing a great deal of confused discussion. It is necessary for initiatives to appear that will provide fresh examples that may be observed and which will create precedents that may shed a ray of light on this new situation. Being aware of the need for these shake-ups, the *Sociedad General de Autores y Editores* (S.G.A.E.) (Spanish Society of Authors and Publishers) backs and produces this project and will simplify formalities for all the writers of the compositions selected by the Fura dels Baus to be registered at the society (unless already members of some other association of authors and composers) in order that they may receive their lawful rights [17].

Changes were made in the program's conception, concerning authors' registration. While any "internaut" can download the application, listen to stored pieces or rehearse with the instruments, users have to register with SGAE before sending a contribution. This simple process is done within the application by filling in a form with fields for name, alias, and E-mail address (optional check-boxes allow everything except the alias to be hidden to other users); a few seconds after this information has been posted, the host sends back a password that the registered composer must use whenever submitting a new piece.

As a collective composition simulation game, FMOL is a closed ecosystem in which all of its inhabitants (few and identified) agree to play by the rules. The full control exertable over the FMOL world obviously has nothing to do with any real and open Internet situation. However, as I will later detail, the SGAE (and some authors) may be satisfied: all the composers of the pieces that were selected and are now part of F@ust's score are receiving their lawful rights.

FMOL'S FIRST BALANCE SHEET

In mid-January 1998 (three months before the Barcelona premiere), the FMOL web site -including the downloadable software, an empty database and additional information about the project- went on-line at the SGAE's site [18]. From 18 January to 16 April 1998 (the last date for the reception of pieces for the show), more than 1,100 brief pieces by around 100 composers were submitted. The more assiduous (about 20 authors) constituted a virtual family, which communicated nightly, exchanging sounds and creating music collectively without knowing each other. These were the FMOL "junkies" -creators who spent several hours a week during a three-month period, and with whom I exchanged numerous technical and esthetic issues. Given the SGAE

promotion, this influx may seem somewhat poor, but the existence of this select and faithful core group was enough to justify all effort involved.

One of our main goals (i.e. to conceive an engine and a graphical interface which could be attractive to both trained and untrained electronic musicians) was fully attained. We now know that several of the participants had never had prior contact with experimental electronic music; a few were even composing for the first time, but all of them took it, however, as a rather serious game, and the final quality level of the contributions was impressive (during this period I did also receive many E-mail from more orthodox composers who, though puzzled and confused by that "crazy" piece of software, still wanted to collaborate with La Fura in a more traditional manner).

We then began a difficult selection process, as only about 50 short pieces could be chosen and included on the show's soundtrack. For each piece, the percentage contributed by each composer was estimated according to the number of selected layers, which meant that a composer could own 25%, 50%, 75% or 100% of the rights of a given piece. The elected authors who were still not members of any association, were quickly registered with the SGAE, with their corresponding percentages.

THE FMOL CD: GOING DEEP INTO ECOLOGICAL ART

During the selection process, it became clear that a great number of interesting microcompositions -and the good job done by many unknown authors- had to be left aside. Moreover, many pieces were begging for an expanded development beyond the 20-second limitation. What were we going to do with the thousands of hours composers had spent playing with our toy? What would happen to the 7 hours of music stored in the SGAE's host? For all these reasons, I made a new "ecological" [19] proposal both to La Fura and to the SGAE: why not produce a CD with new compositions, but all of them being based on the audio material stocked in the database?

In September 98, some of the top FMOL composers (together with new guests), were asked to contribute, and each one received a CD-ROM with more than two hundred 20-second pieces selected from the database (already rendered to audio to simplify the job). The only rule: everything is allowed as long as the raw material is FMOL. And so composers started to cut, paste, overdub and process their favorite bits, composing totally new and longer pieces (but keeping track of the fragments used!) [20]. When the CD was released two months later [21], the new "copyright question" was more complicated and surreal than before. The rights for these new pieces were finally divided into two parts: 50% for the "remixer" and 50% for the authors of the utilized layers (which in some pieces numbered more than 20!).

CONCLUSIONS

I have found working on FMOL to be a very enriching experience for many reasons. First of all, the chance to producing radically experimental and, at the same time, wide and "popular" projects, is not very common. Users' feedback, although not massive has been encouraging, as it seems that many people are ready and willing to expand their

ears. Many of the composers who where not particularly involved in non-dance electronic music have told us that they now listen to sound in a different manner and with a new sensibility. They all have helped to prove the Internet's immense creative potential, too often discarded by crowds hooked on instantaneous pleasure who navigate through the Web as if it were an infinite, zapping TV. As an additional reward, FMOL received the first prize in the multimedia category at the 3rd International Musical Software Competition / Bourges 1998 [22].

As of May 1999, FMOL further developments involving FMOL have taken different courses. After the amazing real-time synthesis software avalanche we have been experiencing this last year, revamping the synthesis engine is no longer a big priority. I am, however, expanding Bamboo's possibilities as a synthesis controller specially oriented to performance. Along the same lines, I'm also planning to develop a King Size Bamboo version, which will use sensors (data gloves? video detection? ...) to capture the performer's hand positions over a 3x2 meters retro-projected bamboo screen [23].

On the other side, La Fura has retained its interest in collective creation on the Internet, and we are now working together in two new, related projects: *Big Opera Mundi* an "Internet global show" for the end of the millenium [24], and the opera *Don Quijote en Barcelona*, which will be premiered at the Liceo de Barcelona the year 2000. In *Don Quijote* some musical fragments will also be Internet-composed, for which we are developing an FMOL-inspired version for orchestra (!), which may be ready by the beginning of 2000. We will probably keep the tree paradigm unchanged, but as composers at their computers will be hearing MIDI, the Java applet solution will probably work this time. The interface will also be a more typical sequencer-oriented one and the sonic results less challenging, but the project should surely attract those more orthodox composers who were puzzled by FMOL - not everyone has had the chance to write for a full orchestra!

APPENDIX A: FMOL SYNTHESIS KERNEL

Generators, Processors, Modulators

FMOL handles up to eight simultaneous stereo buffers or tracks. Each track is made up of a generator and three chained serial processors. Moreover, for each track (except for track 1) the generator can in fact behave as a parallel processor. A processor of this kind, takes its input from the output of any of the lower buffers (i.e. channel 5 can be configured to process channel 1, 2, 3 or 4). The main difference between a parallel and a serial processor is that the former has a buffer of its own, while serial processors do always READ from and WRITE to the same buffer.

Each generator or processor can be configured with a maximum of 32 parameters, four of which can be modulated by four independent LFOs (low frequency oscillators) with frequencies ranging between 0.1 and 12.5 Hz. The type of each oscillator or LFO can also be dynamically configured (sinusoidal, square, triangular, saw tooth or random). Therefore 128 LFOs (4 LFOs/plug-in * 4 plug-ins/track * 8 tracks) can be active simultaneously. Fig. 6 illustrates this structure.
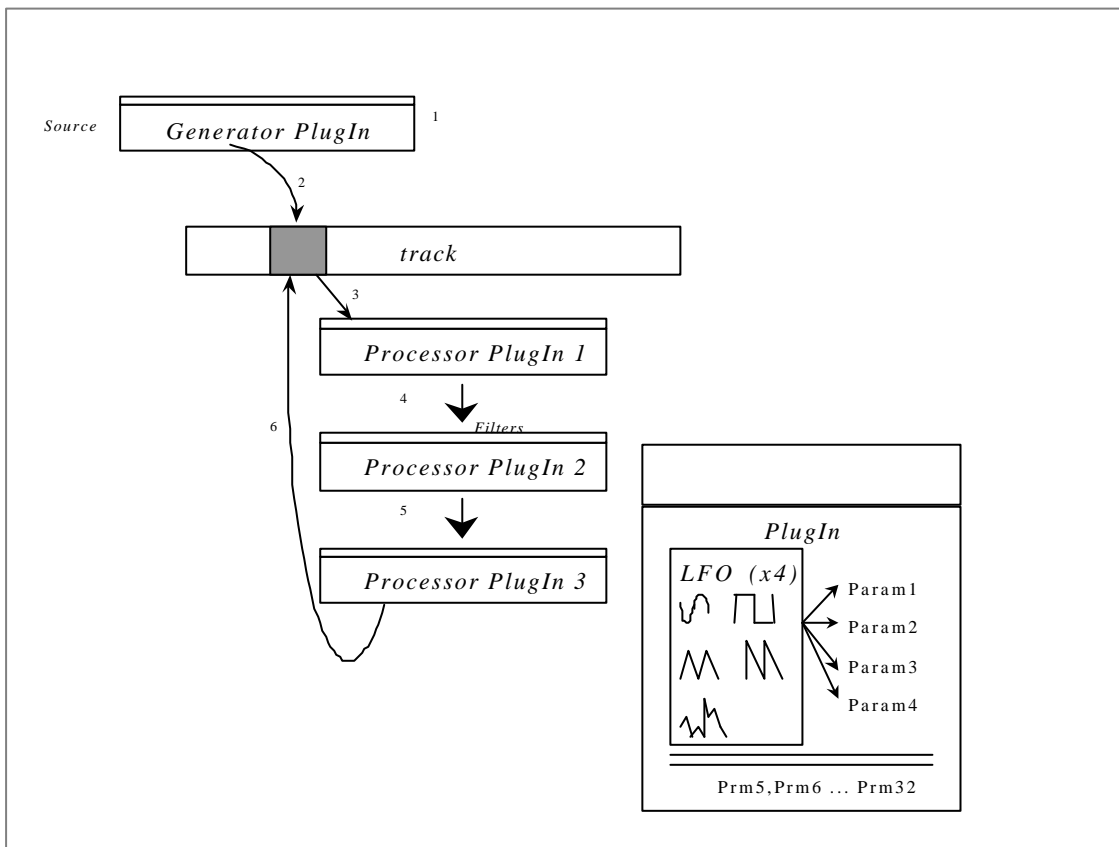

Fig. 6. Scheme showing the generators, processors and oscillators structure of one of the eight FMOL available audio channels or tracks. Each track uses an independent audio buffer, a sound generator and three serial processors. The grey square represents the frame being computed at that time, and the numbers (1 to 6) show the order in which the internal steps are carried. This process is done at a 25-frames/second rate for each track. Furthermore, each plug-in (both generators and processors) has four available oscillators that control the plug-in four primary parameters (secondary parameters are used to dynamically control the frequency and the amplitude of the oscillators themselves.

Algorithms and Presets

FMOL 1.0 has about 20 different synthesis or processing algorithms. As mentioned earlier, these algorithms were selected primary for its computing speed (they all operate, for instance, on the time domain), but together they constitute a heterodox and flexible palette. Moreover, due to their many configuration parameters, these 20 basic algorithms are used to build the more than 100 patches or presets selectable from the configuration screen shown in Fig. 3. This number of presets can be expanded without recompiling the program, just by editing a configuration text file.

These algorithms can be grouped in six different families (basic oscillators, sample players, modulation techniques, feedback algorithms, linear difference equation filters and other heterogeneous processing techniques). A complete list is included in Table 1.

Algorithm	Type	Param. 1	Param. 2
BASIC OSCILLATORS			
Sine Wave	Generator	Pitch	Amplitude
Square Wave	Generator	Pitch	Amplitude
Sawtooth Wave	Generator	Pitch	Amplitude
Triangular Wave	Generator	Pitch	Amplitude
Pulse Train	Generator	Pitch	Amplitude
White Noise	Generator	NO	Amplitude
SAMPLE PLAYERS			
Sample Player	Generator	Pitch	Amplitude
Wavetable Sample Player	Generator	Wave Sound #	Amplitude
Scratch Sample Player	Generator	Frequency	Amplitude
BASIC MODULATORS			
Ring Modulation	Processor	Pitch	Modul %
Amplitude Modulation	Processor	Pitch	Modul %
FEEDBACK ALGORITHMS			
Karplus-Strong	Generator	Pitch	Amplitude
Binary Modulation	Generator	Primary Pitch	Amplitude
Karplus-Strong Processor	Processor	Pitch	NO
Binary Mod. Processor	Processor	Primary Pitch	NO
LINEAR DIFFERENCE EQUATION FILTERS			
High-Low Filter	Processor	Cutoff Freq.	NO
Resonant Filter	Processor	Res. Freq.	Q
Comb Reverb	Processor	Feedback	Delay
Comb Eco	Processor	Feedback	Delay
Comb Delay	Processor	NO	Delay
Comb Comb	Processor	Gain	Delay
OTHERS			
Pitch Shift	Processor	Pitch Shift	NO
Panning	Processor	Angle	NO
Line In	Generator	NO	NO

Table 1. FMOL algorithms and their two primary parameters.

1. "The drama of F@ust 3.0 starts in Faust's dissatisfaction with the impossibility of knowledge, that, in the age of Internet, does not lie in the superiority of nature and the weakness of human knowledge, but in the surplus of information: fragmentary information that creates the hallucination of absolute knowledge, the vertigo of false knowledge, an enciclopedism on a world wide scale." La Fura dels Baus, "F@ust v3.0", (Barcelona , Spain: Institut d'Edicions de la Diputació de Barcelona, 1998). Accessible on-line at <http://www.lafura.com/eng/fausto/infofau.htm>.

2. In 1978, J. Bischoff, R. Gold and J. Horton, formed the *The League of Automatic Music Composers* and started performing *local network* improvisations. "With the introduction of micro-processors at a

reasonable cost, composers can now own microcomputers, and true computer bands, free from major institutions, are possible. Though such bands can take many forms, network music seems the most suitable and contemporary". J. Bischoff, R. Gold and J. Horton, "Music for an Interactive Network of Computers." Computer Music Journal, Vol. 2, No.3, 24-29 (1978). Reprinted in C. Roads. and J. Strawn, eds., The Foundations of Computer Music, Cambridge, Massachusetts : The MIT Press. pp. 588 - 600 (1985).

3. Readers can visit *Res Rocket Surfer* website and download the software at <http://www.resrocket.com>.

4. Although the reasons that made La Fura choose both symbols escape me, the reader may want to know that in Spanish, "Medusa" not only refers to the mythological gorgon that turned everyone she looked at into stone, but it is also the word for jelly-fish.

5. PITEL is a software environment for polyphonic real-time composition and improvisation, based on non-linear recurrence. Written in MAX and C, it can generate, under the control of a "mouse conductor" up to eight voices in the form of MIDI data, while optionally listening and reacting to one or two external MIDI players. Readers can download the software (MAX version), at the Laboratorio de Informática y Electrónica Musical website, <http://www.mcu.es/liem-cdmc/LIEM_Software.html>. S. Jordà, "A Real-Time MIDI Composer and Interactive Improviser by Means of Feedback Systems" <I>International Computer Music Conference Proceedings<D> (1991). S. Jordà, "Componiendo en tiempo real---improvisación musical por ordenador" unpublished article in Spanish, <http://www.iua.upf.es/~sergi/comptreal.htm>, (1993).

6. The QWERTYCaster is a low-tech guitar-shaped electronic instrument (hardware and software combination) I exclusively use for free improvisation. It is made of a QWERTY computer keyboard ("strings"), a trackball ("frets") and a joystick pad ("lever"), all held together in a guitar-like piece of wood. Its four continuous controllers (two degrees of freedom for the trackball and two for the joystick), together with the triggers, buttons and keyboard, steer an old 486 computer with an AWE-32 card sampler and a simple but effective MIDI software. The aim of this instrument (which I designed solely for myself) is to have a fast and direct audio output in response to every movement or gesture the player makes (unlike PITEL [6], which is very "algorithmic" and inertial, but not unlike Nicolas Collins "Trombone" or Michael Waisvisz "Hands").

7. Since 1994 the multimedia performance of EPIZOO (produced by Marcel.lí Antúnez, Sergi Jordá and LOMA productions) turns users/audience into potential transmitters of tele-pleasure and/or tele-pain. EPIZOO integrates elements of performance, installations, body art, videogames and multimedia applications so that the public may play with (or torture) the performer's naked body via the graphic interface of a computer. The nose, ears, mouth, chest, and thighs of the performer are generously offered, together with the possibility of modifying the graphic animation, music, lighting and the entire course of the piece. See R. Lozano-Hemmer, "Perverting Technological Correctness" Leonardo, Vol. 29, No. 1, (1996). More information about EPIZOO can be found at <http://www.iua.upf.es/~sergi/epizoo.htm> (1994).

8. The term "synthesis engine" is used in this article to define both the low-level architecture of the virtual synthesizer and its collection of synthesis and processing primitives.

9. S. Jordà, "FMOL's Synth Engine" <http://www.iua.upf.es/~sergi/FMOL/syntmain.htm> (1998). S. Jordà, "FMOL: A graphical and net oriented approach to interactive sonic composition and real-time synthesis for low cost computer systems", 98 Digital Audio Effects Workshop Proceedings, Barcelona (1998).

10. FMOL real-time control is internally carried by means of MIDI messages conveniently mapped (the engine makes use of all 128 possible control messages on 8 channels), and FMOL scorefiles are Standard MIDI Files with additional headers containing information about their authors and times of creation. The reasons for this decision (instead of choosing a more synthesis-oriented format like CSound) are discussed in [11] *MIDI Control and Mapping*, where a detailed description of the MIDI mapping is also given.

11. S. Jordà, "FMOL's Graphic Interfaces" <http://www.iua.upf.es/~sergi/FMOL/ graphmain.htm>, (1998).

12. This term is a little joke motivated by the continuous triggering of notes associated with any mouse movement. Both instruments (*Karplus Guitar* and *Karplus Mandolin*) use the same Karplus-Strong plucked-string algorithm, a very efficient physical modeling synthesis method, first described by K. Karplus and A. Strong. For a detailed description of its implementation, refer to: K. Karplus and A. Strong, "Digital synthesis of plucked string and drum timbres." Computer Music Journal, Vol. 7, No.2, 43-55 (1983). Reprinted in C. Roads, ed., The Music Machine, Cambridge, Massachusetts : The MIT Press (1989).

13. K. Holm-Hudson, "Quotation and Context: Sampling and John Oswald's Plunderphonics", Leonardo Music Journal Vol.7, 17-25 (1997).

14. "Existing recordings are not randomly or instrumentally incorporated so much as they become the simultaneous subject and object of a creative work. Current copyright law is unable to distinguish between a plagiarized and a new work in such cases, since its concerns are still drawn back from pen and paper paradigms."
"The positive exploration of new worlds of sound and new possibilities of aestheticization, or the idea that there is no need to originate any more since what is already there offers such endless possibilities, or an implied helplessness in the face of contemporary conditions - i.e, everything that *can* be done has been done and we can only rearrange the pieces." Cris Cutler, "Plunderphonia" MusicWorks No. 60, 6-19 (1994). Quoted on Holm-Hudson [13].

15. "It is now time to drastically revise the outmoded copyright laws, particularly with regard to the content of electronic media - meaning anything that is experienced via reproducing equipment the public possesses. The revision of copyright protections is now necessary, because media artists of every variety have long since left Congressional intentions of cultural ownership in the rear view mirror. This, I believe, is as it should be. But, in doing so, today's artists are driving their sporty little art illegally. They can be pulled over and sent to debtor's prison because their only license is an artistic one." C. Bendix, " the audio/visual irritant and copyright", < http://www.irritant.com/copyright.html>.

"A more generous and enlightened approach to copyright law would have it prohibit straight-across bootlegging, provide cover version royalties, and practically nothing else. Virtually all the volumes of statutes which now go far beyond this are not only unnecessary, but counter-productive to the now common practice of piecemeal appropriation in the creation of new work. The crucial difference between simply bootlegging entire works in order to profit from someone else's creativity and the creation of new work which incorporates elements of existing work for the referential or commentary effects thus produced must be made clear to lawmakers. The present "broad brush" of copyright law is acting to censor what artists want to do. Not a desirable role for government." Transcribed from a Crosley Bendix interview that appeared on a CD that came with Negativland's now unavailable magazine "The Letter U and the Numeral 2". The full transcription can be found at <http://www.negativland.com/crosley.html>.

16. Holm-Hudson [13].

17. Fundación Autor, <http://www.sgae.es/fmol/dere_ing.html >, (1998).

18. Readers can visit the FMOL official website and download the software <http://www.sgae.es/fmol >.

19. Printing up plastic CDs is by no means more ecological than storing the files in an on-line archive. The term has to be understood here as the desire to create new pieces of art by recycling existing ones.

20. Some months after the edition of the FMOL CD I discovered *Dub Zap*, a proposal by Ios Smolders. *Dub Zap ^{TM} 1.0 Standard Edition* is a double CD-Extra which combines many very short audio tracks (by different musicians such as John Oswald, Gil Evans, Naked City, Plastikman, Pierre Henry and many others) with shareware audio editing software for both Mac and PC.

"Enjoy, take your pick, zap along the numerous tracks. Mix your favourites into a new combination, thus forming a new composition... The really bold ones among you load these sounds into their CD player and, by using Cool Edit 96 or, for the Mac fan D-SoundPro, that is also delivered in this box, make jelly of the envelopes once again." Extracted from the *Dub Zap ^{TM} 1.0 Standard Edition* CD documentation. Staalplaat STCD120 (1998).

"The owner of *Dub Zap ^{TM} Standard Edition* is allowed to use the sounds as sound source for a new creative project. A new product then either consists of maximum 25% of the original *Dub Zap ^{TM} Standard Edition* or the original material has been edited thoroughly. The producer of this new project must notify Ios Smolders and, if any product is derived from this project, one copy of the product must be sent to Ios Smolders." Extracted from the *Dub Zap ^{TM} 1.0 Standard Edition* CD documentation. Staalplaat STCD120 (1998).

Since the release of this CD, 11 artists have been invited to elaborate the sound material on DUB ZAP Standard, and the results have been published as *Dub Zap ^{TM} Pro version*, Staalplaat STCD134 (1998). Visit <http://www.earlabs.org> and <http://staalplat.com> for additional information.

21. La Fura dels Baus / Sergi Jordà and other authors, "F@UST 3.0 - FMOL", CD Audio, (Fundación Autor, 1998).

22. Readers can visit *the Institut International de Musique Electroacoustique de Bourges* website at <http://www.gmeb.fr/>.

23. There is already an FMOL "installation version" called *the Zumbotron*, produced by La Fura dels Baus. It consists of a telephone-like transparent cabin for two persons, equipped with a big computer screen, many speakers (including a 20 inches subwoofer under the floor!) and a 1000 W power amp. Entering the cabin and playing bamboo's 10 Hz lower frequencies under your feet, is definitely an infrasonic experience!

24. "BOM 2000 proposes the creation of a global show which following the progress of time on the globe, crosses earth's 24 time zones while the day, the century and the millenium change from the 31st of December 1999 to the 1st of January 2000. BOM structure joins together different creative and communication elements to reach the total show. The three main foundations are scenic actions, the Net and TV. The net, due to its proven possibility to stir up collective creation, becomes the best test bench for the final project". La Fura dels Baus, "BOM 2000" (internal documentation, 1999). More information will be regularly published at La Fura's website <http://www.lafura.com>.