Digital management, replay and preservation of musical works through a strongly-commited ontology development

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Abstract

During last centuries, preservation and transmission of musical works were based on a three-tiered stable cultural substrate: score, organology, instrument-making. The advent of digital electronic systems and has revolutionized the world of music composition, destabilizing secular traditions and endangering the preservation of contemporary music. Given the need to update the works to address obsolescence, it seems essential to study the composition process, to extract the relevant information needed to recover some of the composer's original intentions. Our approach is based both on production process modeling and on the creation of a language to represent these composition practices. This language will be the basis for an environment to capture and navigate within a workflow.

1 Introduction

Musical composition practices adapt to technologies of the moment, and sometimes shape them, as they evolve in step with their instruments. Over time, works are born, live and die: some remain, particularly through their symbolic value or popularity, leading to transmission of know-how allowing their reproducibility. In a tradition deeply rooted in culture, music was transmitted until the last century using the score, a stable cultural substrate allowing to abstract sound to return to it with the instrument.

Nowadays, new technologies have transformed the approach to classical music representation: it is now possible to record sound and manipulate it directly. Therefore, music may be played, created or retained without any intermediate representation need. However, there is a strong dependence on technological tools for accessing music, while the score has resisted changes in the instruments and playback modes.

This fragility is unique: we always try to emancipate ourselves from the contingency of human memory, but now we create in return a dependency to technology because we have no more invariant to abstract, while the hardware and software devices become obsolete very quickly. Recognizing this lack, we wish to define, via a *representation language* for audio content as a representation invariant: it will allow to update the works on new technologies of the moment.

Our contribution will focus on the approach developed within the Gamelan project and especially on the early stages of creating a representation language for audio content that will develop tools to better back related electronic documents migration. We begin by presenting the context of musical composition and the preservation issue that arises, then we will discuss the methodology developed to study the creation and update process made to afford to play and replay works, before ending on current results of the production process modeling.

2 How to reach the replayability of a contemporary work?

2.1 The issue of transmission and re-interpretation of works with electronics

During the last century, the composer has evolved the practice of composition, especially with the advent of electronic and digital systems, from *notes* to *sounds*: "we live, at the beginning of XX$^{\text{th}}$ century, a true organological seething, where acoustic instruments, analog and digital technologies from computer science form an increasingly integrated system" [15].

These musical practices pose directly the problem of preservation, as they depart drastically from the three pillars of the multi-secular classical theoretical corpus:

- abstract musical notation, the basis of the score;
- organology, which classifies the instruments;
- the music schools, which transmits the instrumental practices.

This loss is related to the computerization of composition tools. These environments are based on computer programs and the IT community is hiding behind the supposed permanence of standardized languages, designating them as the new invariant representation of the work as the score was. But we know very little about the life of a computer language, including how long it will remain legible or interpretable. In addition, there is no certainty as to the preservation of sound reproduction, because the same C program can produce sounds significantly different on several compilation environments [8].

In the case of classical music, a work like the *Sonata in A minor D.821* by Franz Schubert, then composed for Arpeggione, is now played on cello or viola: the partition held its cultural role of substrate capable of transmitting and updating of the work, which is playable on another instrument. In contrast, for the contemporary works (with electronics), extremely rapid technological obsolescence and the lack of stabilized representation, regularly prevent the update of works to bringing them on a new system.

2.2 State of preservation in music today

No perfect method currently allows to preserve a digital creation. Four preservation processes emerge and are used, sometimes combined [6, 12, 5].

The museum backup: preserve tools used during the creation in a working state. This approach is discouraged because it only delays the disappearance of the work without allowing updates; nevertheless, backed by an archiving model (such as Mustica project [1]), it already offers an access to information and execution contexts.

Emulation: simulate native formats reading tools on available environments. Attractive in theory, because skipping over evolution, it is fragile because emulation is not always *perfect* [4].

Migration: update an older version of a piece to make it appropriate to current technology. Migration generally favors open formats supposedly more sustainable [7]. This activity is most used for adaptation of a work in order to replay it.

Virtualization: make the process independent of a computer music platform in particular. But it is not easy to get rid of all dependencies necessary for the proper execution of real-time programs.

A generalist approach lead to the development of *Cyclops*[1], a modeling tool for works life cycle, and was created following *Distance Liquide* Hans Tuschku [10]. This tool enables the development of production scenarios and comments adding on each archived object, which provides representation and a means of accessing these objects [11]. But its use is limited to the documentation of the work.

[1]Caspar European project: `http://www.utc.fr/caspar/`.

2.3 The value of production process

2.3.1 Aiming at replayability by analyzing the process

The ultimate goal, when we address the issue of preserving music, is to allow the *replay* of the work. The problem is not only technical and does not support the simple change that would transmit a fixed copy for generations with little risk of loss. Music belongs – for example with opera, dance, and theater – to the world of *live performance*: that is to say, that runs in live in front of the public. The interpretative dimension in concert situations is essential, far beyond fixed recordings.

To maintain the work *alive*, we wish to better assist its migrations, which remain for us the current methodological reference for preservation. Thus, our research line is not about the creation of a new substrate to abstract music, but aims at a *good* update of works, that is to say that will retain its authenticity. The replay process is the goal: for each new performance, there will be an update on current technologies, which will keep the musical work *updated*. But to replay this process, we must be able to find it back. Consequently, when the need arises, we must be able to assist the update by providing accessible information as comprehensive and useful as possible, to ensure the identity of the work.

2.3.2 Represent the work and its creation

We want to develop a formal language for representation of these processes, allowing access to that information. A significant proportion of the necessary information during a migration of a work can be extracted from such a representation of the compositional process. We do not seek to explain the morphology of the sound (the *what*) but the way it is produced (the *how*).

This language is devoted to the representation of what we might call the "musical level", referring to the "knowledge level" of Allen Newell: we want to represent the work at the right abstraction level, neither too concrete because too technology dependent and therefore highly subject to obsolescence, nor not enough because information would be too vague to be usable [14]. It aims at providing good replayability of music, clarifying what to do to find back the desired electronic documents. However, this encounters a limit: it uses the words of the device used; dependence whose score was able to abstract.

The creation of a language begins with the development of its vocabulary. To implement this lexicon of contemporary musical composition, one must collect all the terms which we must explain the meaning. For this, we first develop a *domain ontology*, which we present with the method used in this article.

2.3.3 Contribution of musical works modeling

Our approach proposes to model within the same representation both the life cycle of a work and the processes of creation and migration of each life stage of the work. This representation overcomes the current lack of generic representation of proprietary software (e.g. the ProTools environment, widespread in the composition world) and differs from traditional strategies that attempt to virtualize the works.

The contribution of this language is twofold. From the purely knowledge engineering point of view, it will link two approaches that are the production cycle modeling and the life cycle modeling, in order to have a global representation that we could dare to name *representation of the work*. From the users point of view, like musicians and computer music designers, this work might seem more pragmatic: the generic representation of the production labor is totally new and necessary, mainly for preservation and learning, and meets a increasingly high demand hitherto remained unanswered, despite some work already done and quite old [13].

3 Methodology for production process modeling

3.1 Approach originality

In knowledge engineering, it is common to begin the modeling phase by a corpus analysis, usually from a collection of candidates-documents selected depending on their relevance, and to use it in order to select and classify words that will be used in the model. But in our case study, we have no written document that can provide support to terms selection: vocabulary, and by extension, all production work relies on musical practices that are acquired more by experience than by teaching. Indeed, every musical work is a *prototype* in the sense of Elie During, as "the most perfect example, the more accurate", where each creation is an object "ideal and experimental": this uniqueness leads to a possibly infinite number of ways to create [9].

Thus, to achieve this essential phase of study, we will design ourselves our corpus, which is rather unusual, by following several productions to find out invariants.

3.2 Ontology development

To create the representation language of production process, we follow the *Archonte*[2] method [2] in three steps:

[2]Architecture for Ontological Elaborating.

1. normalizing meaning of the chosen words and ontological classification in a tree, indicating the similarity relationships between each concept and its parent concept and/or its sibling concepts: we will have a *differential ontology*;

2. formalization of knowledge, by adding properties to concepts or relations binding the fields to obtain a *referential ontology*;

3. operationalization in the language representation in the form of a *computational ontology*.

Following our corpus development phase and the selection of candidate terms, we will take the first step in the form of a taxonomy of concepts in which we will strive to maintain a *strong semantic commitment* in supporting the differential principles, ie the similarity and difference relations. This taxonomy will be performed iteratively, since it is dependent on our participation in various productions. Thus, each new integration with the creation or update of a work, we will flat our taxonomy and the term normalization, to ensure that the semantic commitment is respected. We propose an excerpt of the taxonomy on Fig. 4.2.

4 Current results of the language creation

4.1 Production monitoring results

Project partners – EMI Music France, INA-GRM and IRCAM – have all three different traditions of composition, from creating a band for distribution on CD, the so-called "mixed music" (usually instrument and electronics), through the "concrete music" (initiated by Pierre Schaeffer). Analysis of different productions has allowed us to isolate *types* of music, in Fig. 1, and classify them according to partners [16]. We chose to present in this article two cases representing two emblematic works regarding the issues of preservation, understanding or transmission.

4.1.1 *Saturne*, Hugues Dufourt

Saturne is a work created in 1979 by Hugues Dufourt. It is written for twenty-two musicians, playing classical wind instruments and percussions, but also uses organology of popular tradition, with two electric guitars and two electric organs. Since its creation, the work has undergone several transformations, sometimes major: for example, in 1991, it was ported on a programmable synthesizer. Since this porting, it follows the technological developments, and migration are regularly made because concert organizers program it quite often. We study it because it is a work that not only suffers the ravages of time as all

Music Type	Definition	Study
Acoustic Recording	Traditional music in the classical sense (on score) and after recording in the studio (to create an album for example).	Interviews: - art directors - sound engineers Production monitoring: - classical work
Acousmatic	The musical production performed through manipulation of existing sounds outputs a work on a fixed support.	Interviews: - composers Production monitoring: - indexing issues
"Mixed music"	It integrates into a single representation both elements from sound synthesis or real-time processing performance and elements performed by musicians on traditional instruments.	Interviews: - computer music designers Production monitoring: - work migration

Figure 1: The different study fields.

creation, but also suffers from its dependency on the technology of the moment: in 2006, a port of the work was launched, but failed and a concert was canceled.

The results of our production monitoring has enabled us, through several encounters with Hughes Dufourt and Yann Geslin, representing knowledge, in Fig. 2, that Yann has found during his porting and that were preserved since the creation of the work. This global view allows us to trace the life cycle of the work and to know in a glance what information is available. This simple representation allows anyone wishing to update *Saturne* to know what he or she can mobilize and visualize the transformation milestones.

4.1.2 *Liszt as a Traveler*

Beside the previous studied work of art music using new technologies, we are also interested in another form of music production: the recordings. At first glance, this seems to be a finished object, as the process stops with the production of mastered audio tracks. A review of practices shows that it is not. First, CD works are often the subject of *repurposing*, e.g. a rerun to be on DVD. On the other hand, the three phases of record production – recording, editing, mastering –, are three sub-projects that operate on shared resources in part, separated in time and often contracted out to various stakeholders. This raises a question of transmission, therefore of representation [17].

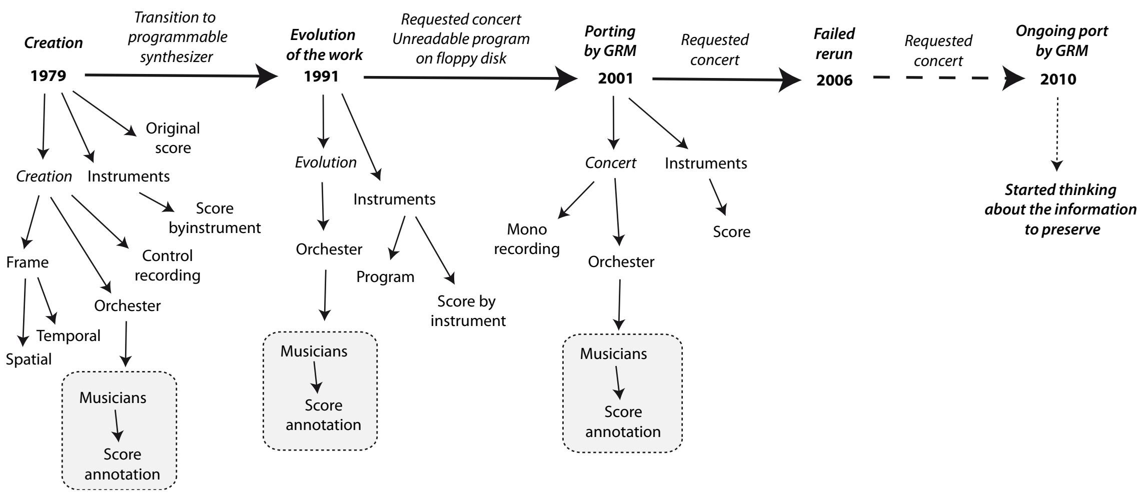

Figure 2: Excerpt from the life cycle of *Saturne*.

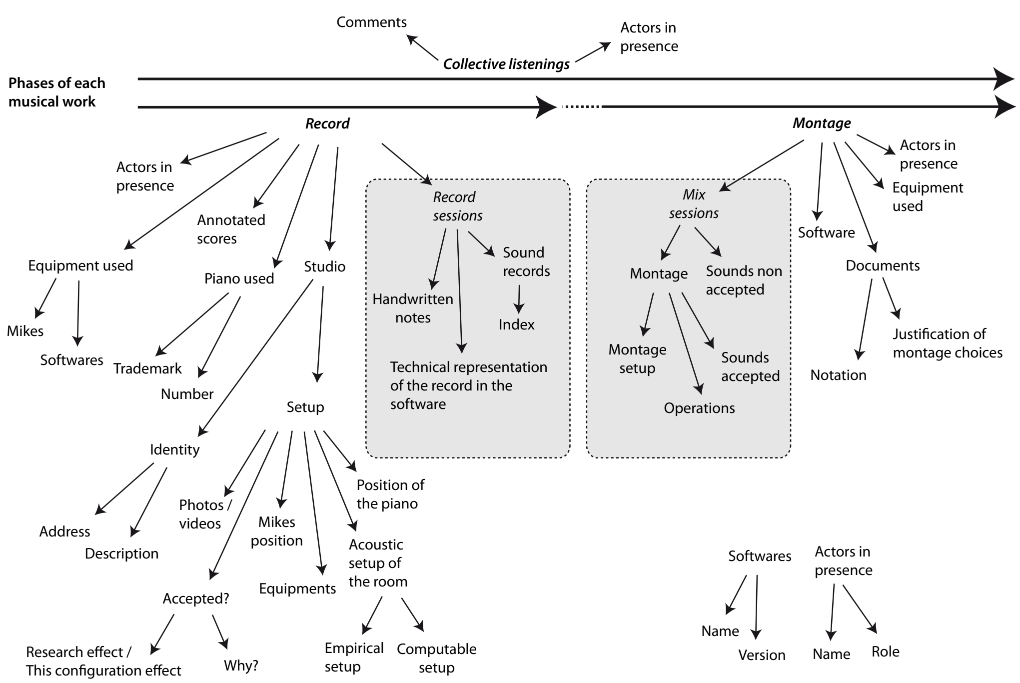

Figure 3: Extractable information from the production of *Liszt as a Traveler*.

This is the reason why we were interested in following the production of a classical piano CD, entitled *Liszt as a Traveler*, recorded by pianist Emmanuelle Swiercz to mark the bicentenary of the birth of Franz Liszt. We had the opportunity to participate in various creation stages and to collect a lot of information. Fig. 3 represents the information that seems worth keeping. We isolated the recording and mixing sessions as they are at the heart of the choices made and very revealing of the way to think up that record.

4.2 Current taxonomy and differential principles

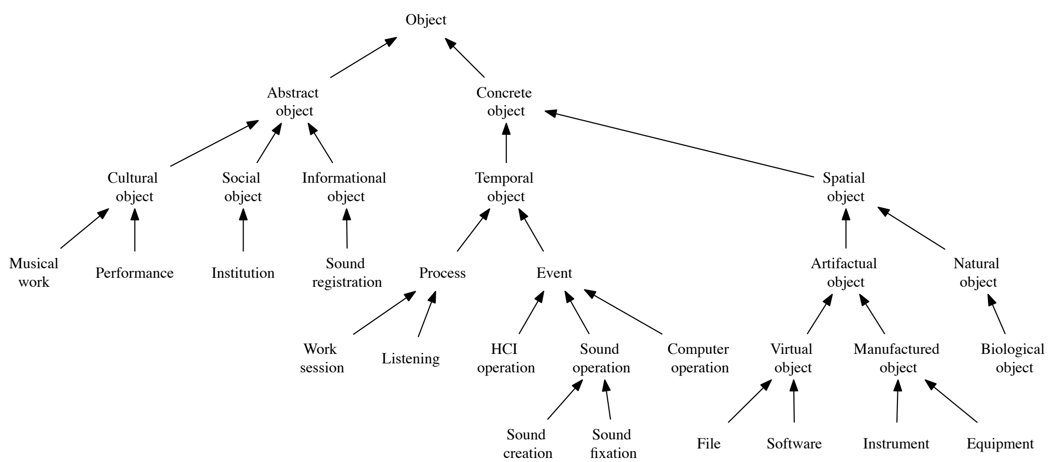

Figure 4: Excerpt from the current taxonomy.

Fig. 4 presents an excerpt of the current taxonomy. Many ramifications were deliberately cut off, to focus on a high part of the tree. Here we find our candidate concepts, which were relocated at each iteration cycle, corresponding to an integration within a compositional process or migration. In developing this structure, we sought to maintain a *strong ontological commitment*, that is to say that for each concept, we ask four questions:

1. Why this concept inherits from the parent concept (*SWP*[3])?
2. Why this concept is it similar to his brother concept (*SWS*[3])?

[3]SWP: similarity with parent — SWS: similarity with siblings — DWS: difference with siblings — DWP: difference with parent.

3. Why is this concept different from his brother concept (DWS^3)?

4. Why is this concept different from the father concept (DWP^3)?

To achieve this semantical normalization work, we used the software DOE [4] [3].

We thus have a *differential ontology*, where the meaning of all terms have been normalized and which helps develop the vocabulary needed to reach the next steps for the representation language of the compositional process.

4.3 Local validation on *Nuages Gris*

To validate the model locally, we used *Nuages Gris*, one of the works recorded for the CD *Liszt as a Traveler*. We present the following events retrieved from the digital recording sessions, formatted from the vocabulary defined by the ontology:

```
[Biologic Object: Alain] - (has role of) -> [art director]
[Biologic Object: Emmanuelle] - (has role of) -> [musician]
[Biologic Object: Alain] - (participates to) -> [Work: Nuages Gris]
[Biologic Object: Emmanuelle] - (participates to) -> [Work: Nuages Gris]
[Biologic Object: Emmanuelle] - (plays) -> [Instrument: Piano]
[Session: Session 1 Nuages Gris] - (is part of) -> [Work: Nuages Gris]
[Track: Track 1] - (is part of) -> [Session: Nuages Gris Session 1]
[Track: Track 2] - (is part of) -> [Session: Nuages Gris Session 1]
[Import: Import 1] - (has source) -> [File: File 1]
[Import: Import 1] - (has destination) -> [Track: Track 1]
[Import: Import 2] - (has source) -> [File: File 2]
[Import: Import 2] - (has destination) -> [Track: Track 2]
[Mix: Mix 1] - (has source) -> [Track: Track 1]
[Mix: Mix 1] - (has source) -> [Track: Track 2]
[Export: Export 1] - (has destination) -> [File: Gray Clouds File]
```

Very little information is represented here (for the sake of simplicity), but we already see the history of operations (create a session and two tracks, import files on each track, then mix between tracks, finally export the result), and the agents (artistic director and musician). We used the ontology to represent a production process, and the extracted information is exploitable. Take the case of musicological study: with the help of captured events, one can find some *intentionality*, according to the choices made during the sessions.

5 Conclusion

We have got a differential ontology which stabilizes and practically no more evolves. We are currently in the second phase: the implementation of the referential ontology and the

[4] http://www.eurecom.fr/˜troncy/DOE/

creation of the representation language for audio content. To build it, we are currently developing a number of *use patterns* that will define composition acts. The use of this patterns will allow to represent a set of actions with a musical sense, incorporating the vocabulary developed in the ontology.

Our integration approach in creations and re-creations of works allows us to access closer to the vision of the different protagonists on preservation issues and needs representation. We hope our work will also influence the development of a storage model, not directly aiming at sustainability but rather at *effective preservation* of all artifacts related to the work and its production, thus ensuring access to an extensive and meaningful documentation.

Other areas of the art world using new technologies may also be interested in the workflow representation as the cinema – and more broadly the audiovisual field –, and contemporary dance which is currently also undergoing research for appropriate representations[5].

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