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DAFNE+: Blockchain for preservation and valorization of experimental music and sound production

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Abstract

DAFNE+ provides digital content creators new forms of creation, distribution and monetization of their works of art through blockchain technology. A new international research and innovation project supported by the European Union (Horizon program), the DAFNE+ platform for fair creative content distribution will empower creators and communities through new digital distribution models based on digital tokens. In an intuitive and simple way, without the need for technical knowledge in blockchains/NFTs, creative communities are invited to join the decentralized autonomous organization (DAO) offering new services and tools that allow the creation and co-creation of content in a blockchain. DAFNE+'s research will also focus on the definition of new business models through the distribution of content, allowing creators and users to monetize multimedia creations. IRCAM's role in DAFNE+ is in particular to organize a community of artists and technology providers on electronic music and sound. Halfway between IRCAM's Forum software and archives of interactive music/sound repertoire, and based on an autonomous organization and distributed infrastructure, the platform will enable artists, researchers and engineers to share and monetize pieces of technology for producing music and performing works - libraries, patches, documentations.

Keywords

Musicology, contemporary music, electronic music, experimental digital arts, web platform, blockchain, NFT, authorship, music programs, digital scores, digital archives, co-creation

1 Introduction

DAFNE+ is a new international research and innovation project supported by the European Union in the framework of the Horizon program. A key aspect of the DAFNE+ consortium is a close, interdisciplinary, co-creative collaboration between stakeholders of technological research and innovation on one side, and artists/creatives on the other side. The design of the platform is based on a study of the needs of different communities in three application areas: User Generated Content for cultural heritage content, the Music creation (IRCAM's use case), and novel forms of media for artistic content. This paper focuses on the second use-case led by IRCAM.

1.1 IRCAM, a key-partner of DAFNE+

The Institute for Acoustic/Music Research and Coordination IRCAM is today one of the largest public research centres in the world articulating musical creation and scientific research. A unique place where artistic foresight and scientific and technological innovation converge. IRCAM's original framework as an organization has been since its inception in 1977, as a component of the Centre Pompidou's project, to gather researchers, engineers and artists in a single place and organize productive interactions between them. Its research lab entitled STMS (Science and Technology of Music and Sound) gathers 100-150 researchers, faculty and engineers specialized in all scientific fields related to music and sound. The artistic and production departments commission and host some of the greatest composers of our time for producing 30 new artworks every year, mostly live performance music pieces based on IRCAM's latest technology. Beyond the presence of artists, a specificity of the lab in the academic world is indeed that most research teams include engineers who develop and maintain over years dozens of technical environments and modules (mostly software but also hardware) that integrate new research results and make them available to artists for their own production. In addition, IRCAM's technology is licensed to many companies, not only for music production tools but more broadly for audio-visual and multimedia production, music distribution, automotive, healthcare, etc.

1.2 The IRCAM Forum: A precursor

The IRCAM Forum was founded 30 years ago in order to make the IRCAM non-commercial technologies available to external users, mostly artists - composers, performers, sound designers, sound engineers, but also researchers and teachers, engineers, etc. The main vectors for this interaction between IRCAM research teams as technology producers and these users are the forum.ircam.fr web platform and the organisation of the IRCAM Forum Workshops gathering part of the community every year at IRCAM and in various countries in collaboration with partner institutions. From a platform of distribution of IRCAM technology, the Forum website turned from 2019 to a community platform, enabling members to publish their own content (software distributions, articles, events) and exchange in specialised discussion groups and collaborate on code through an internal git-based repository system. An important component of the

IRCAM Forum is also to manage the documentation and promotion of the technology through the editorial production of related tutorials, teasers, user documentations in various forms (text documents, sound examples, videos, etc.). Technology distribution in the Forum platform is done through the *Project* model that can include any set of digital elements including code and data, examples, tutorials, etc. in dedicated archives. Projects can be created directly in the platform CMS, as well as mirrors from external source repositories such as GitHub.

1.3 The IRCAM technological ecosystem

For several decades, the main target environment for IRCAM's live performance production has been the *Max* (formerly Max/MSP) application, licensed to and marketed by the Californian Cycling'74 company. Max enables non-professional programmers to graphically program and execute real-time audio and music and image processing algorithms and their user control interfaces from a huge set of objects based on a published API. Most music pieces produced at IRCAM combining live performers and real-time computer processing are based on the development of a set of dedicated Max patches. Algorithms resulting from IRCAM's research are developed in C/C++ and made available to artists as new Max external objects, extending the existing features. In addition to Max as a runtime, Max patches can be developed as MaxForLive plugins to run in the Ableton Live environment, with a simpler user interface hiding the programming layers and making them available to a broad community of live electronic musicians.

Some of the objects developed for Max are also developed for the free, open-source sister environment **Pure Data**. The communities using Max and PureData are similar but do not always overlap.

Other computer languages are developed and used within IRCAM for the development of programming environments. This is the case of LISP and LUA for the **Modalys** and **OpenMusic** environments (more than 100K downloads since its creation). The high-level asynchronous language **Antescofo** allows the control of **SuperCollider**, as well as other sound operators such as **FAUST**.

Finally, **Matlab**, **Python**, **C/C++** languages are widely used within the institute for the development of libraries and standalone software. A **git-based forge** is shared by the research teams to pool tools and resources for deep learning, continuous integration, and source code versioning.

1.4 Private and shared artwork repositories: the Sidney database

The IRCAM Forum is focused on tools for artistic production. In addition, IRCAM manages through its Sidney [1] internal platform a private database of all versions of work repositories produced at IRCAM containing archives of all the digital elements needed to perform interactive pieces (patches, sounds, documentations, etc.). More broadly in the international computer music community, and despite various expressed marks of interest and related studies there has

been up to now no large scale published database of experimental sound/music work repositories.

1.5 Collaborative archiving and creative preservation: the Antony project

Storing, documenting and sharing contemporary music materials is a problem faced by many organizations. Beyond the usual difficulty to find financial resources to work on databases before they can even exist and the challenge to specify and implement a data model that ideally fits for everyone, the specificity of such data is both related to the extreme heterogeneity of the file repositories and their evolution in time.

Starting from the base of the Sidney application and methodologies, a work group has been created inside the French computer music association with several actors of the ecosystem (IRCAM, CNSMDP, Univ. St Etienne, Univ. Paris 8, GRAME) in order to study and propose some common methodologies that would provide better approaches to manage musical data in the long term, especially for generative and interactive pieces [2][3]. The resulting guidelines of this 2-year study are:

1. The code of any content management system for long term archiving should be libre and open source [4]
2. The storage system should be distributed and secured.
3. The data model should follow or extend standard and normative semantical models (like FRBR or CIDOC-CRM).
4. The workflow rules should engage external contributions to maintain the playability of a piece although the technical execution environment varies [5].
5. The granularity of the repositories needs to be exposed for pedagogical and dissemination reasons.
6. The versions of an artistic work as a result of the contributions should be referenced to the original work [6].

To resolve points 4 and 5, a git-based code management has been proposed. Not only it provides a continuity and historicity during the contribution, but it also ensures that the versions of the source code can be differentiable between them and identified uniquely as commits or tags. Practically, it also gives the possibility to create branches to develop, test and prototype new future versions. Of course, this is a very common workflow in engineering and code development but not as usual in the musical use cases.

1.6 Current distribution platforms

Unlike the happy few ones supported by the mainstream music industry organizing massive record publishing and live events, and in absence of any dedicated social networks, most artists involved in electronic music and sound participate in experimental art with few possibilities of exhibiting,

sharing and monetizing their artistic and technical work. Standard social networks (Facebook) and distribution platforms such as YouTube or SoundCloud already bring them a level of empowerment for publishing their work but are too massive and insufficiently specialized for these communities by only supporting fixed media (text, images, sound files, videos) and not the technical components which are the core of their work. Moreover, there is no common, standardized archive of the technical elements needed to perform interactive music/sound works so that their long-term preservation lies on the individual efforts and means of producing artists/institutions and cannot easily circulate between concerned stakeholders.

1.7 DAFNE+'s related ambition

Electronic musicians and sound designers have access to a great variety of technical functions for analyzing, synthesizing and processing sounds and musical information. These functions are available not only as features integrated in existing applications (sound editors, sequencers, etc.), but more and more as third-party modules which extend the applications' features using published APIs: plug-in architectures, external libraries. This is specifically true for the most advanced applications used in experimental music and contemporary composition: using low- and high-level programming interfaces such as visual programming, artists produce "patches" of compound functions of basic processing libraries, which encapsulate and characterize their specific aesthetic approach and technical configuration. In particular, IRCAM's Forum offer includes hundreds of state-of-the-art external objects/devices for live experimental music environments including Max, Live and Pure Data. From this existing basis, DAFNE+'s related ambition is twofold.

1.7.1 To provide artists with new technology

First, to provide artists with new technology from the latest research for the analysis, synthesis and processing of audio and music information, targeted to these environments. New features will include:

1. Novel algorithms based on machine learning for audio analysis, synthesis and processing [7][8] for live human-computer interaction and improvisation in relation to new ERC-AdG REACH project [9][10],
2. Advanced real-time 3D audio simulation as extensions of IRCAM's Spat reference authoring and rendering environment combining all kinds of capture/reproductions systems, including extensions of reverberation algorithms to anisotropic rooms and interfaces with VR multimedia and game design environments [11][12][13].
3. Beyond modules for computer applications, a general objective is to extend the deployment of musical applications to other platforms/devices/network connections first using the web audio API by completing existing libraries for real-time audio processing,

synthesis and visualization functions, and collective musical interaction on smartphones up to a comprehensive set of libraries usable by artists, as well providing implementations on open hardware [14][15][16].

1.7.2 Long-term preservation, diffusion and monetization

The second main objective is to enable the exchange, long-term preservation, diffusion and monetization of the software modules (code and data) used in the production of experimental music works by setting up a reference archive of works open to the community of experimental music artists/producers, based on practices done by institutions starting from IRCAM with its Sidney system and managing successive versions of each work [17]. The blockchain and NFT certificates will be used to trace the parts of ownership from the dependencies between the various digital objects used for performing a piece, and as a support of their licensing to other users (artists, event producers, etc.).

2 Methodology

2.1 General Concepts

DAFNE+ aims to design and implement a multi-disciplinary and cross-sectorial ecosystem, covering the technological, sociological and business aspects and bridging existing cultural communities with new initiatives. In this regard, and based on a decentralised blockchain approach, DAFNE+ provides a real DAOs for communities, where users and creators become the centre of the innovation, empowering them with novel tools not only to create new contents, but also to sell them with new business models and fair conditions.

2.2 Requirement collection methodology

The first phase of the methodology for gathering user requirements for platform design was devoted to a bottom-up process involving all consortium partners in several internal workshops to identify the main pieces of information to be obtained. The process combines:

- The production by use case leaders of storylines associated with each use case and defining the target users, their roles in relation to the assets to be managed in the blockchain platform and their expectations and motivations for the proposed services to be elicited.
- The production by technical, business and legal partners of a set of general questions that cut across the various use cases.

Partners drew up an action plan aimed at reaching the target users in each use case community and obtaining feedback from them by various means, including the organization of workshops and interviews. The questionnaire resulting from the previous phase often served as the basis for these sessions with users, enabling individual or collective exchanges

on the issues it raised with them, as well as feedback from them to improve it, for example by reformulating certain questions.

This process culminated in a final version of the questionnaire implemented as an online survey, which was publicly announced through various communication channels (project website, consortium partner and parent project websites -including STARTS-, e-mailings and social networks).

Use case managers gathered qualitative feedback from these oral exchanges with representatives of their communities. In parallel with the launch of the survey, they compiled them in written form to complement and help interpret the survey responses to feed into the platform specification. Another function of this production was to develop refined versions of the use case specifications.

2.2.1 Storylines – internal consortium elaboration

Several workshops gathered the whole consortium to exchange on the different use-cases through a common analysis grid based on *storylines* identifying managed assets, user types and roles and their potential interests for each storyline. This process enabled to identify aspects specific or common to several use-cases. In particular, although very different on the addressed communities and types of digital contents managed, a lot of similarities emerged on the main categories of assets to be managed and user roles in relation to these categories. A common vocabulary was adopted and converged on the concepts of *Components* and *Repositories*. *Components* are technical modules (code scripts, libraries, executables, databases...) that intervene in digital creative tools, whereas *Repositories* gather technical elements including components for a creative process. The distinction between them lies less on their technical form than on their purpose: Components are produced by technical experts and perform a generic technical process independently of a specific artistic project, whereas Repositories are the support of a creative process, in particular for the production or reproduction of the artifact. Another important dimension resulting from the exchange on storylines was the collective dimension of the creative processes in relation to the managed assets, with different roles assigned to various categories of users.

2.2.2 Scenarios resulting from user feedback

This stage of definition of use-cases by the DAFNE+ consortium was then confronted to the user feedback process combining answers to the survey, workshops and interviews managed by the use-case partners. What emerged then was the necessity of structuring each use-case in several scenarios, involving different assets and/or user communities and roles. For each scenario, one or several user journeys define the succession of stages involving the various stakeholders. Moreover, the presentation of each use-case scenario includes relevant expectations if any on DAO related rules.

3 Key findings from the user-feedback process

In the use case “**Experimental music and sound production**” (see Figure 1), based on the evolution of IRCAM’s Forum, DAFNE+ acknowledges this situation and aims at overcoming the initial unidirectional distribution model by implementing a DAO dedicated to sharing software components (code and data) on which the production of artistic works is based.

3.1 Identification of asset types

More specifically, these components generally combine different kinds of software and data:

- **Open environments**, in most cases available as software applications with their user interface and editors, file format, and external library API. They enable the combination of functional modules delivered either with the application or separately by third parties through a published API. Examples of such environments are Max, Pure Data, OpenMusic, Modalys;
- **Functional modules and libraries**, compatible with the environments’ API and adding specific audio or music processing functionalities to them; they are generally developed in usual computer languages (C/C++, python, javascript,...).
- **Patches** which are the basic open environments’ document files and implement a specific combination and connection of functional modules for producing compound and more complex functions associated to a given artwork. This combination generally includes high-level programming functions (graphical programming, dedicated computer languages, ...). The design and production of artistic works mainly relies on these patches: each artwork is based on a specific approach of modelling, processing, manipulating and interacting with audio and music contents.
- **Various data** (sounds, scores, motion capture recordings, tech riders...) used as input files in the environment.

The DAFNE+ system for this DAO will support the diffusion, exchange and monetization of two complementary and interrelated sets of digital elements: Functional modules, patches and datasets produced by technology providers and artists; Production archives of interactive music/sound works combining structured sets of these components needed to perform the works, in order to address both the need of long-term preservation of these works and of their diffusion to potential producers (venues for music performance, sound installations, etc.).

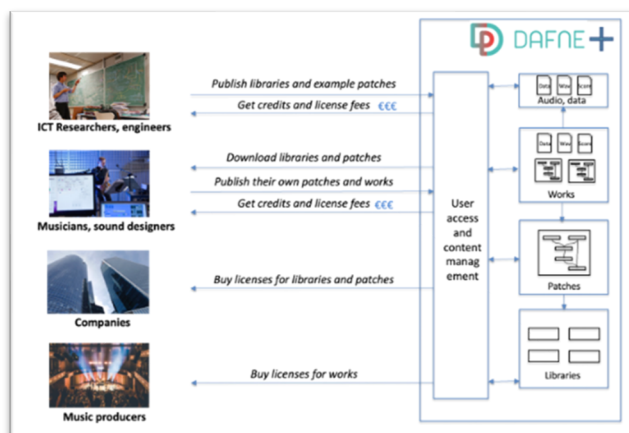


Figure 1. Use case 2: Experimental music and sound production diagram

3.2 Blockchains and NFTs

Most users are not familiar with blockchains/NFT and can hardly figure out what they can get from them. However, in interviews and workshops, after a presentation of the DAFNE+ starting offer, they seemed open to these new proposals, often ended up to new ideas that have fed our use-case specification, and expressed the wish to reflect more in-depth about these possibilities.

3.3 DAO related rules

Few feedback was expressed from our community that may feed the DAO specification. What emerged concerns various positions expressed by asset owners on the way they would like to make them available, which should be foreseen as different options offered to them in the DAO rules:

- Ownership: Identification of the right owners and their respective shares in the asset.
- Asset publication conditions: published by default, or conditional to financial counterpart such as NFT acquisition and/or case-by-case validation by asset owners.
- Scalable user-license:
- Own Usage: Defines the possible use of the asset by users.
- Redistribution: Defines the rights and conditions of redistributing the asset.
- Versioning, forking: allowing anyone to produce a new version/a new fork from the asset, or only upon a validation process by right owners. The motivation behind this latter case is to ensure the integrity of the initial artistic intention through the selection of trusted users.
- Monetization options:
- Prices for primary and secondary markets.

- Split of income between right owners including initial asset creators and creators of subsequent versions, DAO members, platform management...

The main findings of the user-feedback process are presented in the next section under three main scenarios related to the way some user wants to use some asset type.

4 Experimental music and sound production scenarios

4.1 Scenario 1: Publication and access to/use of components/new creation tools

4.1.1 Scenario description

Component authors (developers of creative functions and tools) store their assets on existing platforms like GitHub, GitLab or IRCAM Forum for archiving, sustainability, publication, self-promotion or sale. They also see it as a practical way to make assets available for collective activities such as co-creation, workshop support or academic publication. In a spirit of sharing and building their professional reputation, more and more researchers and creators are publishing creative code, open-source libraries or free applications. Whether it's selflessly distributing tools to artists and creatives, or more directly assisting artists in their production work by releasing new features of an existing library, or publishing a courseware with code to be executed, component authors appreciate the advantages brought by collective management platforms for asset versioning. These platforms have recently integrated mechanisms for sponsorship between their members (GitHub since June 2022 for instance). More and more independent developers are using sites like [Patreon](https://www.patreon.com/) to distribute their releases only to people who have subscribed to a paid membership. Finally, some authors of creative libraries do not hesitate to create their own [e-commerce site](https://www.e-commerce.com/) to sell applications and services. Some are ready to try the NFTs adventure. But not everyone is ready to take the risk of a platform migration, especially if it is not proven and experimental like ours. So it seems necessary to think about an interaction mechanism between DAFNE+ and the existing platforms. For that, the IRCAM forum website integrates git functionalities and makes direct links to GitHub and other platforms (see [OpenMusic](https://www.openmusic.com/) for instance). These "mirror components" have the advantage of being created quickly by a **Component referencer**, without duplication of content and are always up to date. If a monetization mechanism is associated with this type of component, then the user will find an added value and will promote his/her library on the DAFNE+ platform. This will lead to a migration trend that could push these authors to use the platform, if the monetization aspect is more efficient than the sponsorship mechanisms of other platforms. More generally, the approach for this scenario is to build on IRCAM's Forum, define ways of interfacing both frameworks by handling related technical and legal issues, and

focus on the development of new features that emerge as potentially interesting advances for users:

- development of new advanced tools for sound/music processing and synthesis.
- Use of the blockchain as a reference for formalizing authorship (individual or collective) on creative software production as an alternative to software deposit.
- Enhanced management of component versioning and publication.
- Better support of collective work, be it on development including beta-testing, or in groupware for artistic production and/or education using components.
- Experimentation of new monetization schemes for creative software distribution.

4.1.2 User profiles

- Component Author: developer, researcher, company.
- Component Collaborator: collaborator in the development/maintenance of a component: creative in the loop, student, etc.
- Component Referencer: Person who creates a "mirror component", whose content and description are given by a third-party site: DAFNE+/IRCAM Forum Admin, Community managers.
- Component User: creative – composer, computer music designer, sound engineer, performer...

4.1.3 Managed assets: Components

A component is a technical element whose integration gives access to generic functionalities. It is a high-level entity (package, library, compressed folder), grouping multiple files of heterogeneous data types: Standalone, application, software, libraries, program, script and patches: max library, max package, maxforlive device, puredata external, python, colab, AI model, 3D model, Sound bank, Dataset... This element can be hosted by the platform under DAFNE+ license or can be referenced by the platform with delegation of license to a third party - GitHub, IRCAM Forum, bitbucket, third party websites. Example components provided as part of WP3 are:

- [Dicy2](#) library: Max Package for music generativity and improvisation .
- [CoMo](#) and [SoundWorks](#) libraries: JavaScript and apps for collective interaction with distributed audio/music devices.
- [Spat](#) library: Max Package for sound spatialisation.
- [RAVE](#), [RAVE2](#) and [nn-](#): Python script and Max Package for deep learning for sound synthesis/processing.

4.2 Scenario 2: Publication and access to/use of work repositories

4.2.1 Scenario description

Artists, creatives, archivists, musicologists, music/sound producers need a shared database of the technical elements that intervene in the production or reproduction of artworks. A frequent setup for mixed music works combining instruments on stage and computer-generated sounds or processes concerns the programs, the related data and the technical configuration needed to execute the piece during the performance.

In addition, some artists no longer conceive works in the sense of fixed artifacts, but in the form of generative processes that allow the creation of a virtually infinite number of works. This is particularly true in the age of artificial intelligence-assisted creation. Also, these authors are interested, not in selling their works, but rather in selling access to the generative machine allowing the synthesis of new works, which they are certain can be signed in their name. Thus, the platform should allow the management of access to these generative machines, creative application/process, synthesizer, transcoder... This last field of application seems relatively new and particularly in phase with the development of NFTs.

4.2.2 User profiles

- Repository Author: Mainly artists – composers, computer music designers, sound designers
- Repository Collaborator: Collaborator in the development/maintenance of a Repository. Same profiles.
- Repository Referencer: Person who creates a "mirror Repository", whose content and description are given by a third-party site. Same profiles, plus DAFNE+/IRCAM Admin and Community managers.
- Repository User:
 - Composer, computer music designer, sound engineer, sound designer
 - Music performers (individuals, ensembles, orchestras), performing artists, music and art venues, score publishers, sponsors.
 - Musicologist and archivist

4.2.3 Managed assets: work repositories

A technical element whose implementation allows the production or reproduction of a specific work. A repository is a high-level entity (compressed folder, dmg, zip file), grouping multiple files of heterogeneous data types: A zip, a dmg file or a folder that contains the code, programs, data, library dependencies, documentation (including published score), and any other references or metadata to implement a creative process. The repositories usually contain, together with all needed programs and data, the following documentation:

- Differences with previous versions if any.

- Installation instructions.
- Tech rider and hard/soft-ware combination.
- System calibration and tests.
- Initialization routine.
- Technical instructions.
- Performance notes/score.
- Notes for the people who will open this documentation in 2050.

4.3 Scenario 3: Creation and obtention of private ownership/access to an artwork

4.3.1 Scenario description

This third scenario emerged from exchanges with community experts as a potentially relevant approach for promoting and monetizing artistic creation with NFTs through various forms of direct exchanges between artists and their fans and/or sponsors and collectors in the cultural sector. Some of the artists give access to beta versions of their works using Patreon. Others had the opportunity during the time of the Covid-19 pandemic to perform private concerts in virtual rooms with limited access time and number. Others, including artists and their producers, are looking for new ways of sponsoring beyond work commissions to ensure complementary income and develop relations with fans interested in crowdfunding. More globally, NFT-based artwork distribution opens a new space of cultural exchanges that will foster new forms of works in the field of contemporary creation. In this scenario, work authors/producers are proposed to manage private digital spaces in which exclusive resources ranging from goodies to autographed works will be offered in exchange for sponsorship based on NFTs.

4.3.2 User profiles

A work author or producer creates a private space and invites people to join it according to the conditions defined in the DAO. A user of the private space who has bought an NFT can enter the private space and access exclusive content.

Creator/manager of a private space

An artist or creative and or his/her producer who wants to exchange exclusive content with her/his fan base/sponsors.

Work user: Buyer of a Work / Subscriber to a private space

General public

Art sponsor, NFT collector

Cultural institution, performance venue

4.3.3 Managed assets

Here the qualification as an asset is questionable. In this use-case, the attribution of an NFT can concern either on a persistent resource in the blockchain such as a work or an ephemeral advantage such as an event ticket related to the work. Moreover, an important objective being to propose new ways of sponsoring a work in progress during its conception and production process, like crowdfunding, the

scenario should enable to define a counterpart related to a notion of work project, not only to an already completed work.

In all cases, the counterpart to the NFT will be defined by the private space owner and directly managed by him/her with his/her subscribers.

For instance, for various forms of subscription to a work such as:

- Exclusive ownership of the work (unique sponsor).
- Shared ownership of the work, ownership of a limited edition of the work (multiple sponsors).
- Exclusive ownership of a unique variant of the work (parametrized work).

counterparts may include:

- VIP access to work performance premiere.
- Access to the artist (private session).
- Personal dedication published with the work premiere documentation.
- Public sponsoring exposure.
- Use license (possibly time limited) of work repository for work performance.
- Tickets for performance/concert.
- Access to the artwork's "internals", i.e. underlying production algorithms.
- Behind the scene, exclusive stories and content.

Conclusion

"Non-fungible" is a relevant feature in the creative industries as it is *unique* and can't be replaced by anything else. Transactions using NFTs over blockchains allow audiences to easily acquire unique content from the artists, users and creators take part in a cultural and artistic distributed community or gamify the experience with creative content. These novel technologies offer new business models to the cultural and creative industries, improving their global reach and opening up new distribution channels without the imposed rules by intermediaries - even controlling the artists revenues- which in many cases are not based on EU (e.g., YouTube).

Another relevant aspect is that the use of digital tokens / NFTs allows artists to share content with 2 main features which can improve the way it is currently done: there is a clear provenance and authentication of digital copies and creative artists can have a control of the IPRs and revenues in each work, re-sell, keeping track of the heritage and origin. Currently, these tokens and the transactions that involve them empower the artists who sell them and increase the artist's reach to a global perspective, irrespective of the niche market.

But this alone cannot help the cultural and creative industries (CCI) as a driver of innovation and competitiveness: the creation of a community which can be decentralized and where authors and consumers are not in a position to make

decisions on the evolution of such community won't open up the full opportunities found in these novel technologies. Therefore, DAFNE+ aims to create new distributed communities in the form of Distributed Autonomous Organizations (DAO) around digital tokens and NFTs, with a decentralized governance where artists can play a role in the community governance and deciding on the rules of the community. DAFNE+ creates a community where all NFT holders and artists/creators can decide on the future. Since one of the critical points for such digital token exchange in blockchain networks is the energy consumption, DAFNE+ environment runs only over *low-energy transactions blockchains*¹.

The DAOs liaises with other relevant stakeholders around digital art, music, content creators and streamers, to be able to grow and enrich the creations when required (e.g., shared revenue models without intermediaries, in the development of a video piece from a creator requiring the music from another creator).

Another critical point is the complexity of the technology and the adaptation of the production tools from the creators which find difficulties as the created content as it is has a complex digital token environment. DAFNE+ provides novel services and tools for intuitive and simple content creation by developing new applications (in case of absence or closed approach) that enables users to produce and ingest new content which can be directly valued and distributed. These content production tools also make use of devices and creation elements at user's premises or studios, Significant part of the research in DAFNE+ focuses on the definition of novel revenue and business models for the distribution of media content, aiming at empowering the role of creators and users, fostering new actors' involvement and providing new avenues for content distribution and innovative services taking account the user-communities' needs. offering a controlled environment for the creation of high-quality content. DAFNE+ simplifies the framework for the artists so they can participate in the environment with a set of tools which can help them a) easily participate and b) offer their creative content over blockchains, without having technical background.

DAFNE+ also aims at increasing the legal transparency around the creation, online distribution, and sharing of existing and novel forms of artistic content via blockchain technologies and involving smart contracts, NFTs and other digital tokens. Towards this objective, DAFNE+ maps and analyses the relevant IP legal framework in the EU, and in particular the copyright regulatory framework, in order to identify and assess specific legal requirements, opportunities as well as barriers stemming from the identified IP framework which may impact the use of blockchain technologies in online content creation and sharing. In addition, DAFNE+ identifies and analyzes licensing and other exploitation models that are compliant with the identified IP legal framework with particular attention to applications using blockchain and smart contracts. DAFNE+ will further focus

on exploring the data privacy implications and ethics of smart contracting on a blockchain.

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