PayPal for Punks: Blockchain for DIY music

June 2021

Abstract

This research investigated how music organisations and practitioners may use blockchain to distribute, compose, present and perform music. The research aimed firstly to explore the features of blockchain and ascertain potentially favourable characteristics when compared to existing music distribution methods. Secondly it aimed to consider the operational contexts of the DIY musician, small and large organisation (i.e. the partner organisation, Sage Gateshead). This informed the development of novel practical applications. This included a record label and live music events, representing real-world use cases of blockchain technology (unique in academic literature surrounding blockchain and music at this time). This resulted in examples of website and Ethereum smartcontract code (themselves constituting original knowledge) developed iteratively across several participatory projects. Data was gathered from participants to evaluate the success and form conclusions relating to blockchain in music practice. It was found that blockchain offers benefits in payment processing compared to established methods including: potentially reduced processing fees; potential removal of intermediaries; quicker payment; and automation of complex accounting processes including apportioning royalties in collaborative work with smartcontracts. However, blockchain technology has inherent disadvantages including: lack of wider familiarity among audiences; low demand for music accessed this way; extreme volatility in value and hoarding behaviour of cryptocurrency holders; and issues relating to scalability. Therefore it is not practical at this time to operate solely on the blockchain. It was also concluded that the discourse surrounding it is often lacking in veracity. The technology shows most potential in direct-to-fan selling and in ticketing of music performance live streams, with most benefit for DIY musician and small organisations. The opensource nature of the technology further decentralises 'direct-to-fan' practices allowing practitioners and organisations to develop their own webstores and facilitates novel live-performance paradigms, affording new monetisation strategies that suit the nature of streamed live music.

Acknowledgments

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Chapter 1 — Introduction

1.1 Background

The background to this project is my own practice within popular music and, as part of the National Productivity Investment Fund (NPIF) funding, the project is intended to be conducted in with a partner organisation, in this case Sage Gateshead. The NPIF funding also stipulates that projects should explore areas relating to productivity which in this project is explored in the context of music distribution, specifically in terms of generating income from digital audio products.

Alongside input from the partner organisation, this research is informed by my professional practice within music. This includes my background in coding (which is employed in various aspects of my music and performance practice) and part of the outcomes of this PhD project is code that I have authored.

I am a DIY musician and producer currently working under the aliases of ako, Badger and Mausoleums. I have had UK and international record label releases in various formats (including VHS cassette, audio cassette, CD and digital) on Sunset grid (Australia), HOT-Q, SPRIX (USA), No Audience Underground Tape, Nothing but.., Northern Exposure and Kaneda Records. My music has received airplay on BBC6 Music, BBC Introducing and many independent radio stations around the globe and been play listed by Tom Robinson's 'Fresh on the Net'. I have toured nationally across the UK and I make regular live appearances in my native North East of England (including headline festival appearances) and support slots with high-profile touring artists.

I am a co-founder of Kaneda Records (an independent electronic music record label with a catalogue of over 200 tracks) and Northern Electric Festival (an annual 2 day, multi-venue electronic music festival held in Newcastle which in 2019 hosted over 40 artists and DJs). I have 5 years experience as a promoter organising regular clubnights and gigs at venues ranging from 20 to 400+ capacity. This experience includes working on higher profile bookings as well as emerging and local talent. I have also worked freelance as both a live sound and studio engineer with notable recording credits including Penetration and the 999.

Sage Gateshead is an international music and event venue and centre for musical education, located in Gateshead, which holds charitable status and is the home of the Northern Sinfonia and Northern Music Trust. Sage Gateshead contains three performance spaces; a 1,700-seater, a 450-seater, and a smaller rehearsal and performance hall. It also houses practice spaces for professional musicians, students and amateurs. The building also houses a public concourse, including cafes and bars that are often used for public and community events. Sage Gateshead hosts performances from international artists from a wide range of popular, jazz, world and folk music disciplines and, alongside the Northern Sinfonia, a wide variety of international orchestras and classical ensembles. During the course of this project the main contacts within the partner organisation were Esme Flounders (Marketing and Communications Director) and Tamsin Austen (Performance Program Manager). They had an interest in further exploring blockchain technology after hosting lectures by Imogen Heap, who at the time had recently undertaken a blockchain-based music release project (which will be discussed in more detail later).

During the course of the contextual review Sage Gateshead provided desk space and IT facilities to aid in the completion of the project. Various meetings were held to discuss the project with the marketing and programming departments to understand their operations. The findings of the contextual review were shared with them at various stages (with efforts made to make it

understandable to non-specialists). This contact / discourse with the partner organisation fed into the direction of the practical projects and their areas of interest guided which projects were prioritised in year 2 (some other ideas that were raised by them, but not pursued for various reasons are discussed in the conclusions in 4.4.2). Sage Gateshead's involvement was instrumental in informing the choice to incorporate live music / live streaming. This is because they are primarily a live music organisation and they expressed interest in the idea of streaming as this was something that they had employed at as part of several events although was not in widespread use in the organisation at this point. They also guided the project away from the interactive music project as this was something that interested them least. The results of the blockchain ticketed live stream were shared with them after completion; however it was not possible to conduct a similar project at the partner organisation as originally hoped. Contact with Sage Gateshead also provided an insight into the day-to-day operations of a large organisation and gave the background to the general conclusions made in section 4.4.2 surrounding blockchain's current usefulness in the context of a large organisation.

1.2 Relevance of the research

There is a fundamental issue that faces practitioners and organisations at all but the most rarefied heights of the commercial music industry which is that it is increasingly difficult to generate sufficient revenue from music. I know from contact during my professional practice of internationally touring bands, signed to respectable independent labels that should be making a living from their music but still have to hold down day jobs in Pizza Hut, and established bands who have had releases on major labels that at best break even on tours and releases. I can also personally attest to this having been practicing in this field for 14 years, having held self employed status for the last 4, but still struggle to recoup costs. Whilst anecdotal, this is an often recounted story and one that says nothing of early career practitioners who are self-funding their practice. This is compounded in particular in popular music (the specific context of my practice) by the apparent disparity in state funding when compared to classical disciplines for example (Dugher, 2018).

The exact causes of these revenue issues, as shall be discussed in detail in 2.2, are often considered to be rooted somewhere in the rise of peer-to-peer file sharing, which completely reshaped engagement with music, and how its 'ownership' is viewed both on an economic and a personal level. This disruption continued with the adoption of streamed content, which is often criticised in the surrounding discourse for its apparently paltry royalty payments. Issues relating to poor sales and inadequate streaming royalties are also compounded by the necessity in current distribution practice for a plethora of third parties to be involved between artist and audience; whose' fees further reduce payments to artists.

The initial spark that suggested that the blockchain may offer a solution to this complex problem was Imogen Heap's (2017) 'Tiny Human' single that was released using the blockchain on a platform programmed by what is now called Ujo music. Two things caught my interest about this project. Firstly, the promise of immediate payments with fewer intermediaries, which seemed to offer a possible solution to the revenue issues relating to intermediaries in the music industry. Secondly, the idea that music could be presented in new formats, not limited to stereo audio files. Ujo's platform initially provided the option to purchase 'remix stems' (a collection of audio files made up of the component layers of a recording), alongside traditional stereo files, which allowed people to not only listen, but make their own versions of the single. Whilst the idea of distributing stems is not new, it is very rare to see them included with the initial release. This was interesting to me as my practice as a musician is deeply rooted in 'remix culture' having worked in dance music related genres.

1.3 Research questions

1. How can DIY musicians and smaller music organisations use blockchain to distribute music/audio and in what new ways can music/audio be composed, presented and performed?

2. What are the uses of blockchain technology for large music organisations such as Sage, including audience engagement?

1.4 Aims

1. Explore the characteristics and features of blockchain technologies and ascertain potentially favourable characteristics when compared to existing methods employed within digitally distributed music.

2. Consider the specific contexts of the DIY musician and smaller music organisations and larger organisations (such as the partner organisation Sage Gateshead) to understand where blockchain may, if at all, offer benefit to these groups.

3. Develop applications of blockchain technology for digitally distributed music that exploit the favourable characteristics of blockchain technology (as identified above). Gather data from participants to evaluate and form conclusions relating to these prototypes and the potential of blockchain technology in music distribution practice.

1.5 Methodology

Due to the practice-based participatory nature of the PhD project the action research model was chosen as suitable to critically analyse research and formulate practitioner-led solutions for using blockchain for music distribution. The suitability of this methodology is illustrated in the PhD precedent set by Smith (2011). Smith conducted a contextual review and a series of practical art and curating projects which were conducted in an iterative manner and reflected upon.

One of the strengths of this methodology is the understanding that complex practical problems require specific solutions which can only be developed within the context of the problem and in which the practitioner is a determining element (Zuber-Skerritt, 2001, p6). Also unlike more positivistic approaches the aim is not to create generalisable laws but to improve a specific social context, such as in the case of this research: the DIY musician, small organisation or the partner organisation. This approach also accepts that variables cannot be predetermined or controlled but are dynamic and varied and arise from the data (Zuber-Skerritt, 2001; p7). The latter point is important as this project needed to consider a wide range of quantitative and qualitative data from a range of academic backgrounds as well as media reporting, social media interaction, reflection on personal practice, informal feedback from participants and audience engagement data. The approaches taken to the practical projects were also both technical and creative thus further widening the variety of research gathered.

This methodology follows an iterative structure, with each stage following the format of: *plan, take action, collect evidence* then *reflect to form conclusions* then *plan* the next iteration etc. as depicted in figure 1 below. The reflection took the form of considering informal feedback from participants (to understand the practitioners and audiences perspective); analysis of website and social media traffic data (as way to gage the demand and engagement with audiences); and reflections on the efficacy and reliability of the approach from a technical perspective (to inform the further technical development).

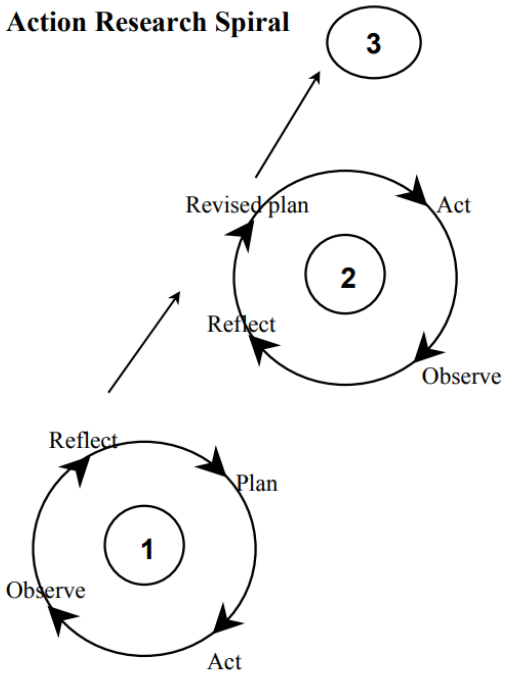

***Figure 1**: Action Research Spiral (*Zuber-Skerritt, 2001, p.20)

Informal feedback was chosen over more formal feedback (such as interviews and questionaires) for two reasons. Firstly, due the complex nature of the problem, the fact that several projects were undertaken exploring different areas and the element of the unknown that accompanies exploring a new technology, it would be difficult to sufficiently plan ahead for and standardise the method of gathering feedback into a formalised method. Secondly, formal methods are labour intensive and themselves constitute the basis for an entire PhD project, and therefore lay outside the scope of this practically-led project.

In terms of structure of the number of iterative cycles, the project began with the contextual review which was initially drafted for the first progress review three months into the project. This was expanded significantly for the first annual review. Subsequently it was updated in year three, representing three significant iterations in total. The second iteration of the contextual review formed the starting point for the first iteration of the practical projects, consisting of the first attempt to develop a paywall type interface based on Ethereum. This led to three areas of practical research: live streaming, selling music downloads for cryptocurrency and interactive music. These projects themselves were also conducted over several iterations with live streaming conducted in 5 iterations, selling downloads: 8 and interactive music 2. The details of which are discussed in chapter 3 alongside the results of these projects at various iterative stages. After completion of these projects and the final draft of the contextual review a final practical project was conducted (project 5)

representing the final iteration of the practical projects and combining ideas from the download selling and interactive music projects. The overall structure of the PhD is illustrated below in figure 2 and an example of how the action research spiral was employed during the development of the practical projects is illustrated (below) in figure 3.

Figure 2: *Map of the research stages*

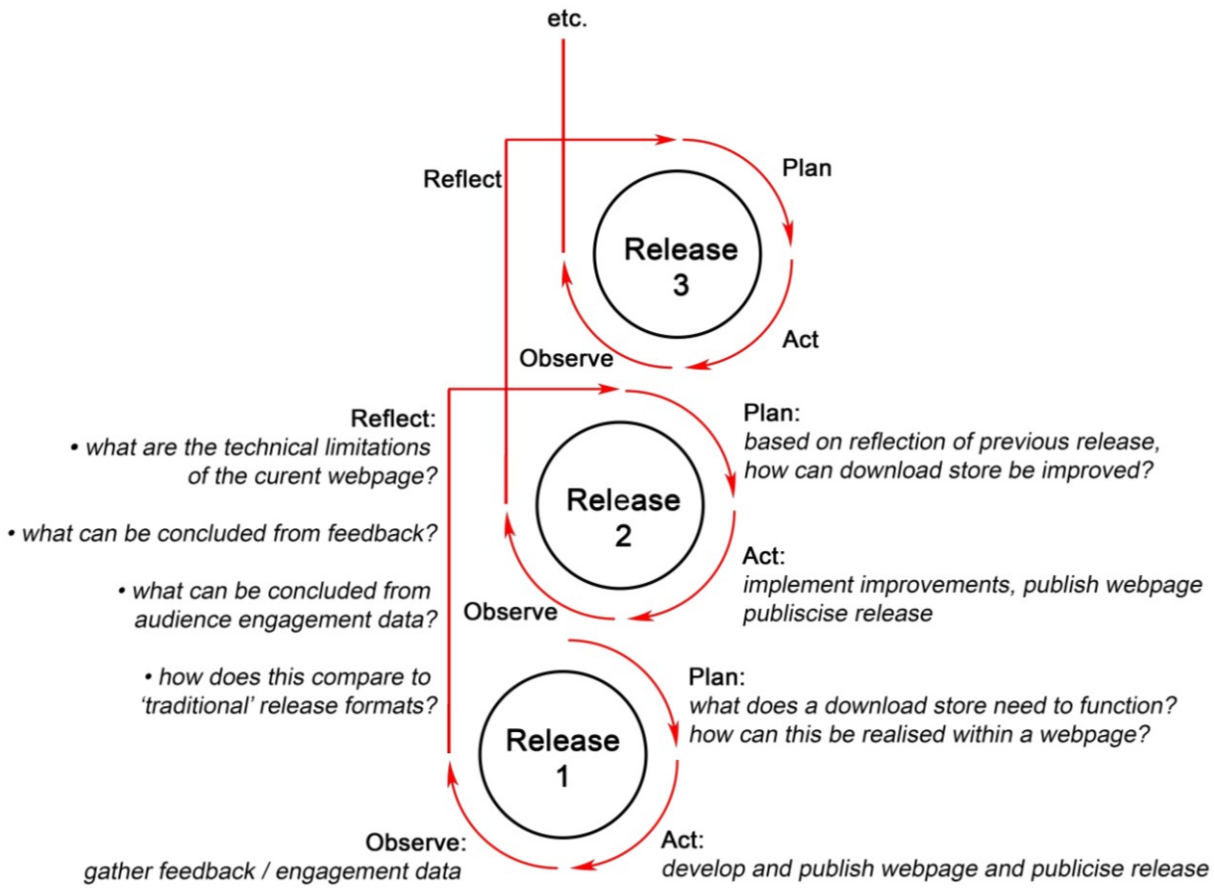

Figure 3: *Iterative development of music download selling projects (project 3) employing the action research spiral*

The iterative approach very much suited the development of the practical projects and mirrors iterative approaches commonly taken when developing code (Agile Alliance, 2021), a key part of the practical projects. This iterative approach allowed gradually more complex and functional code to be developed and refined over the course of a number of projects resulting in examples of payment interfaces and functional smartcontracts (a term that will be discussed in detail later). This code represents a key outcome of the project and is intended to be shared with the music and cryptocurrency communities and is included in the Appendices. It is not intended to be proprietary intellectual property but, rather the opposite, a method for interested practitioners to circumvent the intermediaries of standard distribution practice and the newly emerging centralising forces of the blockchain music platforms.

1.5.1 Structure of the research

In year 1 a contextual review was conducted to inform a series of participatory practice-based projects conducted at the end of year 1, throughout year 2 and at the end of year 3. The contextual review considers:

- The current music industry context

- Challenges related to distribution of digital products and the management of intellectual property
- Existing blockchain related literature and technical information
- Existing blockchain music platforms
- Reflection on own practice as musician/label founder/promoter
- Discussions with Sage Gateshead to understand what potential uses they might have for blockchain

A large proportion of the sources considered during the contextual review were online material. This included media reporting on the blockchain, newly published academic papers, social media content and interactions conducted on social media such as forum posts. This is due to the nature of the area of study in that it is both newly emerging and born out of internet technology and philosophy / thought. It is a field where “most of the state-of-the-art research is scattered across message boards, chatrooms, mailing lists and private discussions” McCorry (2018, p134), and subsequently the materials consulted in the contextual review reflects this.

Once the contextual review had been completed a formative analysis was conducted to formulate conclusions. These conclusions related to the context of DIY musician/smaller organisation and larger organisations and the advantageous (and disadvantageous) characteristics of the blockchain when compared to existing practices. The conclusions were used to inform the planning stage of the development of prototypes and practical projects to demonstrate and test how the advantageous characteristics of the blockchain may be applied to the context of music distribution.

This phase began with a set of preliminary projects with the aim to begin creating applications of blockchain technology that would address the needs of the groups considered by this research. These preliminary projects were developed in various iterations which were critically reflected on to inform the development of the next and improved iteration. The final practical project was conducted at the end of year 3, after originally having been scheduled for the beginning of year 3 as a live music related project. This had to be cancelled due to the restrictions imposed upon live music by the COVID-19 pandemic and was redirected to a music release project and rescheduled for the end of year 3.

During the course of the practical projects data was gathered from a variety of sources including:

- Reflections on my own practice working as DIY musician / small organisation founder using the prototypes developed
- Gathering feedback and observations from practitioners participating in the practical projects
- Gathering feedback and observations from audience members participating in the practical projects where possible
- Gathering audience engagement data from social media and web traffic data from practical projects where possible
- Gathering feedback and observations from the partner organisation

A summative evaluation was conducted of the contextual material, the various types of data gathered from the practical projects and Sage Gateshead’s responses to form the overall conclusions of the research in addition to the specific conclusions to each of the research questions. The code developed during this project is made available online on request and in the appendices of this document.

1.6 Scope

Much research exists into digital music distribution and the changing way audiences engage with music (discussed in 2.2). Concurrently the discourse surrounding the management of musical intellectual property (2.3) been extensively explored. These overlapping areas of music economics and new methodologies in light of unstable music economies are the point of genesis of this project. However, this research does not aim to directly contribute to these areas of research but rather to form an understanding through contextual review of these and other related discourses, combined with reflections on my own practice, of the context of the DIY music practitioner, smaller organisations and larger music organisations (e.g. Sage Gateshead) and challenges they face in relation to revenue generation in popular music.

The project will not consider what is referred to in this work as the 'independent' practitioner (defined in 1.7) because that is a context that differs in several respects to that of the DIY practitioner and is more often covered in academic and media publications. The context of small organisations considered will be the context of the record label and event organiser, as this is the context of my practice. The context of large organisations will be organisations similar to the partner organisation. Large music organisations will be considered from the perspective of the music industry context and from discussion with the partner organisation itself. Results are by no means intended to be generalisable to all of the vast variety of types of small and large music organisation or to all practitioner types. However, solutions and recommendations found will be transferable to some degree in the areas of practice that relate to certain aspects of recorded and live music as applicable to the practical projects.

Concurrently, an understanding of the favourable and disadvantageous characteristics of blockchain will be formed by considering blockchain music platforms, such academic work that exists in this field and the social media and media discourse surrounding the technology. The sources are predominantly from the UK and English-speaking countries. This project hopes to contribute to this discourse, and specifically in the area of actual technical examples (such as the smartcontracts and other code developed for the practical projects) as this is an area that academic literature appeared to be much scarcer, as it is generally focussed on social or economic discussion in broader terms.

The understanding of the music context will be used to develop practical projects featuring prototypical applications of blockchain technology in light of the results of the conclusions of the review of the characteristics of the blockchain. These prototypes will be applied to areas that where it appears they may offer benefit to the groups considered in this research. These practical applications are not intended to be large scale solutions, or commercially successful. These prototypes will be made exclusively for the Ethereum blockchain due to its advanced implementation of smartcontracts and lower processing fees when compared to Bitcoin.

It is beyond the scope of the project to completely reinvent the structure and fabric of the music economy, as is posited as necessary in the rhetoric surrounding some of the blockchain music projects discussed in the contextual review, but more to apply the blockchain to certain specific problems of the existing context and test whether the promised benefits exist in practice. It is my opinion that, whilst inequalities exist within the economic structures of the music industry (such as business models and approaches employed by certain commercial entities), the underlying music industry infrastructure has been developing for over a hundred years and does have the potential serve the majority relatively well (e.g. publishing and performance rights societies, and non-exploitative independent record labels etc.). Therefore, it would be churlish to assume that this could be instantaneously and advantageously supplanted by a blockchain that lacks this lengthy historical evolution. The blockchain is for now considered as a complimentary methodology and would need to

reach a much greater degree of saturation within daily life before it could be considered as a large scale replacement for fiat-based methods.

1.7 Definitions

DIY musician - A musician that self-manages and promotes (publicises) their own music. In the context of this project it is used to describe what can be variously labelled as the *emerging*, *local* or *underground* musician. DIY musicians may release music on smaller record labels and collectives (in addition to self-releasing music) but will not be tied into contracts with option periods (first refusal on new material) and long term stipulations of exclusivity, as is the case with contracts offered by larger and more commercial labels. They are also not represented by agents or management.

Independent Musician – A musician who operates independently of a label, however often will still work with management, similar to DIY (in that most DIY musicians are effectively independent musicians also) however in the context of this project it is more specifically directed at higher profile artists that were often formerly represented by major labels or high-profile independent labels who now feel exploited by record labels, e.g. Imogen Heap's stated goals when working with Ujo, or that of Gareth Emory when founding the now defunct Choon (both of which will be considered in more detail later).

Small music organisations – smaller organisations usually operating on DIY principles or at a more underground or sub-cultural level e.g. lower-profile independent labels, collectives, event promoters etc. Specifically in the context of this project, this is from the perspective of my practice of founding and managing a record label and working as a live music events organiser (commonly referred to as a *promoter*).

Large music organisations – larger organisations, such as larger venues, higher profile labels, and specifically in the case of this project it is the partner organisation, Sage Gateshead.

Record label – a label is a brand or trademark of music recordings (and other music related products such as merchandise and video) and is a curatorial entity concerned with selection, presentation and marketing of music or music related products and is often involved in facilitating the creation of both music and the recordings of music. Independent labels operate independently of the major labels (Sony BMG, Universal Music Group and Sony Music Group).

Music platform - Platforms differ from labels in that a platform is solely a technology for the distribution of music, labels will employ platforms in some or all aspects of the distribution of music, but none the less platforms are a completely different facet of the music industry structure. Examples include Spotify, Bandcamp and Soundcloud etc.

Chapter 2 — Contextual Review

- This contextual review begins by first introducing the blockchain and definitions of key operational characteristics (2.1).

- After which it examines the wider context of music distribution and the current music industry (2.2).

- Following this, there is a review of scarcity and maintaining value in relation informational goods (2.3), such as recorded digital music and managing this kind of intellectual property and the increasing value of live music in relation to the decreasing value of recorded music.

- Next, the innate characteristics (both advantageous and disadvantageous) of the blockchain and where they might relate to possible applications in music distribution were explored (2.4).

- Lastly, 2.5 considers examples of existing blockchain music distribution platforms and evaluates them against conclusions drawn in 2.2, 2.3 and 2.4.

- The final section of this chapter seeks to relate the areas covered in this review and the conclusions drawn to specific aspects of development of the practical projects (2.6).

2.1 Introduction to blockchain and definitions

Despite blockchain's complex technological underpinnings it can be understood fairly simply. In essence it is analogous to a shared access spreadsheet and it facilitates the transmission, storage and retrieval of discreet values. This opens potential uses in wide variety of systems including financial, administrative, crowd funding, ecommerce and web apps. Its most basic usage (and most prevalent) is to send and receive 'monetary' transactions and provide methods to automatically manage these transactions.

At the inception of Bitcoin, its founder Nakamoto (2008) envisioned a "peer-to-peer version of electronic cash [that] would allow payments to be sent directly from one party to another without going through a financial institution". For this reason blockchains are often referred to as 'trustless' systems, as the immutable nature of the blockchain (due to the distributed ledger and consensus checking, features which be covered in more detail shortly) and its autonomy mean that it eliminates the need for trust relationships between institutions, such as banks and the transacting parties. This removal of trust organisations is also commonly referred to as 'decentralisation' (although this also has another meaning relating to the technical underpinnings that will be discussed shortly). The blockchain creates a new networked method of financial engagement. If the internet is about the exchange of information, the "blockchain is about exchange of assets and value", Mulligan (2016).

2.1.1 Definitions and concepts

Coins (e.g. Bitcoin and Ether) are traded across a blockchain and referred to as **cryptocurrency**. Cryptocurrency value is set by normal market forces including: scarcity (which is designed within the construction of the coin as there is a finite amount available e.g. 21million Bitcoin, Nakamoto, 2008) and difficulty to acquire which is the computational effort required mining a coin (Catlow, Garnett and Skinner, 2017, p25). Coins may also be offered as the prospect of an investment, for **example Initial coin offerings (ICOs),** where coins are sold to fund the development of an application or website, on the basis that once that service is successful in its aims these coins will increase in value as they are necessary for users to access the content and features of such a service (e.g. Musicoin.org). Coins can also be minted for purposes other than acting as a currency, for example coins that grant access to digital assets such as visual artwork or to be employed for the purposes of voting or gaming applications, such coins are usually referred to as **Tokens** or **NFT**s (**non fungible tokens**). The coins are 'minted' using code, such as **Solidity** language in the case of Ethereum. The tokens/coins are often used to incentivise miners to mine for the project in question, thus providing the computational power for that network. **Wallet software** is used to send, receive and store tokens and coins.

The topography of the network upon which these coins move is key to the 'immutability' of the blockchain. It is **decentralised** with no central server, unlike traditional networks. Instead it is hosted on **Nodes** held on the network users' computers. Each node has a copy of the **distributed ledge** which is a publicly accessible record containing a copy of every transaction made on the network, (essentially the blockchain itself). The ledger maintains the stability of the network because if one node were to hold a hacked version of the ledger (for example to fake a transaction) it would be compared to the other copies on the other nodes and rejected by the network (Catlow, Garnett and Skinner, 2017, p25). To a hack a blockchain would require simultaneously rewriting at least 51% of the blockchain network for consensus of all nodes to switch to and propagate the hacked version of the chain. Because each new block takes so much computational power (and thus electricity) to mine it quickly becomes prohibitively expense to hack and hacking attempts would require inordinate amount of computational resources. However there are fears due to the formation of large mining pools, particularly on the bitcoin chain, that this could become possible.

Miners are responsible for providing the computational power to move transactions around the network. A miner's computer gathers a 'block' of unconfirmed transactions from the network (e.g. Ethereum) and then races to solve a puzzle (a hash algorithm that can only be solved by trial and error) for that block. Whoever solves the hash first is rewarded with newly minted coins (Bitcoin and Ether for Bitcoin and Ethereum respectively) and granted ownership of any transaction fees paid for transactions within that block. This new block holds a reference to the previously mined block and joins a sequential and unmovable chain of blocks (Catlow, Garnett and Skinner, 2017, p25). The hash solving is known as **Proof of Work (PoW)**; a puzzle solving exercise that is designed to expend energy, and act to add value in the newly minted coins, just as scarcity acts to preserve that value. A miner had to expend energy (and buy hardware and fund other overheads etc) to mint these 'coins', and therefore the miner will expect payment above this value to make the mining efforts profitable.

The **transaction fee** (abbreviated to **TX fee** and also known as **Gas**, represented usually in **Gwei** units on the Ethereum blockchain) is sent with the transaction to pay for that transaction to be mined and confirmed. Gas represents the cost of computing required to mine a transaction and gas price fluctuates constantly based on the value of Ether, number of miners and the demand in terms of amount of transactions. Individual miners can also set a minimum transaction fee that they are willing to accept. The amount of data included in a transaction's data field will increase the transaction fee. With no fee or too low a fee attached the transactions are likely to be unconfirmed (fail) there is also a maximum amount of gas that can be included in each block for Ethereum so there is a upper limit on the total transaction fee that can be paid. There is proportionality between gas amount and

transaction speed. Once all the coins of a cryptocurrency are minted (21 million Bitcoins or 200 million Ether) it is hoped that the transaction fees will continue to incentivise miners to mine blocks.

Ethereum can be used to publish **smartcontracts** which are pieces of software hosted on a blockchain (Catlow, Garnett and Skinner, 2017, p25). They are also touted as an immutable digital replacement to a traditional contract, although the usefulness of this notion of is disputable (Mik, 2017) and they are best viewed as small piece of software that can automate transaction processes on a blockchain. Ethereum is the most advanced blockchain for coding and processing smartcontracts. Computing power within contracts, as with transactions, is paid for with gas (Blockgeeks, 2018). Smartcontracts can be interacted with by wallets and **DAPP Browsers** (browsers with inbuilt wallet features that can be used to browse **DAPPs** – distributed applications, i.e. apps employing smartcontracts / distributed ledgers in place of backend tasks normally handled by centralised servers).

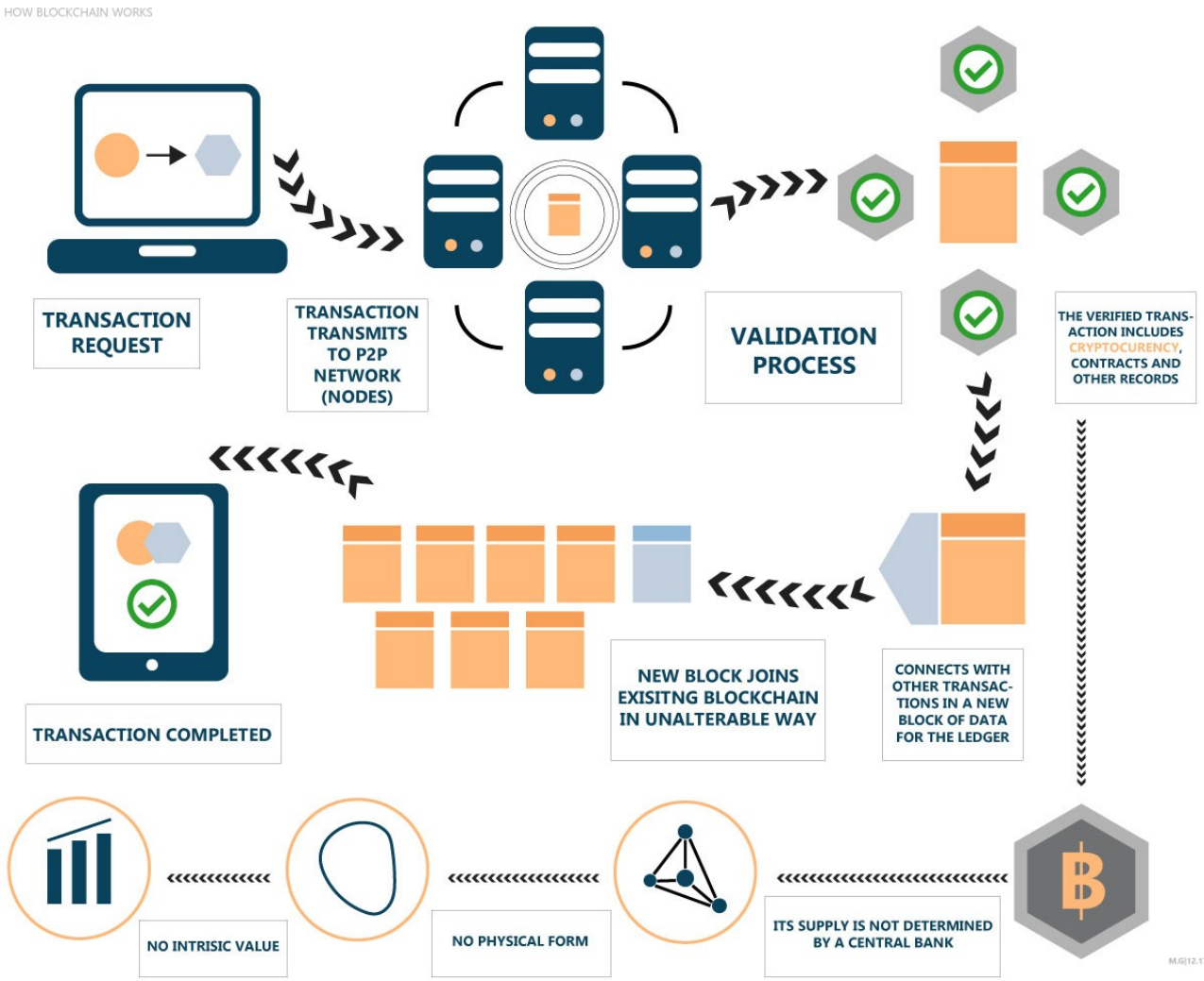

***Figure 4**:* Diagrammatic representation of bitcoin, the topography is applicable to all blockchains (Gkogkos, 2017).

Whilst it is possible to **store data** directly on a blockchain there is a 1 MB size limit per Block for the bitcoin blockchain and although with Ethereum, there is theoretically no limit for the block size (data amount), there is an indirect limit of a few KB because there is a limit to maximum size of total gas

amount that can be included in each block, thus limiting the total amount of data that can be included. Blockchains are not meant for data storage and storing files is very expensive (Stack Exchange, 2016). For example this transaction contains a hexadecimal conversion of an MP3 containing, fittingly, 2001's Hal intoning 'I'm sorry Dave, I cannot let you do that'. It cost the sender Ethereum to value of $105.84 (at current prices at the time of writing in December 2020) to store 3.5KB of audio data. Also as a blockchains such as Ethereum are publicly accessible any file hosted directly upon it will also be publicly accessible, further limiting possible applications. Files in blockchain applications are therefore usually stored off-chain and the data field is used to send and store very small amounts of input data for use in apps and websites, if used at all.

2.2 Digital music distribution and the music industry context: piracy, streaming and criticisms of the industry narrative

From the consumer's perspective file sharing, then subsequently streaming, have shaped engagement with music, and how its 'ownership' is viewed both on an economic and a personal level (Sinclair and Tinson, 2017, p1-9). This shift in paradigm began with the rise of peer-to-peer file sharing around 1999. The advent of this technology caused (previously growing) sales figures to begin shrinking (Mortimer and Sorensen, 2005, p11). The International Federation of the Phonographic Industry (IFPI) reported that piracy led to a 31% decline in recorded music sales between 2004 and 2010 estimating a potential retail loss amounting to €240 billion from 2008 to 2015 in Europe (IFPI, 2012). Similarly, the Recording Industry Association of America (RIAA) claims a decline of 47% in sales (2015). As will be discussed later in section 2.3, attempts at Digital Rights Management (DRM) on digital audio files have done nothing to curb this. Indeed many would contend that efforts to limit piracy are a lost cause, and "the genie is out of the bottle" (Harrison, 2008, p156).

As a result, the industry has had to find new revenue sources that will provide secure income and streaming emerged as apparently the most commercially viable solution. Streaming has now been widely adopted as the main revenue stream for the music industry and streaming, as of 2018, accounted for a 46.9% share of global revenues, with an overall 34.0% growth in streaming revenues (IFPI, 2019, p6). The rise of streaming has also had a positive impact on piracy and for example The IFPI (2014) reported that 89% of Swedish Spotify subscribers illegally downloaded less often because they began to use the legal streaming platforms. The cause of this change in behaviours is evidenced in the work Sinclair and Green (2016, p9) who identify a typography of various groups engaged In music piracy, most important of which for the purposes of this review is "ex downloader" i.e. someone who previously used illegal download to access music but has now moved to streaming platforms. "The evidence suggests that for these consumers, illegal downloading was always about the utilitarian values (e.g. convenience, price and quality)" Sinclair and Green (2016, p9).

As well as giving former 'pirates' an 'easier option' it also seems that some legal downloaders also find utilitarian benefit in streaming and IFPI (2019, p6) reported a 21.2% decline in music download sales in 2018 (as well as a 10.1% decline in physical sales). However despite the impact on physical and digital download, the adoption of streaming is creating new growth in the music industry and the global recorded music market grew by 9.7% in 2018. This marks the fourth consecutive year of global growth and the highest rate of growth since the IFPI began tracking the market in 1997.

2.2.1 Criticisms

The industry supported narrative however is open to some criticisms regarding its long term stance on piracy and whether its effect has been exaggerated. There is an established and convincing school of thought that piracy might not have been as much of a factor in industry decline as the industry bodies and lobbyists would suggest.

There is a wealth of data and research suggesting that pirates are actually good customers, whose spending is redistributed to complimentary physical goods (Mortimer and Sorensen 2005:p2) and live music, David (2010, p7), with evidence that ticket prices have increased as revenues from recorded music declined. Bode (2018) and Masnick (2011) also both suggest efforts to prosecute and demonise pirates are incorrect responses and could exacerbate the problem and posit that the industry should view them as underserved customers, unsatisfied with current options, rather than freeloaders. Similarly, Rojek (2005) also suggests in defence of the pirates, that illegal file sharing could be considered as a positive movement as it is a practice "that is likely to bring about a social good" (p166) as it develops social inclusion, greater choice and access to music for more people; arguing that the music industry's commercial interests have limited the individual's rights surrounding leisure and cultural engagement.

These views are not widely shared amongst large entertainment industry bodies, organisations and companies however and there are a number of examples of the industry suppressing these kind interpretations of piracy. Masnick (2011), for example, points to a suppressed report from the Society for Consumer Research that found users of a film torrent site bought more DVDs and cinema tickets than non illegal downloading counterparts. Speaking anecdotally, it is hard to argue with any of these points in favour of piracy, having benefited directly from piracy of my work. One example of this is a Mausoleums EP that was leaked onto Russian social media site VK.com. This leak was highly beneficial as it drove traffic to the Mausoleums Bandcamp page (thanks to the considerate pirate who fully credited us and included a link to purchase the EP) and the EP received an appreciable number of plays on both Bandcamp and Soundcloud as a result. This traffic also apparently resulted in some sales (not to mention that whoever leaked it seems to have paid for it to obtain the high quality master files used on their page) so consequently there was no inclination on our part to have it removed.

Whilst there is at least some evidence that piracy is and has not been as detrimental to the industry as the official and media discourse may suggest, this spectrum of opinion is partly due to the asymmetry of representation of major artists and lower-profile independent and DIY artists. Mortimer and Sorensen (2005, p4) suggest that, whilst sales for the 'top-ranked' artists have certainly fallen rapidly since the introduction of file sharing, lower profile artists have experienced relatively smaller decline. Their findings are consistent with file-sharing helping to increase the awareness of DIY artists' music and consequently increasing demand for live concert performances, thus mitigating loss in recorded music sales. High profile artists receive little or no benefit from file sharing because they already had wide awareness amongst consumers, so experience a loss in sales without a mitigating increase in live revenues (or other forms of displaced spending).

As well as potentially benefiting artists to varying degrees with wider distribution and displacement spending piracy has also given rise to new, legitimate relationships between musicians and audiences. Whereby "payment is offered rather than demanded" (David, 2010, p160). David (2010) suggests that "low trust methods" of enforcement (DRM, prosecution and vilifying pirates) have failed but giving music away free has "renewed willingness on the part of those who receive to then go out and pay more for what they could have taken for nothing, either in the form of tickets on a door or for recordings in one form or another (or both)" (David, 2010:p160). Examples of this can be seen in the popularity of 'pay-what-you-want' releases on Bandcamp, and the success of Radiohead's pay-what-you-want album release of *In Rainbows* (Thompson, P. 2008). From experience, freely distributed

releases are always easier to promote, reach wider audiences and seem to perform financially at a comparable level based on the donations received, although with more downloads and wider proliferation of the master files. Indeed, when considering sales on the Kaneda Records label I would estimate that at least 40% of label income is generated by donations or people paying more than the minimum price.

Returning to the issue of streaming there is also widespread criticism among practitioners and in the media discourse surrounding this issue of royalties paid. These criticisms relate to poor publishing and master royalties generated from streaming. As a typical example and calculated by averaging streams on a recent Kaneda royalty statement from our distributor, the average gross streaming master royalty per stream is £0.00404, and net (after distributor's 18% cut) £0.00355. Paltry figures like this have certainly fuelled the negative media coverage. Compounding this and despite streaming platforms such as Spotify actually paying publishing royalties (alongside the master royalties) at the same percentage, 70%, of income as download store, ITunes (Berklee College 2015 p3-4), is a need for an increased number of intermediaries in this form of distribution. This results in artists receiving a lower proportion of the money generated than other formats (Berklee College, 2015, p3-4). Compounding this issue, these 3rd parties were also found to be inadequately functioning and research found that in America 30-50% of payments do not reach their rightful owner (Berklee College 2015: p6). Whilst perhaps most noticeable in streaming, this issue of intermediaries reducing artist's shares, and possibly functioning poorly, is something apparent across many aspects the existing industry structure and music distribution practice and something that blockchain's decentralisation may help alleviate as shall be discussed in detail in 2.4.1.

2.2.2 Royalties

Whilst considering the general music industry context of this project, it is probably worth disambiguating royalties at this stage, as they will mentioned several times in the review and following sections and is also something that is often conflated in the discourse surrounding blockchain music platforms as will be discussed in more detail in section 2.5.

There are two broad categories, publishing and master rights. Publishing royalties cover the music itself, rather than the recording, master royalties cover the specific recording of that work. Publishing is further broken down into three types: performance, mechanical and synchronisation (the third will not be covered as this research is not concerned with synchronisation).

Performance royalty collection is handled by a Performing Rights Organisations (PRO), the UK is covered by the PRS. A royalty is generated every time your intellectual property is broadcast in public, this covers radio broadcasts, live music, music in public spaces and venues (for example shops, bars cafes etc), radio play and streaming services etc. Generally, by law, these venues, radio stations websites etc. have to pay license fee to allow them to broadcast this copyrighted material, the PRO sets the fee based on the amount of music they use and the audience sizes and other factors. When an artist makes a claim, it is out of these license fees that the PRO pays the artist.

The second royalty of interest is the mechanical royalty; in the UK these are collected and administered by the Mechanical Copyright Protection Society (MCPS). A mechanical royalty is generated every time your music is reproduced in any format (including digital download). The mechanical royalty rate in the UK is currently 8.5% of the 'dealer price', i.e. the price that the CD is sold to the retailer for.

A website hosting music needs a license (PRS, 2018b) to do so and will pay a license fee from which artists royalties are paid. PRS have licensing agreements with a variety of major digital service

providers, such as Netflix, YouTube, Spotify, Deezer, GooglePlay, Apple Music, Soundcloud, Tidal, iTunes and Amazon. Interactive online streaming services (Spotify etc.), on demand services and webcasting generate both performance and mechanical royalties as they are classified as both broadcast and reproduction (PRS, 2018a). For an artist to claim these royalties they must register their work with PRS/MCPS, this incurs a fee, or if they sign a deal with a publisher the publisher will register them with PROs and collect the fees for the artist, with the publisher claiming a percentage of the artists' earnings .

Master recording royalties are collected for the use of a specific recording of a piece of music. Master royalties are paid to a label (or copyright holder for that recording) when said recording is sold (i.e. download or CD etc.) or is otherwise used in an advertisement, film, television program, streaming service or other medium. Master royalties are typically paid in addition to synchronization or public performance royalties because paying publishing royalties only grants the rights to the use the music, not a specific recording of that music (Royalty Exchange, 2018).

In the case of non-independent / non-DIY artists, once a label has collected these master royalties, and other proceeds, such as the sale of physical media, they are used to reimburse label costs agreed in the contract and then a royalty is paid to the artist to cover their share of the master royalty. How much the artist will receive varies somewhat and depends on different factors and contract types however can be inferred from these 'typical' rates for artists share of revenue for larger independent and major labels:

- Salmon (2007): 14-18%,
- Harrison (2008 p.77): 18%,
- Mortimer and Sorensen (2005 p5): 10-18% of retail, (with the typical rate being 12%)
- Berklee College (2015:p10) 27% when specifically considering streaming revenue.

Whether or not these royalty rates offered by the labels surveyed by the above researchers are *fair* is a rather subjective issue, and it is pertinent to remember that the label does take what constitutes a large risk in terms of resources and capital. Further to this the gamut of labels is broad, ranging from small collectives all the way up to major labels. The data on royalty rates above are based on that of major labels and larger independent labels, but there is very little information on rates offered by underground or collectively managed labels. For example we (Kaneda Records) generally offer a 50% royalty share after costs for releases through the label, and we are aware of other independent labels that offer similar terms.

2.2.3 Summary of digital music distribution and the music industry context

- Piracy and file sharing has been widely seen to have negative effect on the revenue generation of recorded music, however the exact level of this is highly disputed.

- There are indications that while sales for 'top-ranked' artists have fallen rapidly since the introduction of file sharing, lower profile / DIY artists have experienced a relatively smaller decline and there is a lack representation of these lower profile artists in the industry and academic research.

- Wider distribution afforded by piracy, has been seen to be potentially advantageous to DIY/independent practitioners, for example encouraging ticket sales for live events or 'displacing' spending to complimentary products such as merchandise

- Wider distribution has also afforded new methods of working with recorded music such as donation-based pricing strategies and direct-to-fan practices, with indications that this 'trust' based pricing is a successful strategy for independent / DIY musicians

- Streaming has been adopted by default by audiences and the industry. For the former it offers a level of utilitarian benefit compared to both legal and illegal purchasing methods; and for the latter a more secure revenue stream (now representing a 46.9% share of global music revenue). It has also acted to further reduce downloaded music revenue.

- Streaming often criticised for paltry master royalty payments and this is compounded by the increased number of intermediaries necessary for this means of distribution that greatly reduce the artists share. Intermediaries are prevalent across all aspects of the music industry but the decentralisation of the blockchain may help alleviate this.

2.3 Challenges to digital products and the value of live music

Despite the initial apparently negative and widespread effect of filesharing technology on revenue for recorded music discussed at length in 2.2, it has had an inverse effect on live music. Mortimer and Sorensen (2005, p11.) have shown that when recorded music became problematic with the introduction of Napster in 1999, which began to undermine recorded music sales, the relationship between the recorded music and the concert tour began to change. Prior to this, live performance was seen as a way to promote a recorded release to increase sales, and not as a profitable venture in itself. However post 1999 the reverse is true and now the tour is seen as the more important economic opportunity. This is evidenced in an increase in the number of tours, number of artists on tour and average ticket price post 1999 (Mortimer and Sorensen, 2005, p 23.). Performance publishing royalties now also represent one of the most important sources of income for musicians of all categories (DIY, independent and those signed to larger labels) (Sentric, 2017).

The reason for this is rooted in concept of 'scarcity' in goods, and the intrinsic lack of scarcity inherent to digital products. To understand the problem of scarcity in digital products it is first necessary to understand the idea of 'rivalrous' and 'non-rivalrous' goods. In economics, a good is said to be rivalrous if its' consumption by one consumer prevents simultaneous consumption by others; or this consumption reduces the utility of the 'good', or ability of someone else to use that good. A non-rivalrous good is one where one consumers use does not preclude or affect use by another and the cost to provide that good to additional people is nil.

In relation to informational goods including digital music files, scarcity or 'rivalrousness' of a good maintains an asymmetrical relationship between supply and demand and therefore maintaining its' value as a commodity (David, 2010, p42-52). However digital goods are inherently neither scarce nor rivalrous. Such goods are not diminished or 'used up' when distributed (as with physical goods), and could be shared endlessly as demonstrated by filesharing, but the profit from information depends upon retaining some asymmetry based on scarcity (May, 2004, p393-422). Therefore the "post-scarcity" world of file sharing threatens profitability in goods and business built on scarcity, such as the music industry David (2011, p3). This is because cultural goods, such as digital music, are expensive to create but cheap to replicate (O'Dwyer, 2017). Digital files are intrinsically easy to replicate – especially "where every act of digital circulation is also an act of reproduction...digital culture we might say, wants to be free." (O'Dwyer 2017, p297). This trend towards free access of digital culture is played out in the rise of first illegal download and latterly streaming in music.

The industry has made attempts to remedy this situation and impose this artificial scarcity onto digital music in the form of digital rights management (DRM). However, such attempts have generally failed (Sheppard, 2014; O'Dwyer, 2016, p297), especially in the context of downloadable digital audio files. These DRM measures failed for a mixture of reasons including causing inconvenience to legitimate customers and issues relating to audio quality. Competing DRM technologies also meant that files bought from a service supporting one technology might not be compatible with devices that supported another technology. DRM has also been criticised for interfering with a purchasers' legal right to make a backup copy of the media they have purchased (Sheppard, 2014) and rootkits experimented with by Sony caused a major scandal with accusations that it was illegal, deceptive and harmful resulting in lawsuits. Additionally there is the problem that while knowledge exists to unlock whatever DRM method can be dreamt up, that too can, and most likely will, fall into the 'wrong hands' (David, 2011, p5). Lastly there is the fact that regardless of how files may be encrypted or watermarked to limit distribution no DRM as yet has managed to address the so called 'analogue hole' and digital media, DRM protected or not, can relatively easily (at least in the context of audio) be converted to analogue formats then re-recorded as a new file that is completely free of DRM and thus completely re-distributable.

Aside from the practicalities, intellectual property and methods such as DRM to manage it are seen as oxymoronic by some. This is due the tension of limiting access to ideas and information, ownership of intellectual property should only be partial and must balance the private interests of innovators with the general interest of the culture out of which it arises (David, 2010, p4). As we have already seen in section 2.2, there is an argument that freer access to copyrighted digital music due to illegal file sharing potentially leads to social good, for example in music creative practice in the proliferation of sampling, DJing and remix culture in many styles of popular, jazz and contemporary classical music. It is therefore hard to entirely stand behind complete ring fencing of intellectual property when my practice, and that of so many others, is routed in canonical reference and transformative works.

Whilst digital recorded music products face this issue of imposing artificial scarcity (and the prickly issue of limiting access to ideas) live music does not face this challenge. As mentioned earlier, live music remains relatively unchallenged in the face of the wider music industry revenue down-turn, and arguably more profitable as a result of piracy. This is because in contrast to digital music, live music can be said to be rivalrous, one person buying a ticket for a performance does certainly preclude another from doing so but also live music has a quality of uniqueness not found in recorded audio, representing a singularity of experience. As David (2010, p7) explains that in the age of file sharing, the valuation (both material and aesthetic) of recorded music decreases and the valuation of live music increases which can be "credited to the creativity (uniqueness) embodied in live performance". This uniqueness is created by merit of the fact that "an individual performance of music has always been experiential and transient in form" Levtov (2018, p691). These characteristics constitute limiting factors that help instil scarcity and a recording cannot capture and reproduce liveness as it is fixed or static in nature. As Baraka (1964, p198) explains it when discussing the value of live music: "I speak of the *verb* process, the doing, the coming into being, the *at-the-time-of.* Which is why we think there is particular value in live music, contemplating the output as it arrives, listening to it emerge. *There* it is. And *there."* Similarly Benjamin's (1969, p220) observation that "even the most perfect reproduction of a work of art is lacking in one element: its presence in time and space, its unique existence at the place where it happens to be" may be applied to understanding what it is that both instils and maintains the value of live music.

2.3.1 Summary of challenges to digital products and the value of live music

- The “post-scarcity” world of file sharing threatens profitability in goods and business built on scarcity of informational goods, such as the music industry.
- DRM has been experimented with by the music industry to manage this scarcity in relation to downloadable audio files, although the prevailing view is that this approach has failed.
- There is an underlying tension in all matters relating to intellectual property related to the notion of limiting access to ideas that should benefit the culture from which they arose as well as the innovator; and the suggestion by some that fewer restrictions on intellectual property may lead to social good.
- Due to the ‘devaluation’ of recorded music due to peer-to-peer file sharing, there has been a relative ‘revaluation’ of live music due it’s intrinsically scarce/rivalrous nature.

2.4 The blockchain for music

2.4.1 Possible advantages and applications

Heap’s (2017) *Mycelia* project sought to use a blockchain network and smartcontracts to distribute and sell music. Heap cites several advantages to current practice including: greater control over the terms of the release and the profits received; automatic apportioning of money for collaborative works and a tiered pricing structure depending on who is purchasing the track and for what purpose the music is used. She also goes on to suggest further benefits including crediting musicians and collaborators correctly as the move away from physical formats makes this information much less visible.

There are also suggestions from others that the properties of blockchain lend themselves to establishing a fair, decentralised music economy. Research by O’Dair (2016, p4) found several areas where using blockchain could be advantageous including: fast royalty payments; networked database for copyright information; alternative sources of capital; transparency and removal of intermediaries. Other suggested blockchain applications include crowdfunding, donation pricing, and improved methods to receive micropayments (O’Dwyer, 2017, p302).

Using the blockchain in payment situations potentially offers more favourable transaction fees for receiving micro-payments, compared to current payment processing services commonly used for purchases of music and related products. PayPal’s fees consist of a percentage of the total and a concurrent fixed fee, with percentage fee ranging from 1.9% – 5% and accompanying fixed fee ranging from $0.2 – 0.3 (PayPal, 2018). Aside from PayPal, card payment providers in general charge fees of usually 2 – 5% (Miller, 2017) and have some other drawbacks including: relatively high rates of fraud and longer timescales (several days) for funds to reach sellers (Miller, 2017).

In comparison, Ethereum transactions could be completed for as little as $0.0015 at the time of originally drafting this contextual review (gas price taken ETH Gas Station, 2018, on 01/09/2018) and were generally less than $0.01 for simple wallet-to-wallet transactions throughout the majority of this PhD study (although it did increase during the final project as will be discussed in the relevant section). Additionally it is also the sender that is liable for these fees, the importance of these two

factors cannot be understated in a music economy that now inherently involves millions of daily micro-transactions (Berklee College, 2015: p3). It is also advantageous that cryptocurrencies do not incur extra charges for international transactions, which is also certainly useful in the context of online music distribution and the increasingly globalised music economy (IFPI, 2019).

Due to its open source and decentralised nature; blockchain also offers the opportunity for artists, labels and organisations to set up and manage their own payment systems at very little cost. When compared to Bandcamp, (a popular direct-to-fan website used by both DIY / independent artists and independent record labels to sell music), it could be seen as a highly advantageous way of distributing directly to audiences. In the case of Bandcamp over 20% of payments is lost to payment processing fees (figure 5) and takes several days to be processed and paid to the seller.

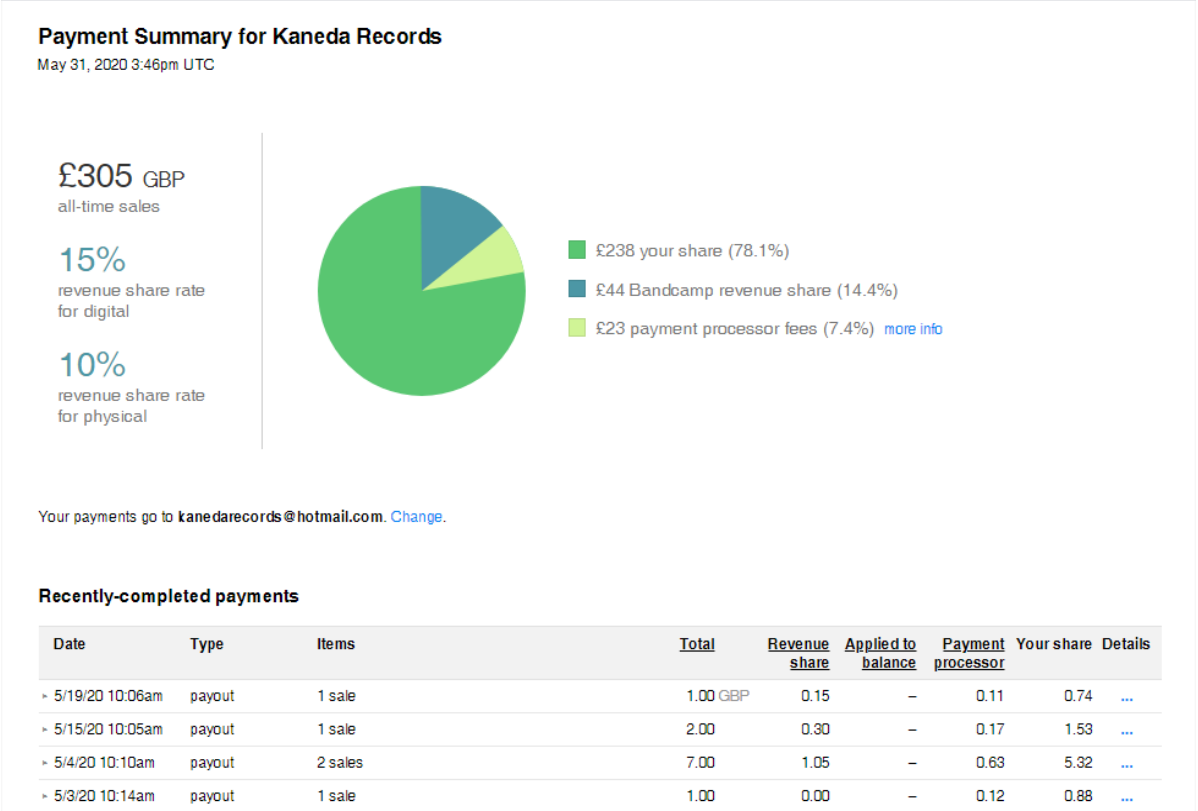

***Figure 5**:* Payment summary for Kaneda Records (bandcamp.com)

Further to this and as briefly mentioned earlier, smartcontracts can also automatically manage and distribute the received funds to all collaborators instantaneously. This constitutes a significant improvement over current models that use several intermediaries, all of whom take much longer periods to make payments, before finally requiring manual accounting and distribution by the parties receiving the payments. Additionally, the total transaction fee paid by the buyer is calculated based on the initial transaction and any subsequent transactions that a receiving smartcontract will make, thus the buyer's initial fee covers all additional costs for distributing funds in this manner, which effectively renders the cost and workload to the receiving organisation or artist nil.

Additionally to the above suggestions, practitioners and organisations may be able to use blockchain as a low cost way to add e-commerce capabilities to a website, adding an interface using the Ethereum Web3 API for wallets such as Metamask (a popular browser plug-in wallet, discussed

further in 2.5) and others, for instance, can provide a substitute for more complex systems of user accounts and customer databases. This can be seen on existing blockchain platforms such as Ujo music (discussed further in 2.5). Metamask (and other web3 wallets) run as browser plug-ins (or are built into certain browsers such as 'Brave', known as DAPP browsers) and can interface with websites via APIs (a set of functions and procedures that allow applications or web sites to access the features or data of an operating system, application, or other service). This means that the user's Metamask account essentially becomes a replacement for a user account on whichever blockchain based service they are accessing in their browser and, for example, can act as their passport to access content. It also bypasses the need for customers to give personal information or fill out potentially lengthy registration forms, or for the website creators too manage this data. It also negates the need for costly SSL security certificates that are often used for securing credit card transactions, as financial transactions are handled by the wallet and the blockchain. It also appears that it is GDPR (General Data Protection Regulation) compliant as information which is "truly anonymous" is not covered by the GDPR (ICO, 2018), in this case the only information required by the website is anonymous data from their wallet and none of this data needs to be stored (providing of course, there is no intrinsic need to provide things like shipping addresses etc associated with physical products).

2.4.2 Limitations of blockchain technology

Many level the accusation that decentralisation is not only inefficient but also wasteful because PoW (Proof of wok) wastes energy and generally speaking decentralising a network can mean dramatically reduce its power efficiency. "Electricity is literally wasted for the sake of decentralisation" with the power cost of confirming the transactions around $10-20 per transaction for Bitcoin at the time of Gerard's (2017:p14) writing. This high level of energy use has potential environmental effects as Stevenson (2018) describes one calculation that found Bitcoin and Ethereum use 42.67 TWh of power every year (equivalent to 0.19 per cent of the world's energy output equating to more 159 countries combined). Fairley (2019), states that a typical Ethereum transaction uses more power than the average US household uses in 1 day. In comparison an ordinary centralised database could apparently calculate equally tamper-proof block of transactions on a Smartphone running on USB power (Gerard, 2017: p58). This general energy inefficiency raises concerns about the longevity of blockchain.

This huge power consumption and ever more competitive mining hardware also drives miners to form large mining 'pools', to stay competitive and this leads to a risk that a particular mining pool may reach the point of holding the majority share of nodes and thus control the network as they would then have the power to rewrite the consensus to create fraudulent transactions. Such a mining pool would then be able to create fraudulent transactions and balances and would completely undermine the consensus checking discussed in 2.1 (Catlow, Garnett and Skinner, 2017).

Faced with the apparent impracticality of decentralisation, it is perhaps important to understand Nakamoto's motivations. From inception, Bitcoin was a political response to the established financial system, rather than a practical system. The political nature of the technology is also a view shared by Brekke, Clara, Jaya, Elenora (2019, p4) who opine its formation was in part "a proposal to resolve 'the political' through technical means". Gerard (2017, p22) opines that this political response to the established financial system was rooted in paranoid conspiracy theories surrounding the Federal Reserve, distrust of fiat currency (legal tender whose value is backed by the government who issued it i.e. traditional currency) and the banking system, authority in general, and nostalgia for the Gold Standard. Mik (2017, p2) also highlights that the smartcontract narrative is often ideologically charged, with technical aspects associated with broader social and economic issues (chiefly disillusionment with financial systems and trust relationships), and exhibiting a remarkable lack of

trust in human actions. There is also a level of unquestioning belief in the technology, amounting to a confirmation bias, that sees any attribute or by-product of the technology glorified in some way, even if objectively speaking it is not advantageous (Mik, 2017). It is with all of this in mind that claims relating to blockchain technology need to be interrogated.

Partly as a result of this politicised narrative, claims are often overblown and theoretical in nature and often have not been fully realised, or are simply impractical. Many are based on a mish-mash of jargon, often incorrectly used or poorly defined, and then parroted ad-infinitum by subsequent projects and tech journalists. Mik (2017) found a similar situation when considering the legal basis for smartcontracts, which have been touted since their inception as a replacement to traditional legal contracts. Stating that technical writings feature "inconsistent and incorrect use of legal terms" (Mik, 2017, p2). The narrative surrounding music based applications is just as clouded with incorrect use of terminology (for example the scattershot use of 'royalties' to describe payments made to musicians) and conflation of various different issues (such as the 'exploitative label' argument with the issue of poor return on streaming) without proper understanding or explanation – which is an area this review will return to in more detail later in section 2.5.

Mik, (2018, p8), concludes that "all researchers in this area face the challenges of finding reliable information and reconciling inconsistent terminology". This has been a constant challenge to this research and one that is compounded by a comparative lack of published academic work in the field. As McCorry (2018, p14) remarks in relation to his research considering off-chain transactions: "Unfortunately, most of the state-of-the-art research is scattered across message boards, chatrooms, mailing lists and private discussions", and this is the general trend with technical information and the general discourse surrounding blockchains.

As a result of the unreliability of literature and discourse, the validity of the claims made about what an ICO, coin, proposed product or service will do for humanity vary hugely – from earnest prototypes that just might work given time; to vapourware and unrealisable ambitions that were flawed logically from the start; to downright scams amounting to Ponzi schemes. This tendency is highlighted jokingly in notable examples of PonzICO (2020) and PonziCOIN (2018), tongue in cheek 'honest' Ponzi schemes. As PonziCOIN (2018) would like to remind us: "Please be careful when investing in shady cryptocurrencies, especially ones that look like pyramid schemes - it's a zero sum game and money doesn't appear out of thin air."

Not only do the prevalence of scams, vapourware (a much publicised software product that in reality does not exist) and promises of benefits that do not entirely stand up to scrutiny muddy the waters of research in this field but they also create distrust amongst the general public (and among blockchain users too), and have a tendency to disenfranchise interested parties and create perceptions in those not experienced, that it is either an elaborate scam, an in-joke, a flash in the pan or some combination of all of these. This distrust is evident, for example, in the strict regulation of advertising of blockchain related products on social media (as will be discussed shortly) and was prevalent within my early social media interactions when disseminating the preliminary music release project (3.1) and the first two release of project 3 which all attracted negative comments.

There is also a problematic unchallenged assumption that anything that connects to or operates on the blockchain automatically inherits these mythic properties of decentralisation and trustlessness (Mik, 2018, p8). However it can be easily argued that an organisation or system that is established ostensibly to decentralise and remove intermediaries (e.g. music platforms such Musicoin, UJO and Choon, which will be discussed later in 2.5) instead, place themselves in the position occupied by the trust organisations that they seek to disrupt (O'Dwyer, 2016, p305). Also there is a common and I would argue almost religious, belief that this 'decentralisation' is always automatically beneficial to whatever it is applied, which is somewhat disputable; and Gerard's (2017, p58) accusation that Bitcoin decentralised things that should not be decentralised, then re-centralises them again wastefully is not without grounds.

The idea of the 'trustless system' is also flawed on a fundamental level as these "trustless" systems will still involve trusting humans wherever it comes into contact with the physical world (Gerard, 2017, p103). Blockchains are systems that are certainly tamper proof for running smartcontract code and coin/token transactions, but outside this secure space it is meaningless. As soon as a digital file is in the outside environment there is nothing that can be done to stop its reproduction, a decentralised database of intellectual property and ownership as posited by Berklee College (2015:p4), Ujo Music (2.5), Heap (2017) and others, in reality would be just that, a database and nothing more, with no bearing on the real world and offering no improvement on the current PRO system which they insist that it must replace. This point is also echoed by O'Dwyer (2016, p297) when considering examples of blockchain based Digital Rights Management (DRM) discussed earlier.

This friction between the idealised world of the blockchain and the real world is also present when attaching value to coins by equating their value to goods and services as with any commerce situation. As Levine (2017) Opines: "My immutable un-forgeable cryptographically secure blockchain record proving that I have 10,000 pounds of aluminium in a warehouse is not much use to a bank if I then smuggle the aluminium out of the warehouse through the back door". Despite a pretence to technological infallibility, in practice that the blockchain hinges on people's actions in matters concerning non-blockchain assets both physical and digital (Steyerl, 2017:p224).

Property of Money	**Description**	**Literature source**
Durable	The durability of money is defined as physically able to use for a very long time without being damaged or need to be reworked	(Bank of Canada, 2016; Jevons, 1890; Sykes, 1905)
Divisible	Money must also be mechanically divisible into usable quantities or fractions and the aggregate value after division should be almost exactly the same as before division	(Bank of Canada, 2016; Jevons, 1890)
Portability	Money must always be easy to be moved and transferred from one to another	(Bank of Canada, 2016; Jevons, 1890
Scarcity/ Stability of Value	Scarcity of money is described as money should not be easily produced and not fluctuate in value but at the same time it must be sufficient for economic exchanges	(Bank of Canada, 2016; Sykes, 1905)
Homogeneity/ Fungible	The homogeneity of money refers to the equal quality of materials and weight and size for money that has the same value	(Bank of Canada, 2016; Jevons, 1890
Verifiable/ Cognizable	The capability to identify the originality of money to avoid people from using fake money	(Bank of Canada, 2016; Jevons, 1890

***Table 1**: Properties of Money* (Bank of Canada, 2016; Jevons, 1890; Sykes, 1905 cited in Khairuddin, 2019, p45 - 46).

On a basic level cryptocurrencies face some obstacles to being considered practical currency. Exchange rates are highly volatile, with the potential to dramatically increase or decrease in value even during the processing time of the transactions. Khairuddin, (2019) outlines the 6 basic principles of money (table 1, above), and whilst it is reasonable to say cryptocurrencies do meet most of the criteria, they do not meet the requirements of 'scarcity / stability of value' due to extreme volatility. This has caused such problems, for example, that one of the largest online game services, Steam,

removed the option to pay with bitcoin (Ghosh, 2017). Transaction costs are also volatile, and are dependent on exchange rates and the number of miners and the amount of transaction activity on the network. For example, Bitcoin transaction fees which have risen as high as $55.16 (22/12/17) (BitInfoCharts, 2020). Ethereum fees are consistently cheaper on average by a reasonable margin, with the highest average recorded up to around mid 2020 being $5.53 (BitInfoCharts, 2020) and with simple wallet to wallet TX fees below $0.01 for most of the practical projects. However, as will be discussed during the final project (project 5), issues relating to scalability and high economic activity pushed transaction fees to around $10 for a short time in the late stages of this research.

There are also some more peripheral issues that will possibly render solely using the blockchain to distribute music impractical, at least in the near and medium terms, which will be discussed here as these were not raised in academic or media coverage found during the contextual review phase of this project.

Firstly, Facebook and Instagram banned advertising of cryptocurrency financial products and related services for the majority of this research period (only relaxing the enforcement of the ban during the course of project 5, although it would still technically appear to contravene their basic policy and require special approval). This is states as being due to the prevalence of scams. This was problematic as Facebook advertising is an incredibly important tool for promoting events and music, and is routinely used by all groups considered in this research. This posed a major hurdle when trying to engage with audiences during practical projects 2 and 3.

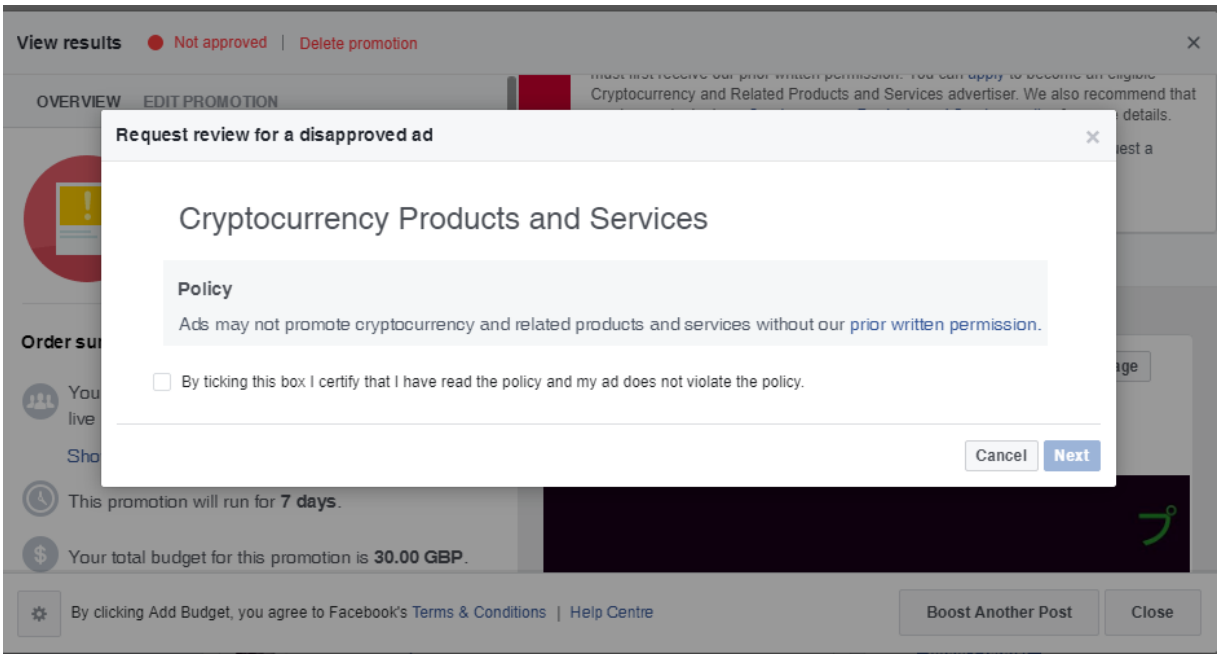

Figure 6: Screenshot from Facebook advert manager taken 10/08/18 when trying to boost a post announcing the first cryptocurrency release on Linebreak Records

Secondly, it is relatively awkward converting between fiat and cryptocurrencies, at least currently in the UK where the process is reliant on using bank transfers to send money to the sellers of the coins and requires an encrypted chat based interaction to arrange the sale. To convert coins back to fiat requires this process in reverse and is somewhat dependent on market demand for the coin in terms of whether you will find a buyer and at what exchange rate. In America some exchanges have compatibility with card payment processors such as PayPal which certainly ease this, however this is

feature not yet widely available in the UK in the context of the Ethereum blockchain. The exchanges also take a fee for the transaction (Coinbase, 2019), which also acts to undermine the positive points about reduced transaction fees when using blockchain.

Thirdly, there is a reluctance to actually spend cryptocurrency amongst those who possess it (Cointelegraph, 2017). This is attributable, firstly to a very strong belief the value of their digital currencies is going to continue to increase (Cointelegraph, 2017), and keep increasing until to the extent that it reaches “the moon” (a prevalent cryptocurrency meme and exclamation of faith in the continued increase in value of a cryptocurrency) . The second reason that people don’t spend their cryptocurrencies is that, as we have seen, it is not yet convenient to spend them. There is no solution currently available that would enable a fluid interaction of the exchanges and in person spending (Cointelegraph, 2017) and it is relatively hard to use in even those limited online applications when use is possible (Gerard 2017:p24) due to the issues relating to actually acquiring coins in the first place.

This suggestion of hording behaviour is also apparent in social media groups dedicated to cryptocurrencies, such as Facebook groups, which are overwhelmed with ‘investment opportunities’ (many of which are fraudulent) and discussions of trading. This trend is also shown in the work of Khairuddin, (2019, p 97-99) who conducted a study with 20 bitcoin users to ascertain their motivation when adopting bitcoin. Out of the 20 participants only 3 had actually spent currency, the rest were interested in it as a store of future value, remarking that spending was the exception rather than the norm. Interestingly 1 of the 3 the spending use-cases here was to commit music piracy by purchasing an unlimited Spotify account on the darkweb, which further highlights the endemic nature of piracy in online communities.

Returning to the example of Heap’s Mycelia project briefly, to highlight the problems of accessibility and demand, Gerard (2017, p129) lays bare the overly optimistic nature of speculation about blockchain commerce. Heap’s blockchain-based single apparently only made gross sales of $133 which equates to 222 sales at $0.60 each and was taken off sale some time in 2016. Whilst this release was a good idea in theory, it is just not accessible for many as there is a low saturation of blockchain technology in audiences and those that do already use the technology are probably not inclined to spend. That being said, it would be reasonable to mention that as this research has progressed, both general awareness and ease of access have improved to a limited degree due to improved wallets and browsers which are considerably more reliable and easier to use than wallets at the outset of this project and as evidenced in the continuing increase in market capitalisation of cryptocurrencies.

Despite the financial failure of the release itself it is reasonable to state that there were some secondary benefits to the project for the artist in that it generated a large amount of publicity for her work (which may well have translated into revenue generated on her back catalogue) and various public appearances and speaking engagements (a further revenue source, including an appearance Sage Gateshead, which sparked their initial interest in blockchain technology).

Despite this myriad of negative attributes blockchains both persist and arguably flourish. This is in no short measure because cryptocurrencies are built on foundations of pure hope and conviction that because of their scarcity and the promises of revolutionising economies, that the value of a particular cryptocurrency will skyrocket in value so much it will reach the lofty height of ‘the moon’ figuratively speaking. Aside from hope, however, there is also at this point lot invested in it. At this moment in time, at current exchange rates and total number of minted coins (as of 30/12/2020), the market capitalisation of Bitcoin is equivalent value of over 350 billion USD and Ether market capitalisation to the value of just over 80 billion USD, and this does not include any of the fringe currencies (‘alt coins’) or forks from main blockchains such as Ethereum Classic which are also still traded. As Fletcher (Fletcher and Kivinen, 2018) observed, at this point it is simply “too big to fail” and may at some point become a widely adopted financial system and therefore merits further research.

2.4.3 Summary of the blockchain for music

Advantages for music applications

- Blockchain offers advantages for receiving micro payments over current systems, primarily due to markedly reduced transaction fees, and more instantaneous payment.

- Smartcontracts offer the ability to efficiently automate complex payment process (for example apportioning and payment of royalties for collaborative music works).

- Due to the open source and decentralised nature of the blockchain it is possible that organisations and practitioners can appropriate it for their own use, more so than current financial systems that are wholly reliant on intermediaries.

Limitations

- Blockchain technology is still in its' relative infancy and is not accessible or convenient for most to use.

- It is considered by some to be a highly inefficient way of working when compared to existing centralised systems and related to this inefficiency there are concerns surrounding the environmental impact of the enormous energy consumption of blockchains and these factors lead some to doubt the longevity of the technology.

- There is much confused reporting surrounding what are actually practical or useful applications for the technology, especially in the narrative surrounding music that often uses misleading jargon and is often politically or ideologically charged.

- It is highly dubious if 'trustless systems' can offer any meaningful improvements on current systems of ownership and licensing of intellectual property due to the intrinsic reliance of these systems on trusting actions of people at the points where they interface with the real world.

- There are indications, that at this time, there is a general reluctance to spend cryptocurrencies on products and no meaningful market demand for music accessed with blockchain technology.

- The exchange rates are highly volatile which severely limits its usefulness as a form of currency.

2.5 Existing blockchain music platforms

Now that the music industry's revenue streams, intellectual property management and royalty structures have been discussed it is possible to begin to assess the existing blockchain platforms and methods against this understanding to help inform the development of practical aspect of this project. This review was conducted initially during the contextual review phase of the project and later updated during the writing up phase. It is not possible to discuss all platforms here, especially given their relatively rapid turnover, however a wide enough range have been surveyed to give a general understanding of the operation of such platforms. This aspect of the review consisted of uploading

music from my ako, Badger and Mausoleums projects to various platforms to explore their characteristics and gage the potential for revenue generation.

One of the more promising examples is that of the opensource Musicoin project. Musicion offers recorded music streaming and aims to distribute 100% of the streaming revenue to musicians on the Musicoin platform (Medium, 2017).The uploader of content is paid one MUSIC coin per stream (with options to 'tip' the creator additional amounts). MUSIC can be traded on exchanges so is a fungible coin (a coin with monetary value) and therefore offers monetary reward for artists. Miners for the Musicion blockchain are also paid MUSIC and Musicoin offers smartcontracts to apportion payments to collaborators. At the time of writing (26/01/2020) 1 MUSIC is valued at £0.00017134 so is generally a lot less (by an order of magnitude) per stream than non-blockchain streaming services, but with the advantage of 100% artist share. MUSIC earned will require being transacted on exchanges through one or more different cryptocurrencies, then sold for fiat currency to actually constitute useful income which somewhat limits the effectiveness of this platform. Also the website is still in the beta testing phase so the user experience is somewhat lacking which is a recurring issue when comparing blockchain platforms to existing ones.

Contemporaneous to the literature review phase of the project, Choon was the other notable example of a blockchain streaming platform. It operated on a commercial basis and it promised to pay artists with its propriety NOTE coin. Artists earned these coins for plays of their tracks and for licensing them for playlists. The platforms also offered the option to set up a smartcontract to apportion royalties to other contributors (Quantalysus, 2018). NOTEs are not fungible, i.e. hold no monetary value, which was certainly of concern when this platform was first considered during the review. Choon have recently merged with Emanate, which operates in a very similar fashion using the EMT token, however with advantage that this coin is trading against fiat currency, although again earning considerably less per stream than fiat platforms and awkward to convert to useful funds. Additionally, as with Musicoin, according to the Choon and Emanate terms and conditions, they do not pay publishing royalties

This avoidance of publishing royalties is again the case with the next platform surveyed, Ujo music (offering digital downloading and streaming services), as it does not permit artists registered with royalty collection societies to upload music. This recurring theme is somewhat concerning because whilst these platforms often promise users that they will keep '100%' of their cryptocurrency 'earnings', it closes a potential tertiary revenue stream. It is also at odds with the stated goals of these platforms, i.e. fairer payments for artists and does not compare favourably with fiat-platforms like Spotify that do pay publishing royalties.

Ujo uses a web3 wallet and Ether and directly interfaces with the main Ethereum blockchain (Mainnet). It costs Ether to register an artist and a release. It cost the equivalent of around $1 to set up and release a single in September 2018 (presumably this fee is how Ujo hoped to generate their revenue, given that transaction processing fees were generally considerably lower than this at the time of testing). Current direct-to-fan methods such as Bandcamp are free to set up, as are many distributors, with any fees taken as a percentage of revenue, although some do operate in a similar manner with a one-off fee. Whilst this is certainly altogether less convenient than Bandcamp for example, the setup cost may be more cost effective in the long run as it is a one-off fee rather than a percentage of each sale and is certainly considerably lower than the one off fees offered by some current distributors for Spotify/ Apple etc. that operate on that basis also. That is assuming you could make enough sales, which seems unlikely especially given that Heap's (2017) release on Ujo apparently performed very poorly and the *ako – Plaintext* single uploaded during the course of the review (which featured in the blockchain single release 1 as part of the preliminary projects) did not sell on Ujo but did generate income on fiat platforms. Also there would appear to be a small user base reflected in the fact that as of September 2018 there was only 172 releases on Ujo despite being operational for at least 3-4 years at that point and despite having worked with Imogen Heap which

raised their profile considerably. This is fairly desultory compared to the millions and hundreds of millions of releases on more established platforms, and another recurring theme when considering blockchain platforms in general.

Using Ether directly for transactions sets Ujo apart from the other platforms surveyed, and indeed most if not all other blockchain music platforms as they tend to use their own coins and wallets, and in the case of Musicoin their own miners and nodes. Firstly, using a much more widely accepted coin simplifies the conversion of the payments (also negating the risk of investing time into coin in the hope it becomes fungible only for the platform to cease operating as with the example of Choon). Secondly, it makes the store itself more widely accessible, as it removes the need to sign up and create log ins to the platform's proprietary wallets (and user account systems) and the need to obtain obscure coins, either by mining for the network or by some other form of exchange, to use the platforms. Also the user sign-up process of the platforms with custom coins/tokens undermines the anonymity of the blockchain, which is a key selling point for the technology. Thirdly it markedly simplifies the process of creating such a platform and encouraging participation as it there is no need to create custom coins and encourage participants to mine such coins or host network nodes etc or indeed provide personal information such as email addresses or social media verification. Likewise there is no need to develop custom wallets as the platform / store will also be potentially compatible with a wide range of existing wallets and DAPP browsers that support the Ethereum Web3 API.

It is a conclusion of this aspect of the contextual review that one of the fundamental flaws of existing blockchain music platforms is this tendency to overcomplicate the solution because of the insistence on including some form of custom token / coin. The drive for which is the ICO and the initial investment it brings and hope that these coins will gain value to the point where it becomes profitable for those in charge of the supply. This is also likely why there is such a turnover of these solutions, as these projects seem to rarely (if at all as of yet) reach this point of profitability and are subsequently abandoned. In any case, as discussed in the section relating to piracy (2.2), for any new music platform to catch on it needs to be easy to access and using Ether directly removes a layer of complication that will discourage consumers and this guided practical projects toward the Ether based store interface approach taken in the music release and ticketed live stream projects that will discussed in Chapter 3.

Ujo also promised to build a decentralised database of copyright and copyright ownership, however the usefulness of this is somewhat limited as Ujo does nothing to address digital scarcity - once you purchase music it is downloaded as a standard MP3 with no DRM, which can be shared as easily as if it were purchased elsewhere. Secondly for this database to have any impact it will be wholly reliant on the interfacing of the blockchain with the real world which as discussed in section 2.4 is problematic and undermines the goals of this database rendering it of no real benefit.

Whilst discussing these existing blockchain music platforms, it's worth exploring their stated aims and the promises they make to potential users. Both Heap (2017) and Choon's founder, electronic music producer Gareth Emory (Choon, 2018) suggested that primary benefit of the blockchain is to remove intermediaries, with both parties referring to the notion of label exploitation discussed previously in section 2.2.2. This is something that is often remarked upon during the discourse surrounding the motivation behind the formation of these kinds of platforms. There is one rather large flaw in this argument however (aside from the fact that label exploitation is a subjective issue in itself, with many smaller labels operating less exploitatively), and that is, whilst artists like Heap and Emory could expect to benefit in this manner as they had previously worked exclusively with record labels, the vast majority of (DIY) artists that these platforms are aimed at already operate independently in a direct-to-fan fashion. Therefore these DIY artists will see much less immediate benefit as they do not have the label intermediaries to remove. Also as mentioned before Emory's platform opted out of paying artists publishing royalties, which further undermines the idea that this platform was set up to benefit artists. Further to this, establishing a platform is an act of re-centralisation, and it becomes an intermediary

just as fiat based platforms are said to be, and therefore would incur some kind of charge to artist (with the exception of the opensource Musicion project). Therefore at best these platforms can be said to only offer improvements in transaction fees for artists and help with management of royalties in collaborative situations with smartcontracts, although paying considerably less than their fiat-based counter parts. As remarked previously, this kind of overpromising was a recurring theme when considering platforms such as these and generally very common in surrounding literature and discourse.

2.5.1 Summary of existing blockchain music platforms

- Demand for music delivered in this fashion seems low when considering both download stores and streaming platforms, especially in comparison to the existing fiat-based examples.
- There are no indications yet that there are any noticeable benefits in terms of better management of intellectual property for practitioners and organisations when compared to existing non blockchain platforms.
- The rhetoric surrounding the formation of some of the commercial platforms (i.e. the benefits of direct-to-fan practices and circumventing 'greedy' labels) is only applicable to the context of non-independent and non-DIY artist. DIY artists who already operate in this manner (i.e. the target user base of these platforms) will have much less to gain.
- Whilst it is possible to argue that the artists may benefit from a larger share of revenue earned, the benefits of removing intermediaries is somewhat over stated and these platforms also act as recentralising force and therefore undermine some of the benefits of the blockchain's 'decentralisation'.
- Musicoin and Emenate pay less per stream then Spotify and as with the tokens employed on other platforms, it is rather awkward to convert to usable funds. These platforms also exempt themselves from PRS/MCPS royalties (unlike Spotify for example) closing a potential tertiary stream of revenue.
- Blockchain solutions have a tendency to use custom coins/ICOs which overcomplicate the solution and add to the difficulty of user experience, and further compound the issues relating to low saturation of the blockchain. However employing a more widely compatible coin and wallet may help, such as Ether and Ethereum Web3 API compatible wallets.

2.6 Summary of the contextual review in relation to practical projects

This contextual review begins by first introducing the blockchain and definitions of key operational characteristics to establish familiarity with the reader of specialist terms (2.1) that will be used throughout, and to give an operational understanding of blockchains which underpins projects 2, 3, 4 and 5. After which it examines the wider context of recorded music distribution (2.2). It was necessary to understand this as it forms the over-arching context of any practical projects that were to be conducted. It was also necessary to include criticisms of the 'official' view of the current music industry context as it is disputed; specifically where it concerns the DIY practitioner and smaller organisations (groups considered by this project) as they are often underrepresented in this discourse. In light of this gap in the literature, knowledge gained from my own practice is used to temper the understanding of the context and conclusions.

After completing 2.2 it began appearing doubtful that piracy is actually harmful to these groups. This conclusion, and the general consensus in the following section that considered intellectual property etc. (2.4) that DRM in music had failed and was unlikely to be worth pursuing from the perspective of digital music files, guided the practical projects away from notions of blockchain based IP/rights management (something that was often posited in earlier blockchain literature surrounding both art and music). This was due the problems of expecting the immutability of the blockchain to have a bearing on the actions of people in the real world.

The disputed effect of piracy and issues surrounding streaming revenue, both in the literature and in my own experience, suggested that streaming was not a meaningful replacement to selling music for the DIY/small organisation groups (contrary to the prevailing view of the music industry at large). The conclusion being that, whilst streaming is certainly a useful revenue stream, donation pricing and direct-to-fan selling is probably just as important if not more so for these groups. This realisation helped guide the practical projects away from streamed content as a method of distributing recorded music chosen for practical exploration, and lead to development of the music download paradigm adopted for projects 3 and 5 (blockchain music releases).

The intellectual property section (2.3) also gave rise to the notion of the devaluation of recorded music in favour of live music (David, 2010). As a result of this, ideas of liveness were explored from the perspective of online music distribution as it was apparent that as the project was concerned with improving revenue for musicians and finding new ways for music to be distributed; then any profitable aspects of music must be explored, even if they existed outside of the usual context of music distribution. This was also seen as an important avenue to consider as Sage Gateshead is primarily a live music organisation and this appeared to offer opportunity to develop practical applications that would coincide with their operational context.

Firstly in relation to live music in the context of digital music distribution, as live streaming was beginning to reach a point of widespread popularity on social media during the contextual review phase and was an area the partner organisation was interested in (as ascertained during consultations with them), it seemed to be a logical starting place for a practical project. This instigated the series of practical live streaming projects, including the live stream portion of the preliminary projects, and project 1 and project 2 (blockchain ticketed live stream). Second to this, and in light of the work of Baracka (1964) concerning the fleeting nature of live music, which is concluded to be a factor behind its 'scarcity' and ability to maintain value, the question became in what other ways could this temporal nature, and innate scarcity, be explored in the context of digital music distribution aside from the live streaming projects.

From this arose the idea of replicating this 'uniqueness'/'liveness' by using algorithmic techniques to broadcast music that would be considered 'live' by nature of being generated in the present. It appeared that it could be contended that this work could be understood as live performance. For example Kraftwerk's *Robots* is performed not by the band but by pre-programmed robots and has been widely accepted by live music audiences, some critics even seem to prefer the robot version of the band (Pareles, 2003).

Further to this, when considering the qualities of live performance Godlovitch (1998, p89) states that "a performance is an exceptional instance of a work only if it involves actively making creatively novel instances". It is fair to state that a live algorithm would meet the criteria of creating novel instances, and thus further bolsters the argument that a live algorithm may be considered a live performance.

The approach chosen was through the creation of coded music distributed in real time through the internet as a continuous, temporal performance that is both autonomous and interactive. The content of which can be understood as 'generative' or 'algorithmic', as defined by Brown, Bell and Parkinson (2014) as any process "whereby what happens next is not determined directly by the performer, but indirectly by algorithmic processes set up by the performer" (p14). Which can be further understood

as computer processes such as randomness used for creating melody or other musical features (Brown, Bell and Parkinson 2014:p14).

When relating generative music to live music, it is important to understand the states of 'recorded' and 'live'. In a similar vein to the sentiments of Baracka, Kim (2017) asserts that live performance, in opposition temporally to recorded music, can only exist in the present, a recorded live performance is nothing more than a revival of past live performance. This is also true of generative music, once it is fixed to a medium it is no longer generative (or live), but some reproduction of past events. "Because algorithmic compositions rely on real-time execution of processes to generate sound" once recorded, they are deprecated and become merely "static snapshots" Levtov (2018, p693). This further reinforces the contention that a live algorithm could be considered a live performance. Also, this is important in the context of exploiting 'liveness' to maintain value in a musical work, as this devaluation as a result of recording would preclude attempts at piracy by recording the work and distributing it as a recording.

Second to this, we must understand what constitutes performance and to what level of importance are coinciding temporal and spatial locations for audience and performer. Kim (2017), when considering the discourse surrounding live performance suggests importance is placed on the material presence of *either* performer *or* audience, there is no requirement for both parties to be present it seems (a phenomena also evident in live streamed live music). With the advent of audio-visual recording live became synonymous with occurring in "real time," diminishing the concern for co-presence in space Kim (2017). Interestingly, Kim (2017) also posits, when considering the holographic performance, that this puts into question whether human presence itself should also be disqualified as an agent of liveness. This line of reasoning led to the interactive/generative music project discussed in the preliminary projects section and to project 4 (the 'live' sonification of the blockchain).

Next, the understandings of how the characteristics and qualities of the blockchain (2.4) may lend themselves to music distribution and the evaluation of the existing blockchain platforms (2.5) (informed by understandings of the wider context of music distribution) helped to point to which areas the blockchain could be applied during the development of the practical projects. The most important conclusions were as follows:

- Firstly, it appeared that the blockchain could be most usefully applied to areas involving the receipt, accounting and management of micro-payments and would offer the advantage of removing intermediaries when selling direct-to-fans (this could benefit all groups considered, but specifically in the area of direct-to-fan selling this would most benefit DIY artists and small organisations and these are common modes of operation for these groups).

- Secondly, DRM did not present a useful application for blockchain due to the problematic point of interface between the blockchain and the real world and because of the generally problematic area of managing intellectual property compounded by the fact that it appeared that making intellectual property freely accessible is actually beneficial for the DIY artist and small organisation groups considered and for the partner organisation whose context is live music which is an area that has specifically benefited from displacement spending (caused by freely accessible intellectual property)

- Thirdly, while streaming was certainly useful, DIY musicians / small organisations probably benefited as much (if not more) from actually selling music downloads in terms of generating revenue due to the poor royalty rates and increased number of intermediaries in streamed distribution

These conclusions specifically informed the concept and development of a cryptocurrency store interface to sell digital downloads used for project 3 (blockchain music releases, after initially being

trailed as part of the preliminary projects) and the donation pricing interface used for project 5. The decision to take the approach of selling music also lead to the formation of Linebreak Records as an imprint to conduct these projects through. This also allowed the perspective of the small organisation, such as this record label, to be considered alongside that of DIY practitioners participating throughout these projects. At the time of founding Linebreak was (and still appears to be) the first and only record label operating solely on the blockchain, as efforts in the development community are wholly dedicated to developing platforms.

Chapter 3 — Practical Projects

3.1 Preliminary projects

3.1.1 Live streamed performance projects

RSVP Kaneda Presents TIN SESSIONS 001
SIMON (DJ), DIZ (DJ), BUHL / DAUGHTERS & BADGER (LIVE)
Video: https://www.facebook.com/kanedarecords/videos/1680294212034540/

RSVP Kaneda Presents TIN SESSIONS 002
ROHLI (LIVE), OM10 (LIVE), CASS LAMB (DJ), TUNNEL CLUB (LIVE), RANDOM MAT (DJ)
Video: https://www.facebook.com/kanedarecords/videos/1770957896301504/

Kaneda Live Stream (TIN SESSION 003)
JOHN DOLE, AKO, BUHL & CALLUM ISAAC HAZE
Video: https://www.facebook.com/kanedarecords/videos/1837393652991261/

***Figure 7**:* Kaneda Records Tin Session 001 (Buhl DJ set)

Three live streams of live music performance events were conducted via Facebook Live. The first two streams were conducted from a Kaneda Records free party (a club night with a physical venue and audience) that was also broadcast live; the third being a live stream only performance with no attending guests. Data was gathered from Facebook including: engagement, reach and viewing figures.

The aim was to test live performance attended virtually, which at this point was a relatively new methodology and something we had not yet tried with the label (Kaneda). Live streaming was also something that the partner organisation had expressed interest and appeared to present a way to include activities suitable to a live music organisation (i.e. the partner organisation) in this otherwise virtual realm of the blockchain. Further to this, the inclusion of live music within the research was seen as desirable due to the favourable conclusions drawn in 2.3 about it as a resilient revenue stream in the current context of the music industry. Live streaming performance therefore seemed to offer all groups considered a potential methodology to explore this resilient revenue source in a new online context which could be expanded upon later with some aspect of blockchain technology. The burgeoning popularity of live streaming services around the time of the commencement of these projects suggested that it could offer great potential as a tool for audience engagement also.

The objective was to gather audience engagement data on live streams, in an attempt to understand what role live streaming could play in future distribution practice and to determine whether it warranted further exploration with a blockchain / cryptocurrency related project.

In terms of audience engagement the preliminary streams reached 7389, 3834 and 1562 people respectively with 842, 1489 and 554 views respectively during the live stream events.

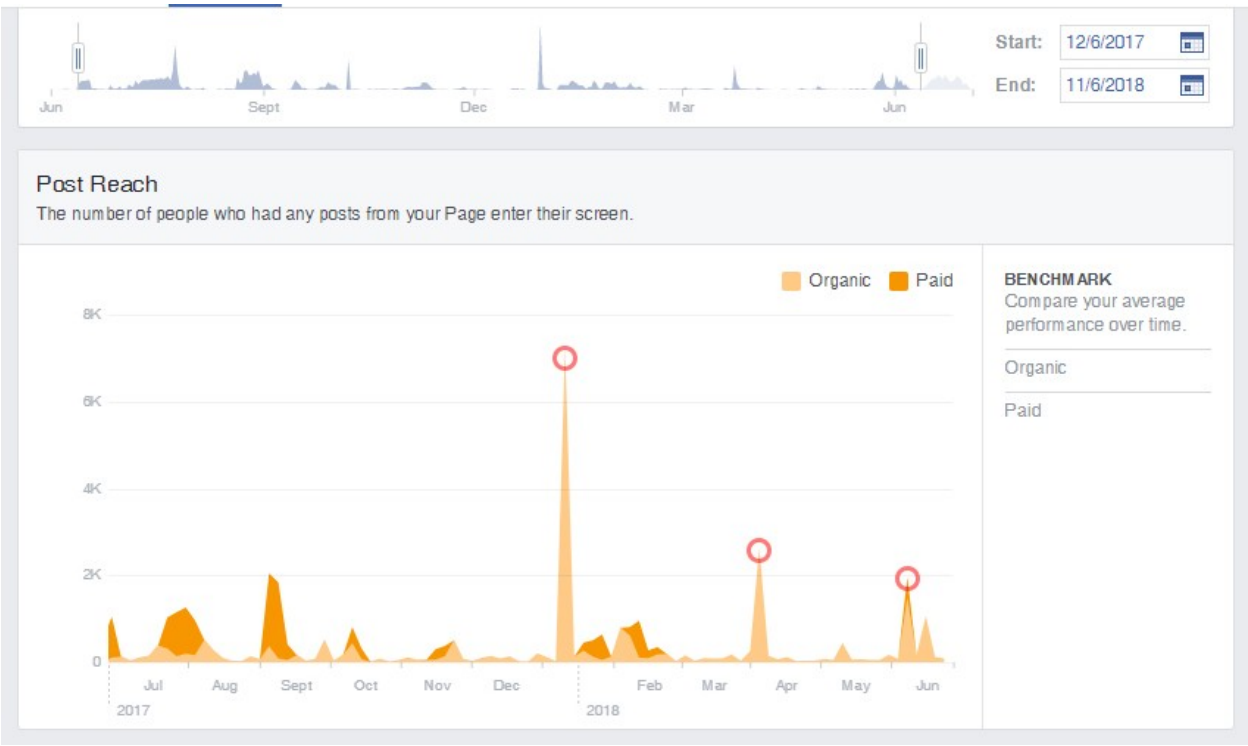

***Figure 8**:* Facebook post reach for year 12/6/17 – 11/6/18. Lighter orange indicates natural or 'organic' reach (the number of people who have seen the post due it being shared into their timeline by people they are friends with or pages they follow) and darker orange indicates paid reach (the number of people who have seen due to Facebook marketing)

Figure 8, above, shows post reach, with 3 peaks indicated (circled in red) that represent the live stream videos. It is clear from the graph that these live streamed posts perform far better than other post types in terms of organically reaching audiences. These were some of the most engaged with posts and also notably, the reach is greater than sponsored posts. These streams also reached international audiences who accounted for 7.5% of the total cumulative viewing time, which was surprising and points to the usefulness of live streaming as way to engage with new and widened

audiences. It also might be tentatively argued that live streaming also does not seem to affect attendance when coupled with a physical live event as both of the free party events were at capacity so perhaps live streams might be employed in a complimentary fashion with live events.

Next steps

After reflection on these live stream projects it was concluded that live streaming of live performance is an effective way for DIY musicians / small organisations (the performers and stream hosts) to reach and engage with audiences. Live streaming also offers an approach for moving live performance to an online space which may be further developed to offer a supplementary income source to digital recorded music. However, to exploit the value of live music delivered in this way, other than for wider exposure, it needs to be monetised in some fashion. Whilst streaming services like Twitch and YouTube offer monetisation, this project was focused on using blockchain based methods, and at the time of these preliminary projects none such platforms existed so it was decided that some form of blockchain ticketed live stream should be hosted. Also I would argue that the monetisation methods employed by Twitch and YouTube do not lend themselves well to the irregular, potentially 'one off' nature of live music performances, being subscription based in the case of Twitch or advertising based and only available to popular and well established channels in the case of YouTube.

From a technical perspective, blockchain at this stage appeared to have the potential to lend itself to ticketing due to the 'distributed ledger' offering the potential to be employed as a customer ticket database. Smartcontracts also appeared to offer automated management of funds which seemed useful in the context of collaborative live events. Also it was found that the Ethereum Web3 API had the potential for creating webpages to interface with the blockchain relatively easily.

During consultation with the partner organisation, Sage Gateshead, the suggestion of research into blockchain ticketed live streaming was an area that was highlighted as potentially aligning with their interests and current activities as streaming had been offered with some of their events but was an area where they had to rely on external contractors to provide this service. However it was unclear at that point if it would be successful and scalable to their needs or if it would fit with their programming commitments and resources so a trial stream was necessary. If it was not possible to conduct a streaming project at the partner organisation, it was suggested that the findings of a trial stream hosted elsewhere could be shared with them instead (this trial stream was conducted as project 2). A further Facebook live stream, project 1, was also conducted prior to project 2 to finalise the streaming equipment to be used for the ticketed live stream.

3.1.2 Interactive music

Due to the favourable attributes of live music and Sage Gateshead's operations in this area, as discussed above, it was decided to attempt to approach the incorporation of live music in other ways too.

This project aimed to explore how the notion of 'liveness', as described as 'uniqueness' or a temporal or fleeting nature (David, 2010; Baracka, 1964) forms a limiting factor in that live music can only be viewed or engaged with contemporaneously to be considered 'live'. Therefore any recording after the fact is a reproduction, a piece of recorded music, and as such devalued to reflect this new status, thus maintaining the scarcity and thereby the value of live music.

This argument lends itself to be extended to other paradigms of contemporaneous music creation and reception beyond live streaming. One such idea of replicating this 'uniqueness' or 'liveness' is by the

use of algorithmic techniques to ‘broadcast’ music that would be considered ‘live’ by nature of being generated in the present, as discussed in 2.6.

This interactive music project was also envisioned as an attempt to move live music into the online context in a manner that is a more experimental and creative exploration of music-making itself, compared to the repackaging of the live experience explored in the live streaming projects. Also it was hoped that there was potential to host the resultant interactive musical work either on Sage Gateshead’s website or in one of their public spaces.

Plaintext soundboard

As a learning project a soundboard was constructed using stems from ‘Plaintext’ (the preliminary single release that will be discussed in 3.1.3) and other audio clips (pictured below figure 9). A soundboard is a website or app that catalogues and plays back audio clips, generally used for the purpose of satire.

However in this case it is used to playback audio loops taken from the track in addition to a video loop. When the mouse cursor moves over certain areas of the page, additional sounds are triggered and this movement also controls the volume of some loops by tracking the position of the mouse on the screen forming a simple but interesting remixing tool. The aim being to create an interactive work that incorporated the idea of remixing posited in Heap’s (2017) mycelia project to be used as a promotional tool for the first single release (3.1.3). This notion of a novel webpage as part of a promotional campaign for a music release is something that will be returned to in project 5. Visually, the project was influenced by the Jodi collective’s work http://wwwwwwwww.jodi.org/ (pictured below, figure 10), a deliberately nonsensical website.

Due to browser updates the webpage is no longer compatible with most browsers but can viewed as screen captured video here: https://youtu.be/KxOGrTV0I4k

Edge browser was still supported as of writing and a live version of the webpage can be accessed here: https://www.linebreakrecords.com/plaintextSOUNDBOARD.html

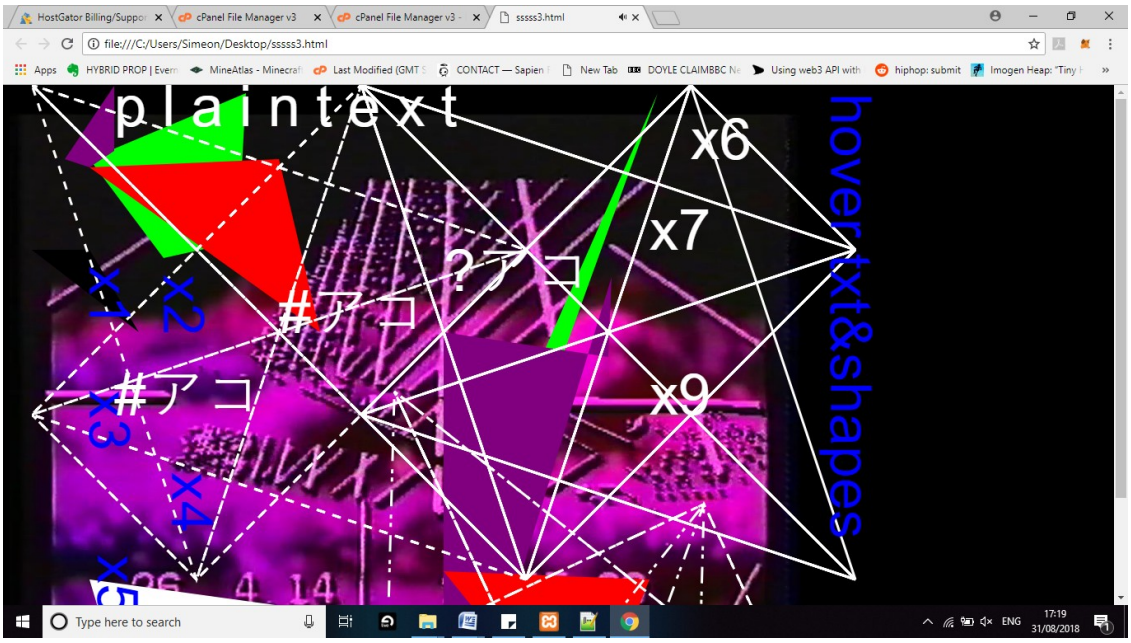

***Figure 9**:* Plaintext soundboard, coded in JavaScript and HTML

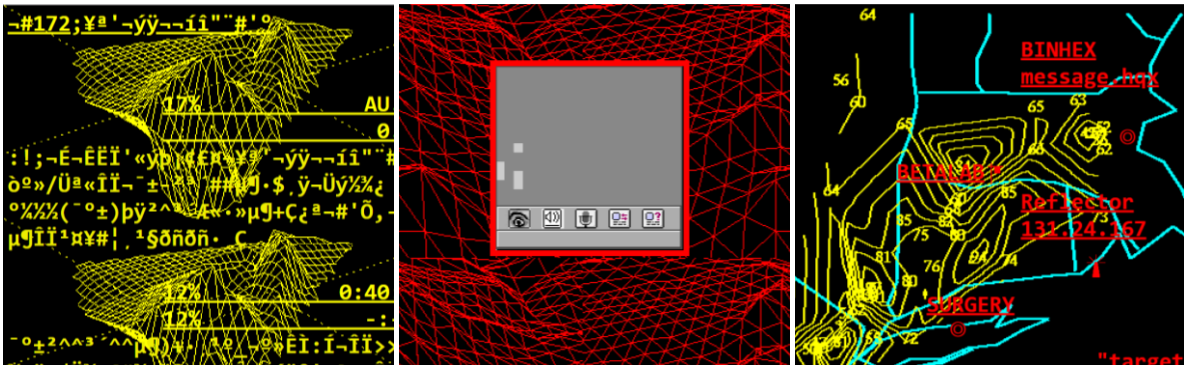

Figure 10: Three screenshots from http://wwwwwwwww.jodi.org/

Audio as blockchain data

To explore the technical possibilities for using blockchain to directly store and retrieve data, such as audio recordings, as part of the interactive element an MP3 was encoded as hexadecimal data (a system using the numbers 0-9 to represent the values of 0-9 and the letters A-F to represent values of 10-15) and then included in the transaction data field of a transaction between wallets (shown below, figure 11).

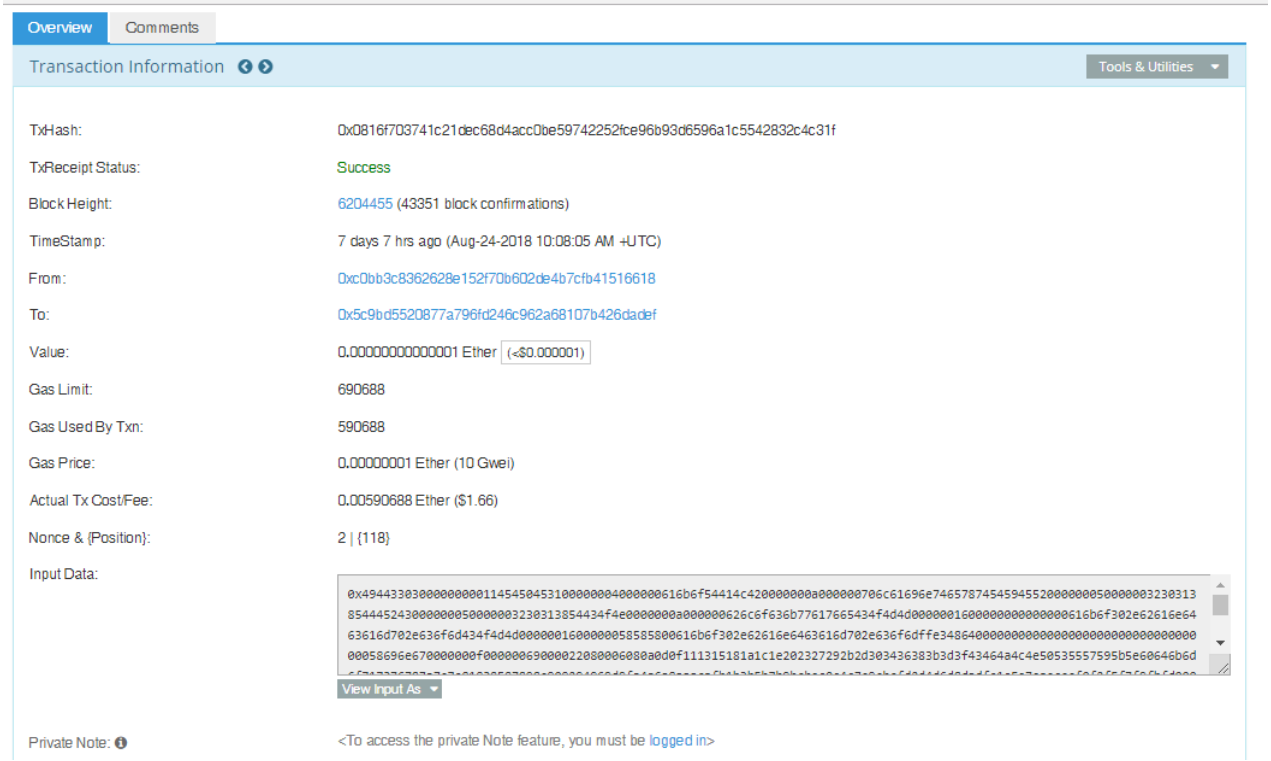

Figure 11*:* Screenshot of transaction [0x0816f703741c21dec68d4acc0be59742252fce96b93d6596a1c5542832c4c31f](). MP3 data is located in the 'Input Data' field (etherscan.io)

This experiment further illustrated the limitations of data within blockchain transactions. The largest successfully transacted file size I could achieve after much trial and error was just 17kb of data, consisting of around 7 seconds of very low quality MP3 data (8Kbps at 11kHz). Whilst early Ethereum reporting suggested that this blockchain offered a theoretically unlimited block size (in contrast to

Bitcoin's 1MB limit), there is, in practice, a limit. This is because the amount of data included increases gas amount dramatically, and there is an upper limit (block gas limit) to how much gas you can actually pay, limiting data that can be included to just a few kilobytes. Also as the Ethereum blockchain is publicly accessible and therefore so is the encoded data, this limits the possible applications of data stored in this way.

Due to the nature of public blockchain data it is impossible to know how many people accessed this piece of music, but I do know of at least one person who did access the data (as they commented on social media posts surrounding this experiment) and successfully converted it back to MP3 and who found this to be an amusing way of presenting music. This was one of the first pointers, during the course of this research, that the novelty of blockchain music releases could provide means to attract audience engagement (as discussed in 2.4.2 and as will be discussed in much more detail in project 5 and in the conclusions in chapter 4).

In relation to uses for data on the blockchain in interactive music, sending limited data in transactions could potentially be used in conjunction with APIs that can read blockchain data to facilitate audience interaction by allowing the sending of data to be used by the algorithms / generative processes of the music. For instance, this combined with aspects from the soundboard project could work to create a long term evolving composition.

Next steps

From reflection on preliminary interactive music projects and the pertinent sources consulted in the contextual review (2.6) it became possible to begin to envision an algorithm, or set of generative processes, which transforms data from the blockchain, operates continuously and broadcasts 'live'. Data could be a mixture of arbitrary blockchain data (such as: transactions, block completion, exchange rates, values etc.) generated by the day-to-day running of the blockchain and 'audience' submitted data, included in donation transactions sent by the 'audience'. The envisioned system is depicted below, figure 12 and project 4 continues the development towards this.

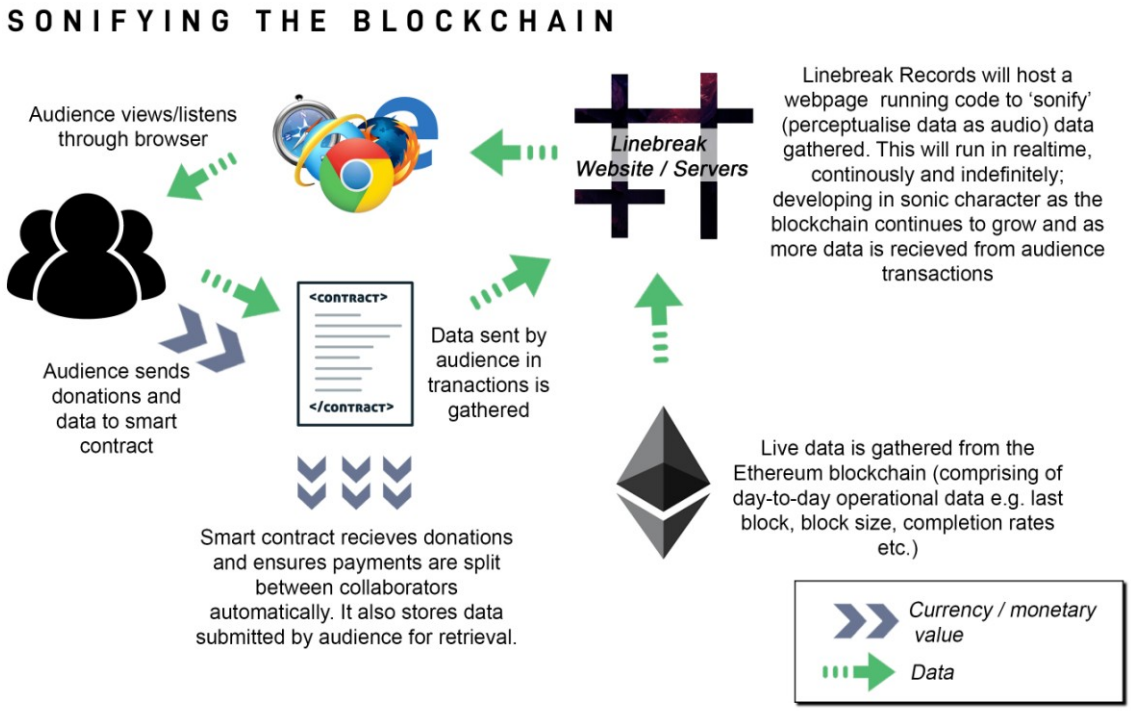

Figure 12: Diagram of proposed interactive work for project 4: interactive music.

3.1.3 Blockchain single release 1

During the contextual review a new record label, Linebreak Records (https://www.linebreakrecords.com/) was launched to manage blockchain releases. This label and website were used throughout the practical projects to release music (this preliminary release and Projects 3 and 5) and to host the blockchain ticketed live stream (Project 2) and the interactive music page (project 4).

The first release was the 2 track ako single 'Plaintext / Concrete Beach' released on 27/07/2018

Store page: https://www.linebreakrecords.com/plaintext.php

Streaming link: https://ako0.bandcamp.com/album/plaintext-concrete-beach

Music 'zine article covering the Linebreak Records label and single release 1 published in NARC.magazine :
FEATURE: LINEBREAK RECORDS - MY INSPIRATION
https://narcmagazine.com/feature-linebreak-records-my-inspiration/

This single is purchasable from the store page, above, by sending Ether to a smartcontract. Once currency is received by the smartcontract, the senders' wallet address will unlock a download page that contains both standard stereo WAV/MP3 files, but also remix stems.

This project aimed to test the demand for music on the blockchain and gage interest in receiving music in non-typical forms, i.e. remix stems, when purchasing. The music was also released simultaneously on 'fiat' platforms including Bandcamp and Spotify as well as blockchain music platforms (Ujo, Choon and Musicion). Alongside this preliminary single I also uploaded the ako, Badger and Mausoleums back catalogue (and later some subsequent releases) to these blockchain music platforms as further research into the demand for music on these platforms as part of the research into existing blockchain music platforms conducted in 2.5.

The project also aimed to test the supposed benefits, found during the contextual review, of automatic/instant apportioning of payment as well as the potential for cheaper transaction processing and to explore what other potential benefits the decentralisation of the blockchain may offer DIY musicians and organisations.

This was realised by employing a smartcontract that receives incoming funds and splits them instantly, apportioning 90% to a wallet representing the artist and 10% to a wallet representing the label, although this system could also be setup with any number of additional recipients to pay other collaborators e.g. individual band members. The smart contract is pictured below (figure 13). The store functions on a pay-what-you-want basis, a donation of any amount will unlock the download. A suggested amount equating to $1 in Ether is calculated and displayed on the page. A full explanation of the store page and it's development throughout this research is given in appendix 9, the final iteration of which (used in project 3) is provided in appendix 1 and 2 as annotated code, the original version of the store page used in this project is preserved on Linebreak Records where the code and interface can be viewed.

browser/Untitled.sol

ContractDefinition linebreakCONTRACT

```
1  pragma solidity ^0.4.15;
2
3  ////Creates and names contract
4  contract linebreakCONTRACT1{
5
6  ////events to gather address sender and value
7  event senderLogger(address);
8  event valueLogger(uint);
9
10 ////sets up variables (things to store values), one for each collaborator
11 address kanedaAdress;
12 address akoAdress;
13
14 function () payable {
15 senderLogger(msg.sender);
16 //// Records the total value of payment recieved
17 valueLogger(msg.value);
18
19 //// Firstly, this stores each of the collaborators wallet addresses
20 //// Secondly, it divides  the total value recieved to pay the collaborators
21 /// 10% and 90% respectively
22
23 kanedaAdress = 0x8d916EF7aFc56a335607417E55D238c77EDC8d5E;
24 kanedaAdress.transfer(msg.value / 10);
25
26 akoAdress = 0xC0BB3c8362628E152f70b602de4B7CFB41516618;
27 akoAdress.transfer((msg.value / 10) * 9);
28
29 }
30
31 }
```

***Figure 13**:* Screenshot of annotated source code for the *Plaintext* smartcontract

To purchase the single, the user copies the Ethereum address of the receiving smartcontract by clicking ‘copy address’ and sends their desired amount using a Web3 compatible Ethereum wallet (e.g. MetaMask). Once the transaction has been processed and confirmed the user then pastes their address into the input box labelled ‘enter address’, and clicks ‘check address’. A JavaScript function then checks whether their address has a transaction to the receiving smartcontract associated with it (using blockchain data retrieved with the Etherscan API and PHP). If it does, then download links to the single and remix stems are unlocked, if it does not the user is prompted to check the transaction has successfully completed. The full operation of this address checking function is explained in appendix 9, alongside further updates made during later iterations of this download store.

The pay-what-you-want digital download format was chosen over streamed delivery, despite the wider trend in more mainstream music towards the preference to stream (as discussed in section 2.2), for economic reasons specific to the context of the DIY musician.

The issue with research surrounding the move towards streaming (2.2) is that it either wholly or largely focuses on the mass-marketed mainstream music industry context where artists would expect a higher streaming turn over (to the point of making it worthwhile economically) but also a high rate of piracy due to their wide appeal. Also as discussed in section 2.2.1 and 2.3 the whole premise that piracy is harmful itself also is somewhat uncertain in the context of the DIY artist as there is evidence suggesting that these artists may benefit more from the wider distribution it affords (David, 2010) and it is not guaranteed that these pirates would have actually bought the content anyway had illegal access not been available (Masnick, 2011). Also my practice has benefited directly from piracy in the form of wider exposure after the VK leak discussed also in 2.2.1. Based upon these arguments, it

therefore it can be suggested that in the context of the DIY practitioner, arguments in favour of streaming do not wholly apply and this steered the project towards digital download as the format for this and future releases.

In financial terms, each £1 (net) a digital download earns equates to between 300 and 1200 streams (depending on platform) in stream revenue. This is illustrated in my own practice where I have generated considerably more revenue via download sales than for streamed music. Download formats also allow for 'pay-what-you-want' and donation pricing, which are hugely important for the DIY artist as discussed in 2.2.

Findings of blockchain single release 1

There are two areas where this system offers clear advantage over current practice. Firstly, it is advantageous in apportioning of money to all collaborators instantly and autonomously. Current methods rely on either an independent practitioner or label to collect and apportion the payments to other collaborators manually which can be laborious and in the case of work distributed via a third party (e.g. distributor) means waiting potentially months (minus reimbursements to the third party for admin and other costs). Secondly, it is advantageous in terms of transaction processing fees. Blockchain offers possible benefits when compared to PayPal and other online card payments services commonly used online; namely potentially lower fees, no currency exchange fees if selling across international borders and it is the buyer not the seller that is liable for the fee.

As it is hosted on the label's (Linebreak) own website it also affords the freedom to include remix stems with the purchase, which is not something that is readily available on other platforms. One other point worth mentioning is that the blockchain offers a level of transparency that is not available on other platforms – both sides can see who has paid and where it has been sent – which could be said to offer an advantage over current practice where an artist has to trust the label/third party to make fair remuneration.

This project illustrates a model of a DIY artist working with an independent label (small organisation), and within this model the label is able work more efficiently and potentially offer much better royalty rates due to the fact this release has very little cost or labour attached to it (i.e. no distributor involvement, hosting on website considered to be of negligible cost as a website would already be established for most labels/organisations, payments and management of blockchain sales is completely autonomous and there are no intermediaries eating into payments).

To give a source of comparison for a similar release with more established methods the single was also released on both the Kaneda Records Bandcamp and the artist's Bandcamp. Then, to evaluate the usefulness of the existing blockchain platforms at the time of this project the single was uploaded to Musicoin, Choon and Ujo, representing streaming and digital download options. Subsequently the single was then also released through a distributor to all major online streaming and download services to provide a comparison for revenue generation potential for both artists and labels.

In terms of revenue generation, the single generated income on fiat download and streaming platforms (with download providing the most revenue). The blockchain download versions of this release generated no sales (Ujo, Musicoin and the Linebreak Records store). The blockchain streaming versions, hosted on Choon and Musicion, generated a small number of plays, although generated no discernable revenue as Choon paid in a coin that had no monetary value and the Musicion coins (paid per stream) were trading for a monetary value that was orders of magnitude less than what would be expected per stream on Spotify. The blockchain versions also generated almost no interest in terms of audience engagement.

These results were the first indications in practical testing, of the accuracy of the predictions made in the contextual review of low saturation of blockchain technology within music audiences and low

demand in general for music received in this way (both from the Linebreak stores and the apparently more established blockchain music platforms).

Next steps

Whilst the website code used in this release project functioned as intended, and requires an address that has a payment to the contract associated with to be entered before it will allow access to the files, the blockchain data that is recalled to determine the validity of an address is actually publicly viewable due to the nature of the distributed ledger. Therefore anyone could look up the receiving smartcontract's address on a blockchain explorer (e.g. Etherscan) and retrieve an address that has made a valid transaction and paste that into the address checking box and thus access the download links without actually making a donation. To improve this, Ethereum Web3 APIs was employed in future versions (used in project 3) so the webpage can interact directly with a web3 wallet (this development is explained in appendix 9 section 1) in a similar manner to the Ujo website discussed in 2.5.

3.2 Project 1: WIRE NCL - Kaneda X THROB (28/02/2019) with: ako (live), Bad Luck Ginger (DJ) & Simon (DJ)

3.2.1 Introduction and supporting media

Video (stream broadcast in two parts):
https://www.facebook.com/kanedarecords/videos/547626662415389/ (part 1)
https://www.facebook.com/kanedarecords/videos/405703383329815/ (part 2)

Figure 14: *Wire NCL – Kaneda x Throb Live Stream*

This was an open-access live music Facebook live stream in collaboration with WIRE Newcastle (stream co-hosts) and THROB, a club night (Simon), and Kaneda records (ako and Bad Luck Ginger). This was the final instalment of the Facebook live streaming project started during the preliminary projects (3.1.1).

3.2.2 Results and findings

As with the previous publicly accessible streams this proved to be effective as a way to engage with audiences albeit with some limitations that will be discussed. This stream, across both parts, reached

a total of 1094 people and a total of 334 ‘engagements’ (like/reactions, shares and comments), with a total of approximately 2100 views on the night. Overall, across this stream and the preliminary live streams, live streaming proved a very effective way to engage with audiences with the streams reaching a total audience of 13879; with a total of 4988 views overall. On average the streams had 3470 reach; 1247 views; and 825 unique viewers.

Whilst this project was conducted with organisations (Kaneda Records & Wire NCL) and artists who represent the DIY artist and small organisation categories considered by this research, I think it's fair to argue, based on the general success of this and preliminary streams that a large organisation could expect to see similar or even better results given their typically larger social media presence as an organisation.

During this stream, audiences viewed for a total of 670 minutes (across both parts) equating to 11.16 hours. However the average viewing time was just 40 seconds (0:36 & 0:44 for parts 1 and 2 respectively). Low average viewing times were a trend across all streams of this nature, with the overall average viewing time, across all streams, being just 30.75s (calculated from 0:37, 0:23, 0:23 and 0:40 respectively).

The overall conclusions of this project and the preceding streams are that public Facebook live streams are an effective way for musicians and music organisations of all categories considered by this research to engage with audiences in a manner that is of both relatively low financial and time cost, attracting high viewing numbers and very good reach. The drawback, however, is the low average viewing time which is the result of a large volume of people who passively watched for very short periods of time (seconds in many cases) as they scroll past it in their news feeds. Overall I think the experience lacks a sense of value as it lacks the ‘scarcity’ normally associated with live music events as discussed in 2.3.1, which is something that the use of blockchain ticketing hoped to address in project 3.

From a technical perspective, a Logitech C90 webcam was used and proved much more reliable and user friendly than cameras used in the previous streams where DSLRs, camcorders and video capture cards had been experimented with. However due to the low bandwidth of Facebook live, the audio / video quality is relatively poor and this can be an issue for music performance. Also DRM (digital rights management) poses another problem as live streams featuring DJ’s can be problematic, with certain copy protected material causing the stream to cut off or be muted and is the reason for stream 4 being in 2 parts.

3.3 Project 2: Kaneda Crypto Stream #1: SQUARMS / Bert Verso / Badger (05/04/2019)

3.3.1 Introduction and supporting media

Facebook event: https://www.facebook.com/events/551907045290696/
Ticket interface/stream webpage: https://www.linebreakrecords.com/livestream1/
Video sign-up guide: https://youtu.be/4xMkigocUdo

Blog article on the broader conclusions of the research so far and the event itself:
PayPal for Punks: opensource money for DIY music
https://medium.com/datadriveninvestor/paypal-for-punks-opensource-money-for-diy-music-d9021ffe9ec
(This article was republished on Data Driven Investor https://www.datadriveninvestor.com/)

Music 'zine article for NARC.magazine:
FEATURE: KANEDA CRYPTO STREAM #1 - MY INSPIRATION
http://narcmagazine.com/feature-kaneda-crypto-stream-1-my-inspiration/

This stream was co-hosted with The Potted Wolf: https://www.facebook.com/thepottedwolf/

***Figure 15**:* Kaneda Cryptostream #1 Clockwise from top: Bert Verso; SQUARMS; Badger; sound checks / set up.

The aim of this stream was to test the effectiveness of, and demand for, blockchain ticketing of live music performance live streaming events based on the finding of the preliminary streaming projects and project 1 that live streams were an effective way for all groups considered in this research to engage with audiences. Additionally It was an attempt to test a strategy to monetise such live streams as there was no effective way to monetise live music live streams in a manner that suited the nature of live music events. It was also a further attempt to address the interests of Sage Gateshead (i.e. their interest in live streaming in general, and ideas posited by them about using blockchain to control access to supplementary online content relating to live events such as, in this case, a streamed version of a performance).

This stream was ticketed using Ethereum Rinkeby Testnet coins, making it free to view for anyone who had a MetaMask (or other web3 compatible) wallet installed and a compatible browser (Chrome, Firefox, Opera or Brave on a desktop/laptop computer) and a small quantity of Rinkeby Testnet Ether. Testnet coins could be requested free of charge by either messaging your wallet address to the hosts (Kaneda Records) or from a faucet such as: https://faucet.rinkeby.io/ . Tickets could be 'bought' in advance.

Tickets were available from the stream page here: https://www.linebreakrecords.com/livestream1/

This page is also where the stream was viewed once tickets had been 'purchased'. Testnet coins are a fully functional coin that runs on a test network (in this case Rinkeby) which is a fully functioning blockchain environment. They behave and operate in the same way as Mainnet (or 'real' coins) except, unlike Mainnet coins, have no associated monetary value so are ideal for testing scenarios such as this trial stream as they can be distributed to participants at no cost.

The sale of tickets was managed with essentially the same interface as that employed in the project 3 music release download stores and the operation, design and development of this interface is explained in detail in Appendix 9. The code is presented as Appendix 1, the main page code (the same as that used for the project 3 download store), and Appendix 3, the PHP file specific to project 2, that loads the stream player once a ticket has been 'purchased'. Once a ticket has been 'purchased' the 'buyers' wallet address is stored on the blockchain, and the website accesses this blockchain record of 'buyer' addresses to determine whether access to view the stream is granted to users who access the stream page (a full description of how this functions is included in Appendix 9).

To purchase a ticket with Testnet coins, the user sends an arbitrary preset amount of Rinkeby Testnet Ether to a smartcontract published specifically to receive these ticket 'payments'. Once Testnet coins had been received as 'payment' for a ticket, these coins were automatically apportioned and distributed to four different wallet addresses representing the artists and the label (stream hosts). Meaning everyone involved got 'paid' upfront, ahead of the performance at the moment of sale which itself is a fairly major paradigm shift when compared to how money is managed at 'traditional' performance events (where fees are normally paid after the performance), and this in itself makes the event novel. The smartcontract employed for the stream is included as Appendix 7. The topography of the ticketed live stream is shown below in figure 16.

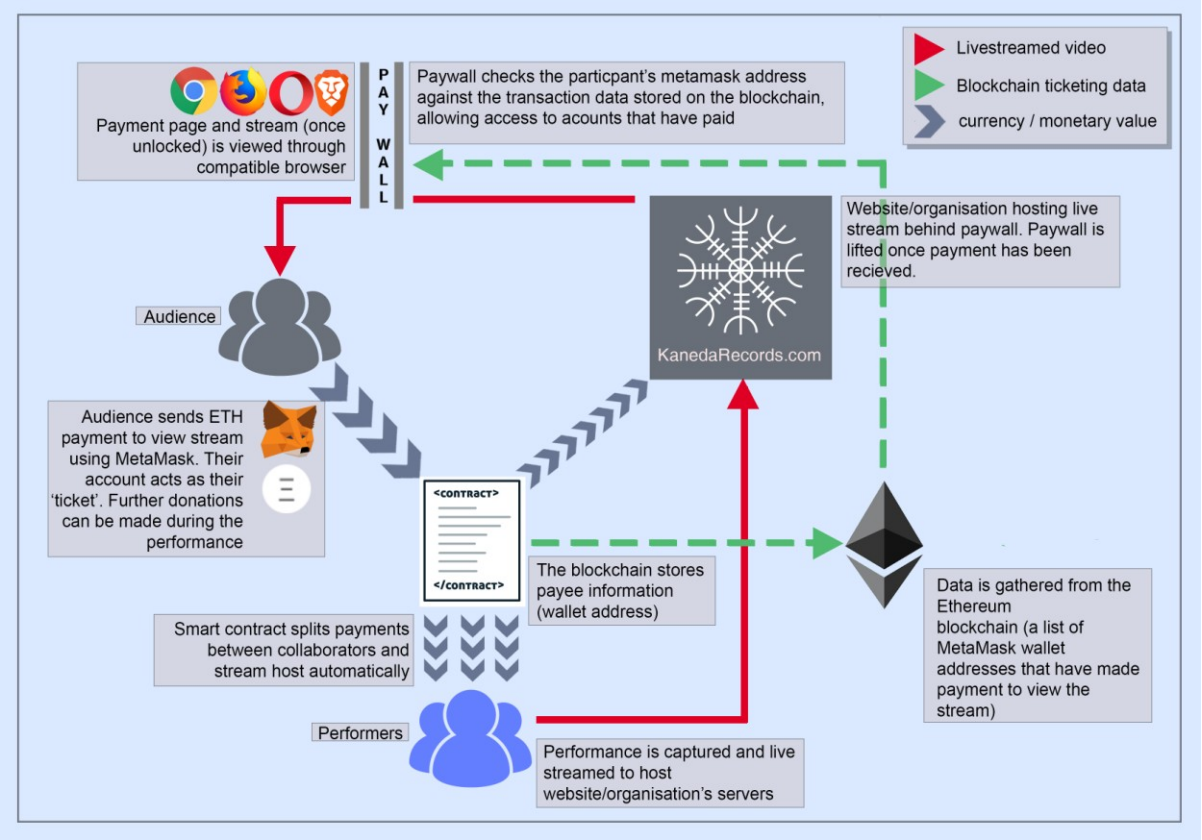

***Figure 16**:* Topography of the blockchain ticketed live stream *for project 3: blockchain ticketed live stream*

The stream was hosted on an NGINX RTMP/HLS server (broadcasting a HLS M3U8 stream, chosen for maximum browser compatibility) hosted on an AWS Windows free-tier server. The version info of the NGINX server is included in Appendix 5 and the config file (conf) can be found in Appendix 4. The stream was filmed using a Logitech C920 and a Tascam audio interface was used for capturing the audio. The stream was broadcast to the server with OBS broadcasting software (a GNU Public License, free, software).

For a step-by-step sign up guide, click 'about: Stream # 1' section on the stream page

3.3.3 Results and findings

This stream was successful from a technical perspective and the interface and streaming server functioned correctly.15 tickets were 'purchased' and the purchases through the contract can be viewed on Etherscan blockchain explorer here:

https://rinkeby.etherscan.io/address/0x48464e8c387a6793a342919b56c67f8cdfa9f3c3

(All transactions dated later than 18/02/2019 are ticket purchases, transactions prior were part of testing)

Comparatively, this stream had a much smaller audience than the total numbers of viewers of open-access social media streams (which averaged 825 unique viewers per stream across all four social media streams) and is evidence of the lack of wider familiarity/saturation of cryptocurrencies. It is also likely to be, in part, due to the fact that the stream required prior sign up, rather than being something

that viewers could passively find themselves watching as it appears in their news feed (as is the case with open access streams).

However, importantly these low figures were not due the interface being prohibitively complex or un-user friendly (it was remarked by audience members that using cryptocurrencies was actually easier than more established methods such as PayPal etc. once they had been introduced to it by this project). The video sign-up guide , which was suggested by the stream partner (The Potted Wolf), proved to be very helpful in encouraging audience participation and this should be repeated if similar projects were undertaken in the future to help encourage engagement from non-blockchain audiences.

Viewing duration statistics are not readily available for the crypto stream due to the nature of the webhosting used, however discussion with audience members (facilitated by the fact they all had to message me directly to request the Rinkeby Testnet tokens required to access the stream) confirmed they viewed consistently for the whole stream (approx 2 hours) or the majority of it, which compares favourably to average viewing time across the Facebook streaming projects of around 31 seconds.

Therefore despite the total number of viewers being lower, the advantage of this is arguably a more committed audience who engage with the stream, and the live music within it, for much longer periods of time. This also creates an experience much more akin to a 'traditional' live event, which is beneficial in terms of being able to view live streaming as something of similar value to physical live event (and therefore monetise it in a similar manner), as it is much more 'scarce' in nature compared to the more 'disposable' sensation of the open access social media live stream. The markedly increased audio and video quality it afforded compared to that of Facebook live also added further value to the prospect of this live stream.

The artists involved were interested in the concept of the project and saw benefits in the characteristics of blockchain payments (lower fees, automatic/instant apportioning of payments via smart contracts at the moment of sale) as did some audience members who were consulted. The artists involved also approved of the shifting of the ticket sale and artists payment paradigm (i.e. instant apportioning of ticket sales at the moment of purchase rather than after the event as with traditional models).This is also important in that it, in combination with the live streamed aspect, can be argued to represent a novel payment structure and event model for live music.

The event also formed an interesting talking point, as it was relatively unique which attracted interest from NARC (music zine) and also to the blog article (covering this project) which was 'republished' on DDI, an online publication that covers blockchain related topics and content. Medium was selected as the blog site as it is where a large amount of blockchain related content such as articles and whitepapers are published.

Based on the informal feedback gathered, most of the audience were new to blockchain with only 2 out of the 15 of the audience having had prior blockchain/cryptocurrency experience. From this it could be concluded that there is little crossover with our (Kaneda Records and the performers) local music audience and regular users of cryptocurrencies. Also neither of these audience members with prior experience of cryptocurrencies had prior experience with Ethereum itself, instead having invested in and traded alt-coins (currencies other than the main currency of particular blockchain, e.g. Litecoin) as store of value or means to make profit.

The ticketing system used in this stream could very easily be modified to use coins with actual monetary value (rather than the free coins employed here) which would have been the next logical step in this line of enquiry. However, the Facebook advertising ban was still in effect, which was an obstacle in trying to promote this event to wider audiences beyond that of Kaneda Records. This was problematic as if this stream was repeated as a pay-per-view event (with coins with actual value) then wider marketing would be necessary to reach audiences beyond the local music audience (who, as

illustrated by this project, are unlikely to possess the cryptocurrency required) to audiences that possess cryptocurrencies (a necessity to make the event financially viable). For this reason, and because it was looking unlikely that a similar stream could be organised at the partner organisation, the decision was made to discontinue this specific line of research at this point. All results of this project were shared with the partner organisation as per the agreement made with the partner organisation during discussions held in the planning stages of this project.

In a slightly different vein, a final live music project had been planned which was to incorporate blockchain ticketing into a physical event as a final opportunity to test the blockchain in live music ticketing however due to the COVID-19 pandemic and the restrictions this imposed on live music, focus was redirected towards a final release project instead (project 5).

The pandemic also, for the first time, forced live streaming into the forefront of music performance culture. During the first lockdown there was an abundance of open access live streaming. Interestingly however, based on my observation both as a streamer and a stream viewer, viewing figures and general interest in the notion began to wane in both in artists and audiences as time went on. Then, during the second lockdown monetised, ticketed streams began to appear. These followed the same basic model as the project 2 stream, but realised with established fiat-based means, whereby a viewer would buy a ticket via a ticketing site (e.g. Skiddle) and the organisers would then email them the streaming link. These were also often accompanied by physical attendance, and the increased limitation on numbers of physical attendees acted to encourage uptake of the streaming, removing the question of whether one mode of viewing would discourage uptake of another. This was something that had not proved to be an issue for the two preliminary project streams with physical attendance, but these had been free events with open-access streams and I did have concerns that in the realm of paid-access events and streams, one attendance option may devalue or negate the other. This new interest in paid-access ticketed live music streaming adds new relevance to this project and the blockchain model employed in this project does offer the usual benefits relating to decentralisation and payment processing. Also, post-pandemic, audiences should be considerably more familiar with receiving live music as ticketed streams so this blockchain ticketed model would also have increased relevance.

3.4 Project 3: blockchain singles and EP releases

3.4.1 Introduction and supporting media

Continuing from the preliminary release, 5 further singles and 1 EP have been launched using an improved version of the same store interface. The cryptocurrency releases can be viewed here: https://www.linebreakrecords.com/music

And most are also available from the Kaneda Records website cryptocurrency store here: https://www.kanedarecords.com/crypto-store

Rohli – Bertha Krupp/FDL (Spring Offensive) (2 track single with remix stems)
Streaming link (for Reference) : https://kanedarecords.bandcamp.com/album/bertha-krupp-fdl-spring-offensive
Linebreak Store: https://linebreakrecords.com/rohlispringoffensive.php

SQUARMS – She Left The TV On (single)
Streaming link: https://kanedarecords.bandcamp.com/track/she-left-the-tv-on
Linebreak Store: https://linebreakrecords.com/squarmsshelefttthetvon.php

Holy Braille – Murder She Spoke (single)
Streaming link: https://kanedarecords.bandcamp.com/track/murder-she-spoke
Linebreak Store: https://linebreakrecords.com/holybraillemurdershespoke.php

Mausoleums – Rapture of the Beast (2 track single)
Streaming link: https://kanedarecords.bandcamp.com/album/rapture-of-the-beast
Linebreak Store: https://linebreakrecords.com/rapture-of-the-beast/

Mausoleums – Parasite / Alive (2 track Single)
Streaming link: https://kanedarecords.bandcamp.com/album/parasite-alive
Linebreak Store: https://linebreakrecords.com/parasite/

Om10 – Range Anxiety (4 track EP)
Streaming link: https://kanedarecords.bandcamp.com/album/range-anxiety
Linebreak Store: https://linebreakrecords.com/om10-range-anxiety/

***Figure 17**:* Cover art for the blockchain music releases (project 3)

The store interface is based around a smartcontract that can receive payments in Ether (from the buyer of the music) and then automatically apportion and pay wallets corresponding to the record

label and the contributing artists their respective share. The final iteration of the smartcontract is included in Appendix 6.

The webpage uses the Ethereum web3 API and JavaScript to interface with the MetaMask browser plugin wallet (or other web3 wallet / DAPP browser). This provides the page with the functionality to set up a payment at a pre-set price (ranging from $1 to $4 depending on the release) to the smartcontract and to fill in all the necessary transaction details for the user.

Once currency is received by the smartcontract, the page can check the senders' wallet address by comparing it against the list of transactions made to the smartcontract (representing all buyers of the music), retrieved directly from the Ethereum blockchain using the Etherscan.io API via PHP in earlier iterations and JavaScript in later versions (for reasons explain in appendix9, section 7).

If the wallet address of the currently signed in Web3 wallet in the users browser matches an address on the transaction list (representing all buyers of the music), the store page will load and run a PHP file on the hosting server which will display the download links. If, however, the user's wallet address is not on the list, the page will prompt the user to purchase instead. The download links, once unlocked by a completed purchasing transaction, offer a choice of digital formats (WAV/MP3) and, in one case, remix stems.

Coinbase's API is also employed to give a real time exchange rate in dollars so the price of the music can be set in a more stable 'fiat' currency and remain fixed and tracking the changing the price of Ether. This helps to negate the issue of volatility of the cryptocurrency when pricing products for sale.

The full code for the final payment interface webpage is included as Appendix 1. The PHP file that runs to unlock the download links is included as Appendix 2. Appendix 9 details the full iterative development from project 3's first release up to the final version of the store. The final smartcontract code used for this project is available in Appendix 6.

The buyer's wallet replaces the need for a user account on the Linebreak website, essentially becoming a passport that is automatically recognised by the webpage which the website then checks against the public record of the blockchain (the 'distributed ledger') to verify that access to content has been paid for.

3.4.2 Results and findings

Only one sale was made during the course of project 3, which was of the *Holy Braille – Murder She Spoke* she single, which was purchased for $2.

The final iteration of the website interface functions adequately, and is secure enough for the purposes of this project, i.e. a prototypical application and proof of concept, and is simple to use (in the context of blockchain music platforms anyway).

There are, however, two major limitations in terms of the overall security of the interface. Firstly the links for the downloads (i.e. the zip folders containing the music) are static and whilst obscure enough and held within multiple layers of folders where the 'read' permissions are disabled to ensure that they are not easily locatable outside of the store interface, due to their static nature they in theory could be shared outside of the interface to users that had not purchased the music. If this project was aiming to produce fully robust store interfaces then some kind of dynamic (randomised) download link system should be employed, although this was outside the scope of the project as it is not directly concerned with blockchain.

The second flaw in terms of security is as follows (see appendix 1 and appendix 2 for full code referenced below):

The site is pulling the data on all addresses that have sent valid transactions to the destination contract (stored in the 'data4' variable in the JavaScript). Once the signed in user has passed the checkAddress() address check (which checks to see if they have a valid transaction associated with their address) 'data4' is then copied to another variable named 'postdata' before posting that postdata in an Ajax request to the 'fetchtest[RELEASE NAME].php' – the file responsible for loading the download links once a user has paid to access the music (appendix 2).

However if a user were to access the JavaScript console in the developer tools of a desktop browser and set:

```
postdata = data4;
```

And send an Ajax request thus:

```
$.ajax({
type: "post",
url: "fetchtestOM10-RANGE.php",
data: postdata,
success: function(html){
document.getElementById("status").innerHTML = html;
}
});
```

Then the download links would be unlocked without having to purchase first.

This is because the 'fetchtest[RELEASE NAME].php' file doesn't recheck the data in 'postdata' against the signed in user – it merely performs a Boolean (true/false) check to see if there is any data in the 'postdata' variable, as data being present within this variable would indicate that they have a valid transaction associated with their address and therefore had paid to access the music. If 'true' then download links are unlocked, if false then a prompt to purchase is returned. The address checking function – checkAddress() – is responsible for injecting this data providing the signed-in user has a valid transaction associated with their address. However as seen above using the JavaScript console a user could bypass the checkAddress() function and inject any data they wish into 'postdata' and thus pass the Boolean check and access the download links.

This could remedied in several ways including:

1. Requiring the user to sign the purchasing transaction with their Ethereum private key, the server would then checks the signature before releasing the download link.

2. Having the '[RELEASE NAME]fetchtest.php' file use the data in 'postdata' to perform the same address checking function for a second time.

As this download store is a prototype and the above discussed method of circumventing the interface is well beyond the expertise of the average user it was deemed not be of major concern. The above mentioned ways of remedying this were not implemented as, for the final release project (project 5), it was decided that a donation download format was preferable anyway due to the favourable conclusions drawn about donation pricing in the contextual review (2.2.1) and within my own practice during the course of this PhD research (all of which shall be discussed in more detail in project 5) so a new interface was built instead to facilitate this donation pricing format.

Despite the security flaws the interface employed was suitable for the purposes of project 3 and it was concluded that due to the nature of wallet software the overall buying process is markedly simpler and

quicker than that of comparable services (Bandcamp / PayPal / Apple etc.) as there is no requirement to login or fill in any personal data or card payment data.

There were also intermittent issues relating to correctly calculating gas required when setting up transactions to the contract (see Appendix 9, section 6 for details on this) which appears to a bug in certain versions of MetaMask as this occurred intermittently throughout the series of releases. Also several instances of forum posts concerning reporting this bug were found at various points. As of the last two releases however this seems to be remedied and would now appear to be functioning correctly. The short term fix of including a higher than default gas value in the transaction (see Appendix 9, section 6) also proved to be effective, and since unused gas will be returned to the sender anyway, is also seen as acceptable to include this to prevent this bug causing problems if it reappears in later updates of the wallet. Redesigning the webpage to use the web3.eth.contract object may well also offer a solution, however it is a little unclear how setting a transaction value that tracks the exchange rate would be achieved while using this object, and it seemed unnecessary to go to that length for the purposes of this project.

Also a further issue regarding smartcontracts that is worth clarifying at this point, as when conducting the initial research, the literature was not entirely clear on how internal transactions (such as splitting the total payment and sending it to artist and label wallets) affect the gas fee for payments to that smartcontract. Each internal transaction adds to the total transaction fee, so the more parties that are paid out from the smartcontract ('payees') the higher the transaction fee the buyer must pay. Also the computing power required to perform the apportioning within the smartcontract must also be paid for, further increasing the cost of transacting with smartcontracts with higher numbers of payees as each additional apportioning activity increases the total computational requirement.

The ramification of this is that smartcontracts with more payees cost more to send money too, so in the situation of the smartcontract used for the live stream which had 4 payees (Appendix 7), this would cost more in gas to buy from than the smartcontracts discussed above (and Appendix 6) that only have 2 payees. Whilst this is a fairly rudimentary observation this is certainly something that is often not made clear in the literature.

As a result of this, smartcontracts with higher numbers of payees may begin to lose their competitive edge (i.e. lower transaction fees) when comparing transaction fees to that of fiat card processors (i.e. PayPal etc.). Additionally, importing external scripts for use within a smartcontract, such as SafeMath (employed in the smartcontract included as Appendix 8 and explained in Appendix 9, section 4) also increases the initial publishing cost of the contract as each additional script must itself be published as a separate smartcontract.

Whilst on the subject of developing smartcontracts, it is worth discussing the environments in which they are developed. The *Remix Solidity IDE*, which is browser-based and runs using a web3 wallet, such as Metamask, was the best development environment I found whilst developing these smartcontracts. It offers ease of switching between Testnet and Mainnet and compiling, debugging and publishing facilities.

In terms of testing the following conclusions, surrounding the benefits of blockchain technology, made after the contextual review:

1. *lower payment processing fees (by removal of third parties in the form of card payment processors)*

2. *quicker processing and easier and automated management of royalties after sale (using smartcontracts on the Ethereum blockchain)*

3. *the opensource nature of the blockchain facilitates more direct artist-to-fan selling of music by DIY practitioners / small organisations as it affords the opportunity for artists to code*

> *their own online stores. Thereby removing the necessity of third parties in the form of platforms such as Bandcamp and music distributors for download stores such as Apple Music etc. by enabling the direct sale of from artist's / organisation's own websites*

It can be argued that the characteristics of the interface in this project meet all of the above. In terms of 1 and 3: the payment processing fee for the $2 sale that was made of the Holy Braille single equated to $0.02 at the time of sale. If this had been handled by PayPal it would have equated to around $0.12. Furthermore, as this sale was direct and not via a platform like Bandcamp that also saved a further processing fee of around $0.30 (totalling around $0.42) in the example of Bandcamp. Had it been through a distributor and download store such as Apple music the total processing fee would have been approximately $0.40. Additionally, the transaction fee was paid by the buyer and not the seller, meaning that the total $2 was paid to the label and artist, and the buyer's fee also paid for the apportioned royalties to be sent to artist and label wallets too, covering administrative costs for the label and further increasing the artists share by reducing costs for the label. Whilst the results relating to payment processing fees were promising in this project, some of the results of Project 5, which will be discussed later, call this into question.

As for point 2, processing of the payment took around 13 seconds (based on transaction processing times for the date of sale) – which compares very favourably to Bandcamp/PayPal which usually takes several days to pay, or working through a distributor that can take up to 3-6 months or more in some cases. Finally, as the smartcontract handled paying the artists share automatically there was no additional requirement for further accounting or payment to artists on the part of the label, which makes this approach very convenient for all involved and means that I, as the label, could offer the artist a much higher royalty share than fiat-based methods.

The smartcontract also has a tertiary benefit in that in situations where income is generated in small amounts, potentially over long periods of time, such as the current music economy that now inherently relies on millions of daily micro-transactions (Berklee College, 2015: p3) (i.e. the slow trickle of royalties), manual accounting and apportioning becomes difficult and often appears to be a waste of time when considering the small amounts in question and often this money 'falls through the cracks', and is never properly accounted for stopping this trickle accruing into anything significant. The DIY musician's income is a portfolio of performance royalties, recording and sales royalties, physical merchandise sales and performance fees, and with the exception of the latter is all in small amounts that have to be managed carefully for any significant income to be generated.

As discussed in Appendix 9, section 2 the decision was made to embed the interface on the Kaneda Records website, alongside Linebreak, to help increase traffic This was because Facebook was still enforcing a ban on paid-for promotion of any content relating to cryptocurrencies at this point. It is difficult to drive traffic to a website if you cannot rely on social media platforms to propagate it and paid-for Facebook promotion is a widespread and important promotional tool for DIY practitioners and organisations of all sizes. Sabine (2019), of established music magazine and ticket website *Resident Advisor* describes this phenomenon as "homeless content", whereby in the past audiences would visit specific websites to access content, but now expect it to be presented to them via social media and may very well only be aware of a certain site's content solely by what is posted onto social media or another platform rather than by actually engaging with the website directly. Whilst organic audience reach is still a tool available when paid for promotion is not, this is a limiting factor and makes it hard to reach new audiences and audiences specifically interested in cryptocurrencies. To help mitigate this other approaches to promoting the releases had to be taken.

A successful example of this alternative approach are in the circumstances leading up to the sale made of the Holy Braille's track *Murder She Spoke*. The sale was made after making these posts (and some others) about the single on Ethereum sub-reddits:

https://www.reddit.com/r/ethereum/comments/bv76eb/i_set_up_a_webstore_where_you_can_buy_my_friends/

https://www.reddit.com/r/Metamask/comments/bv7bfb/i_set_up_a_webstore_where_you_can_buy_my_friends/

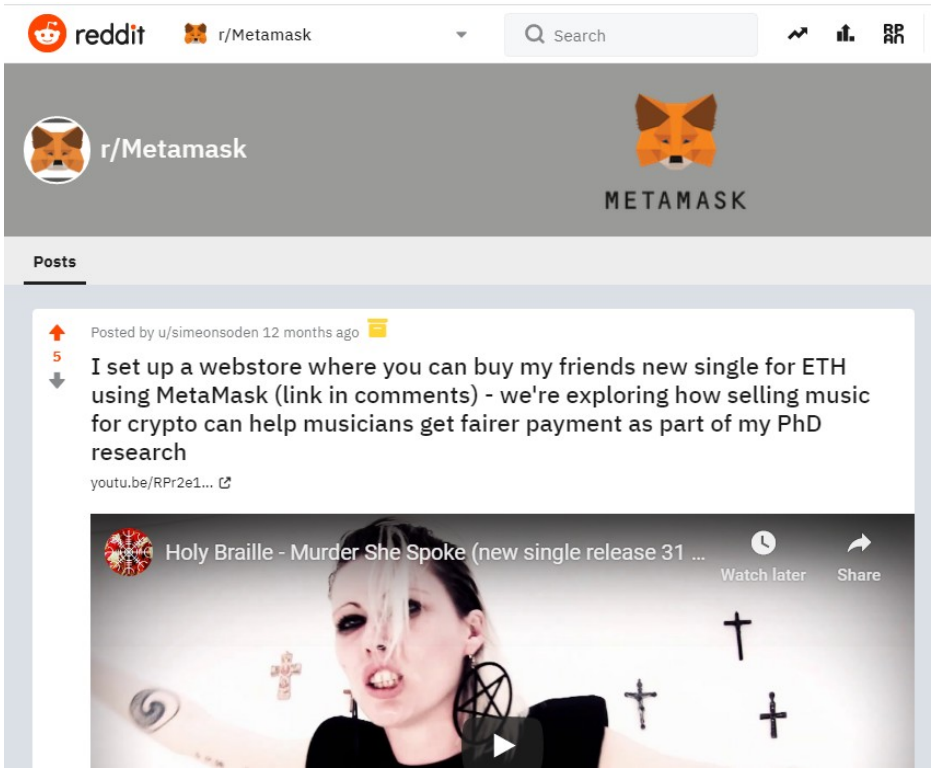

Figure 18: One of the posts to r/Metamask regarding blockchain music releases

The single was purchased at the same time the initial comments on the thread were made, illustrating the need for approaches that focus on organic interaction to niche audiences to promote music sold in this manner.

In regards to the response to these posts and the others surrounding this release, discussion ensued, generally around the whether or not the commenters are willing to pay for music or no. Some comments were supportive, however a greater number expressed sentiments similar to *'I just don't pay for music'*. This is illustrates, and perhaps explains one of the issues that has faced this project, i.e. there just isn't a big enough market of people who want to buy music for cryptocurrency within the cryptocurrency community. This also true on a local music audience level where it has been illustrated (in the results of the blockchain ticketed live stream and the general lack of uptake of the cryptocurrency releases when compared to uptake of the 'fiat' versions of the same releases on Bandcamp etc.). It seems there is generally little uptake of cryptocurrencies within music audiences despite there certainly being some curiosity surrounding the idea of music accessed via blockchain.

A further hurdle for this project, and also potentially a factor in the low demand for music accessed via the blockchain, is that evidence suggests that for consumers the adoption of a particular method for accessing music is about ease of access (2.2.1). For projects like these blockchain releases to succeed, the payment technology must be as widely understood and used as that use by existing fiat platforms and be of comparable ease of use.

It is also worth noting at this stage that at the time of purchase of the discussed single, the market was experiencing a period of ebullience after a long period of recession, and it is at points such as

these when people are most inclined to actually *spend* cryptocurrencies (the Ethereum to USD exchange rate over time is shown in figure 19 below, the cursor is indicating prices on 30th May 2019, the date of the single's release). As discussed previously, the tendency with cryptocurrencies is to buy or mine them as an investment and hoard (or 'Hodl' – hold – as the popular meme refers to it) them, until such time as they have gained suitable additional value to be sold for profit (Cointelegraph, 2017; Khairuddin, 2019). It makes much more sense to spend when you can get a lot more for your money and I think it is fair to argue that the favourable exchange rate from Ether to dollars was a major factor in this sale.

Figure 19: Historical Ether prices in USD Source: https://etherscan.io/chart/etherprice 20.08.2019

3.5 Project 4: interactive music

3.5.1 Introduction and supporting media

The Sound of People getting Rich
(*or* the Sound of People Losing Everything)

A live blockchain explorer sonifying the blockchain

Screen captured video of blockchain explorer working: https://youtu.be/9Uu_DD-pKPY (the webpage is no longer widely supported by browsers), also pictured in the screenshot below (figure 21).

An explanation of the operation of this webpage (with code examples) can be found in Appendix 10.

The aim of this project was to explore the idea of replicating the notions of 'uniqueness' / 'liveness', peculiar to the context of live music, by using algorithmic techniques to broadcast music. This music would be considered 'live' by nature of being generated in the present as it appeared that, based on the contextual review findings, this was a core characteristic of live music. This project was a further attempt to incorporate live music (because of Sage Gateshead's areas of operations and the positive

findings about the resilience of live music as a revenue stream). It was also hoped that this may have developed into something that could be hosted at the partner organisation, either in a public space or virtually on their website, as an outcome of this research.

At the end of year 1 a project involving sonifying the block chain was envisioned, the overall topography of which is illustrated in the diagram (figure 20):

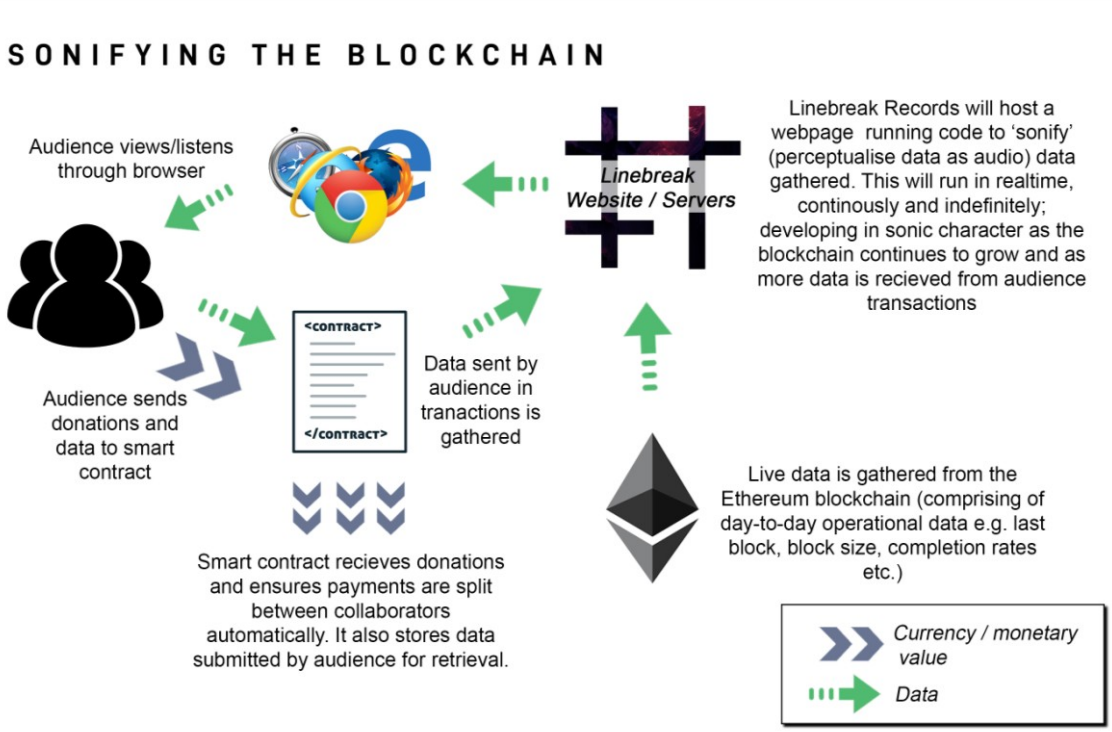

***Figure 20**:* Diagram of proposed interactive work for Project 4 (interactive music)

This project is based on the notion of a blockchain explorer, which is a website that retrieves live data from the Ethereum blockchain to present the current status of that blockchain. This explorer is novel however, in that it uses that data to generate live musical and visual responses using both chance and deterministic methods. This has been partially realised with the completion of project 4, however it lacks the apparatus for audience interaction (the smartcontract for receiving donations and data, as depicted in the diagram above), for reasons that will be discussed shortly.

This project employs an Infura.io endpoint to gather live blockchain data. JavaScript based logic then selects which notes to play based on changes in this data. The notes are played back using Tone.Js synthesisers, in three tonal layers representing 3 strands of live blockchain data with a total of 72 different combinations of notes in C Major. The notes are selected from predetermined note tables, with their selection dependent on factors relating to the changing data.

The rate of change is directly connected in real time to the activity of people using the blockchain and the type of change linked to their activity, thus creating a sonification (or sonic representation) of the blockchain in the form aleatoric (chance based) music realised using deterministic methods. Visuals are also generated based on some aspects of the blockchain data using an embedded processing sketch. Full details of the operation can be found in Appendix 10.

The approach of using logic to step through predetermined note tables in a fixed key was chosen to make to make the results of the sonification aesthetically appealing. This is not a necessary

precondition of sonification. It is an attempt to use sonification principles within the context of Algorithmic composition and therefore produce a “musically motivated” mapping of the data (as described by Neirhaus, 2009, p268-269). Rather than an attempt at a literal representation of the data as may be expected from a direct sonification.

***Figure 21**: Screenshot of ‘The Sound of People getting Rich (**or** the Sound of People Losing Everything)’*

3.5.2 Results and findings

Compatibility overall is somewhat of an issue, Tone.js functions differently across different browsers. Secondly, changes to CORS (Cross-Origin Resource Sharing) security policy in many browsers recently means that in the intervening time from initially coding the webpage to present, it has stopped functioning in most browsers.

The partner organisation was also much less interested in this project when compared to live streaming, so a prototype blockchain streaming application was pursued instead (project 2), and is why the audience interaction aspect of this project was not developed or implemented.

The musical output of this blockchain explorer is somewhat simplistic and only involves 3 strands of data from the blockchain. Musical complexity would need to be increased to sustain interest, and sonifying more aspects of the live blockchain data would help in this regard, as well as employing more complex logic in the selection of notes. Also an alternative to the Processing sketch to generate visual aspects would be beneficial too due to the issues with refreshing the data interrupting the rendering of the sketch as discussed in appendix 10.

It can be contended however that it does meet the original objective and could be considered a live performance in relation to the work of Baracka (1964) and Kim (2017) due to its fleeting/fugitive and temporal nature. It represents a novel attempt at creating live music within the context of internet based music distribution which could be developed further at a later date and may be an interesting way to engage wider audiences with blockchain.

Other than the originally intended model of using this interactive music project as a music release in its own right, as a way to accrue donations, another potential application for such an idea is as complimentary promotional material for a music release. In this scenario a novel webpage, such as this blockchain explorer, could be employed as a way to engage audiences with the musical content in a similar way that the Plaintext Soundboard from the preliminary projects was designed as a webpage to encourage engagement with the main *Plaintext* single release.

3.6 Project 5: ako – West Babylon album release

3.6.1 Introduction and supporting media

Standalone cryptocurrency store: https://linebreakrecords.com/ako_westbabylon/

Linebreak Records store: https://linebreakrecords.com/ako_westbabylon/

Streaming link: https://ako0.bandcamp.com/album/west-babylon

The album was also released through Australian label 'Sunset Grid', who provided sales and engagement data from their Bandcamp (included in the results of this project): https://sunsetgrid.bandcamp.com/album/west-babylon

The full donation store page code is available in Appendix 11 and 12.

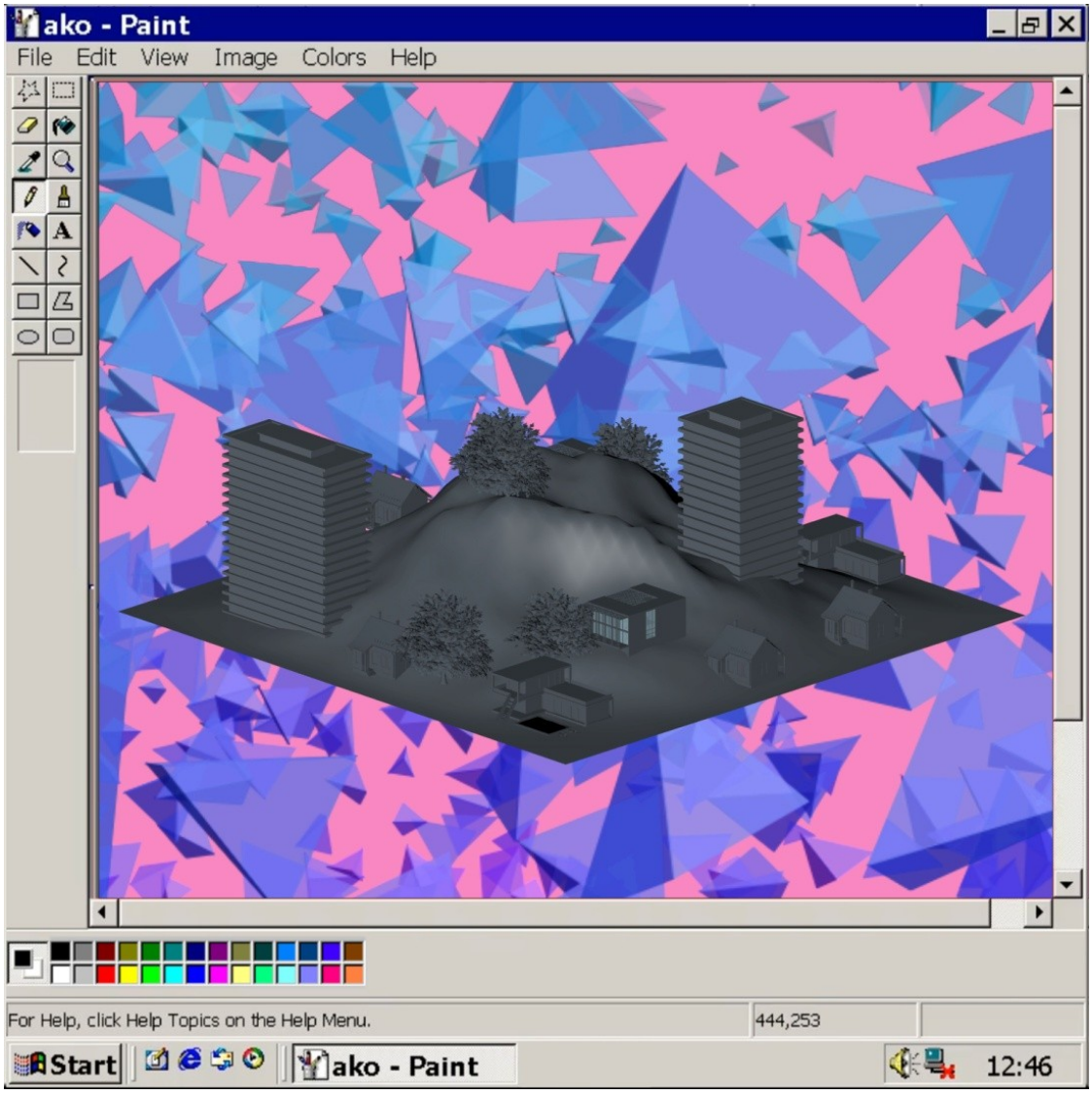

***Figure 22**: ako – West Babylon Alum cover*

Figure 23: *West Babylon standalone donation store user interface*

For the final practical project it was decided that a donation release format would be adopted due to the positive conclusions drawn about donation pricing during the contextual review (2.2.1). This had been a feature of the preliminary release project but had not been possible during the Project 3 releases as the manner in which the direct integration of web3 wallets into the address checking function had been realised meant that transaction value (i.e. price) had to be pre-set within the function that interacted with the wallet. This release also differs from the previous releases as it does not use a smartcontract to apportion received funds, this is firstly because this was my own solo (ako) release, with no collaborators, on a label that I also run so it seemed unnecessary to split the payment. Secondly, to help keep the transaction fees low as a result of the issues relating to transaction fees and internal contract transactions highlighted in the project 3 releases (explained in Appendix 9, section 6) i.e. internal smartcontract transactions increasing the buyers overall transaction fee cost and wallets exhibiting issues correctly calculating the necessary transaction fee when interacting with smartcontracts at points during project 3.

From experience as both a consumer and a seller on Bandcamp (the leading donation pricing platform) it was important to include a prompt to enter an amount of $0 or more before offering the download links (rather than offering the download link immediately with an option to donate alongside). This is because the prompt to enter $0 or more, whilst it will not deter anyone from downloading for free, does help to encourage a donation.

To realise this, a PHP form handler was employed which was set to require a user input of 0 or more before the user can proceed to the next stage which is to either download for free or confirm donation amount and send donation prior to download. In the case of a donation, once the user has confirmed the donation and sent the transaction in their wallet the page loads the download links. However the page does not check that the transaction has been completed successfully as this is a donation not a minimum purchase price so it was not deemed necessary to enforce checking of the successful transaction. The full donation store page code is available in Appendix 11 and the PHP form handler that confirms donations and unlocks download links is provided in Appendix 12. Such a form handler combined with a transaction confirming function (such as the one employed in project 3) could be combined to create an interface that would request a minimum monetary amount, such as $1 or more, if desired.

Both a store page on the main Linebreak Records website and a 'standalone' store page were built (pictured above in figure 23). This standalone store aimed to explore the premise of the preliminary interactive soundboard project (3.1.2) and the discussion relating to project 4, that a novel webpage may be useful in generating interest in music. This was seen as an important goal for the project due to the conclusions drawn about novel blockchain release projects (such as Heap's blockchain music projects) being a way to generate publicity and interest in an artist or their work and thus generate indirect revenue as discussed in 2.4.2, rather than being financially successful in their own right. This was a major goal due to the expectation of low actual sales revenue for cryptocurrency music releases which was a conclusion of the contextual review (2.4.2), the project 3 releases and the relatively low engagement with project 2.

The idea of a novel webpage was realised in terms of an attempt to appeal to the aesthetic interests of the target vaporwave genre audience (a genre often typified by visual references to Windows 3.1-2000 operating systems and neon and pastel colours) to attract users (both new to the blockchain and those already familiar) to the project. To achieve this, the graphic design elements of the page drew upon a Windows 9x computer UI aesthetic by utilising a typical colour scheme for the era, images with limited indexed colours and fonts such as MS Gothic etc. (figure 23).

As this page and release format was largely seen as promotional tool, rather than a particularly successful way to sell music, links to the other release formats were included on the donation store page (Bandcamp, Apple, Spotify, VHS cassette) to drive traffic to these other formats and give users without prior blockchain experience or inclination to set it up a means to engage with the music.

3.6.3 Results and findings

Format	Revenue (£ gross / net)	Paid for downloads	Number of Free downloads	Number of streams	Number of visits to store page	Visits generated from blockchain store
VHS (deductions incl. production & Bandcamp fees on 4 cassettes)	**80 / 32**	n/a	**8** (included in purchase of cassette)	n/a	n/a	Data not available
Bandcamp (ako and Sunset Grid) donations	**36.95 / 29.56**	**39**	**167**	**867**	n/a	**52**
Streaming (Spotify and Apple music)	**3.53 / 2.89**	n/a	n/a	**1176**	n/a	Data not available
Crypto	**0.75/0.75 ($1 / $1)**	**1**	**84**	n/a	**1302**	n/a

Table 2: *Sales figures and traffic data for the album between 12/09/2020 and 12/11/2020.*

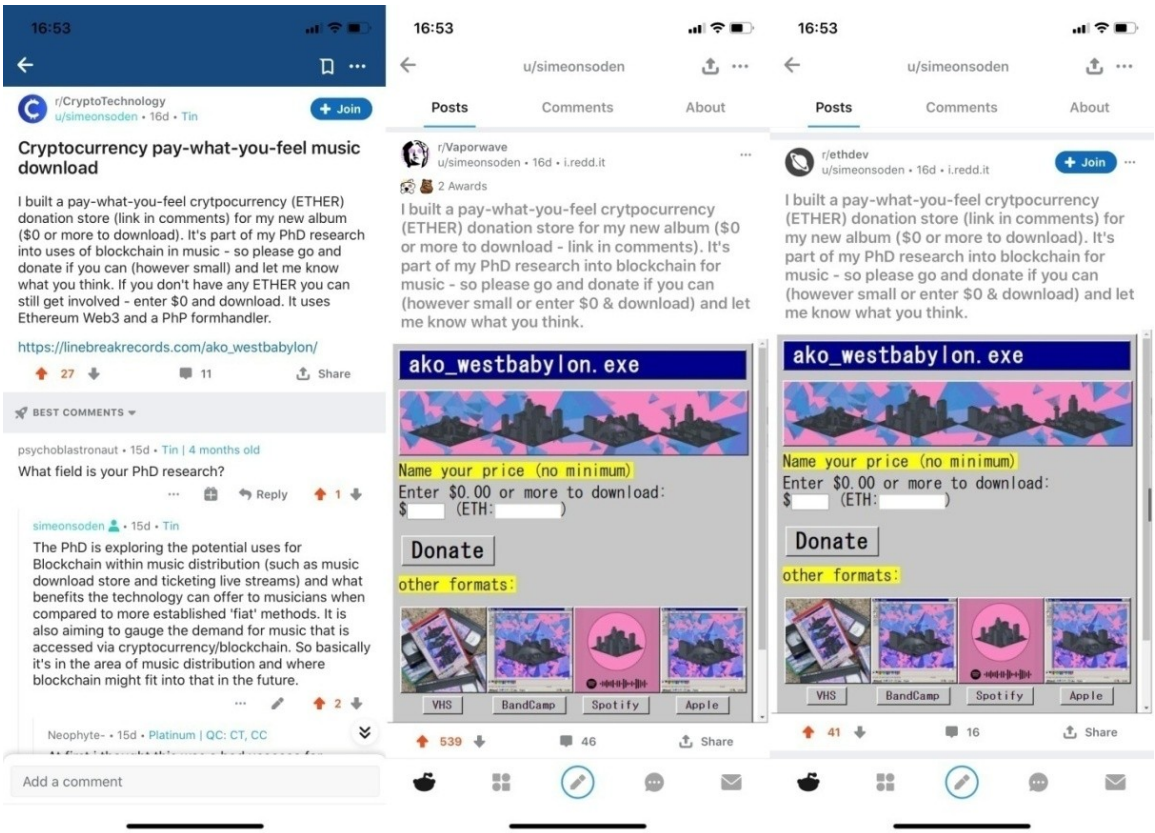

Figure 24*: Screenshots of posts regarding the West Babylon album release on various Subreddits*

A full list of Reddit posts is available in [appendix 13]

Sales for Ether were low, with only one purchase being made for the equivalent of $1. This is despite the market prices being high (strong against the dollar) at the time of the release, a condition that would have lead to predictions that users would be more likely to spend cryptocurrency (as indicated in project 3). This is due to the unusually high average transaction fees (TX fees) at the time of this project (averaging around $2 per transaction, which are paid by the sender of the transaction). Many of the responses to the forum posting (listed in appendix 13, some of which are illustrated above in figure 24) cited these record high TX fees as the biggest hurdle for this release. This illustrates an important problem when adopting cryptocurrency, which is that it is not just the exchange rates are volatile but the TX fees can also be subject to extreme change. It also undermines claims that blockchain offers improved transaction fees, which is often cited in the discourse (and had been previously concluded as a positive factor in the other practical projects) and one of the factors that previously held most promise for this PhD project.

The recent and marked increases in transaction fees (TX fees), and the historic increase in bitcoin TX fees, is an indication of high economic activity and the pressure this puts on the network in terms of scaling to meet demand. This phenomenon is explained succinctly by user o-_l_-o (2020) in his response to my post relating to the donation download store in the Reddit sub r/CryptoCurrency:

> *"A common misconception around blockchains is that more miners will result in lower fees. The way most blockchains work is that the protocol sets rules for how much can fit in each block (Bitcoin uses a size limit and Ethereum uses a gas limit), and all of the miners fight to fit transactions into that space and find a block first.*
>
> *Miners in Ethereum can choose to increase the gas limit for a block, but larger blocks can result in them being less competitive - it may take longer for previous blocks to replicate to them and it takes them longer to validate every transaction since there will either be more transactions, or simply more complicated transactions."*

So in times where there is more demand, such as the heightened activity linked to the increased market value around the time of this release project, there is more demand in terms of transactions to be included in a finite space (the block size) so miners can charge more per TX but still continue to remain competitive. o-_l_-o (2020) goes on to outline ways to remedy this (although these have the inherent drawback of lessened decentralisation and increased reliance on trust relationships):

> *"This is why some blockchains choose delegated proof of stake (DPoS). DPoS allows for a small number of machines filling the role that miners fill in Ethereum and these machines can be very powerful. Since there are fewer of them, the replication if block data between them is less of an issue and those chains can scale better.*
>
> *Having fewer machines increases the trust that users must have in the "miners" and leads to less decentralization. These DPoS chains will still hit a scale limit like Bitcoin and Ethereum have, and just like Bitcoin and Ethereum, they will need to find layer 2 solutions to reduce the congestion.*
>
> *Ethereum is working towards fixing the scaling issue through sharding in Ethereum 2.0, but no blockchain can expect to solve the problem of scalability with a single solution since cheap block space will almost always get used if there is sufficient economic activity in the chain.*
>
> *Things like [the latter] 2 solutions will be great for scalability and cheap payment systems and would be worth looking into if you want to dig deeper into the realm of fast payments."*

Returning to the issue of the average TX fee, while it is a useful marker, it is somewhat unhelpful as this will probably be higher than a simple transaction, such as the address to address transaction employed in this donation store which will be cheaper. For example as of the date of purchase

(08/11/2020) of the Ethereum version of the album, the average TX fee was $0.93 but the actual fee paid for the transaction from the buyer to the receiving wallet of the donation store was $0.20. However, the general perception of the commenters on posts surrounding the store was that the TX fee required would equate to the actual average amount and thus discouraged users from interacting with the store. Also whilst $0.20 is very much in line with fiat downloads in terms of processing fees, it does still have an advantage to the artist in that it is the buyer who pays.

It is interesting to note that because the transaction fee is paid by the buyer, the buyer is actively discouraged by high TX fees even in this example of a donation store, where they could logically reduce their donation to offset the higher TX fee. This undermines another core benefit of the blockchain discussed in the contextual review (2.4.1) and project 3, which is this reversal of the TX fee burden.

The acceptance of other coins (alt-coins) was suggested by commenters to alleviate the issue of the high TX fees although this is something that has been avoided throughout the duration of the project due to the general short lifespan of these coins (apropos interest in them or popularity) and their extreme volatility. Ethereum, up until the recent rise in TX fees, offered the best option in terms of balance between wider adoption, volatility and transaction fees.

In regards to actual revenue generation, the results are outlined alongside format in table 2 from inception to 8 weeks. The most profitable format was VHS by a slim margin followed by donation download. Streaming is markedly less profitable, as expected, and as was discussed earlier in the preliminary projects section (3.1.3) in relation to why digital download was chosen as the main format for the project (although still generated more revenue than the blockchain release).

The sales of the VHS format point to the trend of ‘boutique physical’ releases being a strong income source of the DIY musician (something that is apparent in my wider professional practice). This wider trend towards merchandise and boutique physical formats is related to the idea of displacement spending (i.e. spending on other products relating to the music, rather than the music itself which is freely available) as discussed in 2.2.1. It also further highlights how little actual demand there is for music on the blockchain given that a format that has been obsolete for over 15 years (VHS) is still considerably more popular. Despite the physical format earning marginally more than donation based digital download, download is more popular based on actual number of purchases. Download also has some major benefits for artists because it is considerably easier to manage (no production or postage) and requires no specific upfront investment unlike physical formats which will entail materials and/or production costs.

In terms of aiding in wider distribution of the release the donation download store proved to be highly successful and received a very positive response on Reddit including ‘trending’ (unusual popularity) on various Subreddits (including the examples pictured above in figure 24). The popularity of the donation store is evidenced by the visitor traffic data in table 2 (around three quarters of which is traffic driven by the Reddit posting), the number of free downloads from the donation store (around half of which are attributable to the Reddit posts) and the visits to the Bandcamp store from the donation store page (most of which occurred during the period of posting on Reddit).

Spotify unique listeners and plays were also up considerably during the period of popularity of the Reddit posts (particularly the post on r/Vaporwave) although it is not possible to get exact figures for this. Also some of the Bandcamp paid-for-downloads and VHS sales were a direct result of the posting about the donation store release, several commenters mentioned specifically that they had purchased in these formats as a result of being made aware of the project by the posting regarding the blockchain release. Around a third of the donation revenue was generated from visitors to the donation store page and at least one VHS tape was also sold as a result. The cryptocurrency release project also generated blog coverage on Zwentner.com.

This project, alongside publicising the wider album release, also proved to be a useful opportunity to disseminate the research with several commenters. This included consultation with a blockchain start-up called *Wavemint* on their blockchain music platform (details in Appendix 14). Also I provided the code for project 5 (Appendix 11 and 12) to an individual working for *r0g_* (Agency for Open Culture and Critical Transformation / Openculture.agency – a German cultural development agency) who was developing an Ethereum donation interface for their website (which currently hosts a fiat-based donation option). This individual was also the purchaser of the Ethereum version of the album. Aside from these organisations, advice relating to the blockchain and music was given to several DIY practitioners in comments on the Reddit posts, private messages and in comments on the sponsored adverts on Instagram.

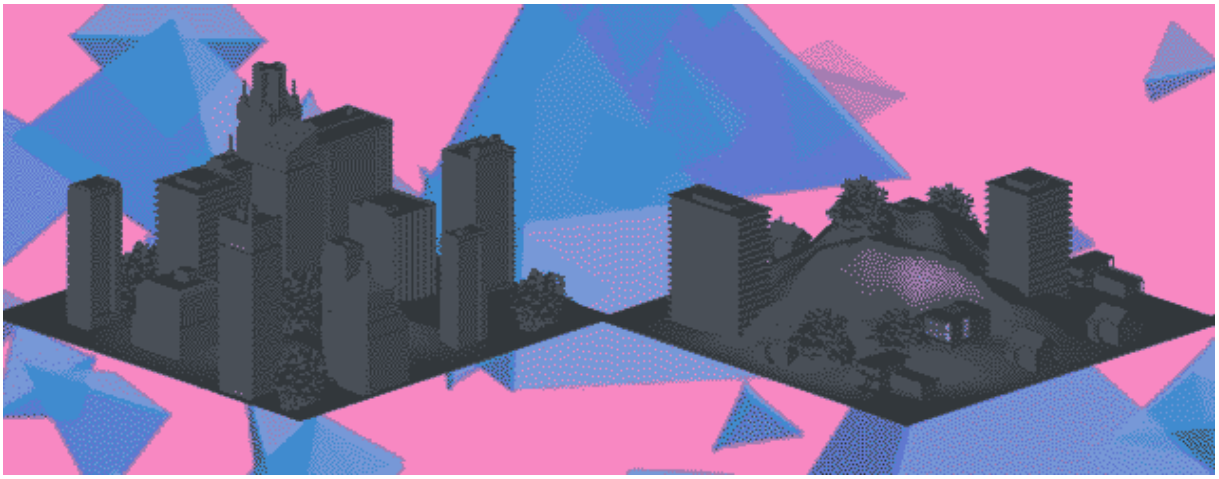

***Figure 25**: Image with limited indexed colours, part of the donation store interface.*

With regards to the aim of this project to create a novel webpage as a way to promote the release, the resultant standalone donation store achieved this goal (regardless of the amount of cryptocurrency donations) and was aided in doing so by the inclusion of links to the other available formats. An appreciable number of commenters remarked that they enjoyed the aesthetic of the donation store interface and the design aspects of the interface (such as figure 25, above). The design of the UI was key to the posts success in r/vaporwave (these posts were focused on the screenshot of the UI presented in figure 23), where the post achieved unusual popularity and generated the most traffic, free downloads and revenue from the other available formats.

This success suggests that such pages, whether they be fully interactive as envisioned originally in the interactive music projects (project 4), or as in this case, a UI that piques interest, do have potential as a useful tool in the promotion of music releases by DIY artists. Also, despite the issues discussed above relating to higher than expected TX fees, a copy of the album was sold to someone on the basis that they were interested in the code behind the project. This individual would have been extremely unlikely to have ever engaged with my music had it not been for the novel blockchain nature of the project. The same could also be said for Wavemint and indeed a large proportion of the people who went on to interact with the album in other formats. This further highlights (alongside the previous sale in project 3) that whilst the audience is small, there are new audiences to be engaged with on the blockchain (and judging by the reception of project 5 compared to project 3, these audiences would appear to be growing).

During the course of this release project it was also found that Facebook / Instagram has now relaxed its ban on advertising cryptocurrency-based products and it was possible to run adverts on both platforms for the donation download store (although they still require special approval). This proved useful and accounted for approximately half of the free downloads (which occurred during the period the adverts were running) and approximately a quarter of the total visits to the donation store page.

Had these adverts been available during the other practical projects they would have certainly improved audience engagement for these too.

The discourse on Reddit surrounding this release also highlighted some other points. Firstly there was widespread support for the donation pricing format, further supporting assertions made throughout the research about the positive reception of this kind of pricing. Secondly, Non Fungible Tokens (NFTs) were mentioned several times (both in the comments and in private messages relating to the posts), as a way to generate income for musicians. NFTs are token-based assets that grant exclusive ownership of some digital asset. This asset can include, for example, in-game items on Minecraft (Erazo, 2020), visual digital artworks and Cryptokitties (Cryptokitties, 2020) a blockchain game based around collecting NFTs.

A prominent example of an NFT platform is Rarible, which is built around digital visual artworks only accessible to owners of a token corresponding to that work. It is both a place to 'mint' (create) and sell brand new works and a market place to re-sell previously purchased works, from the sale of which the original creator is awarded a royalty percentage of the revenue generated. These Rarible NFTs can include a piece of 'unlockable' content, which is usually a link to some other resource that is made available to the recipient of the NFT. NFTs were considered at the outset of the project however it was concluded that audio could not be stored directly on the blockchain, as illustrated in the preliminary projects (3.1.2). Secondly, as discussed during the contextual review (2.3) there is no satisfactory way to enforce 'scarcity' onto audio files with DRM if they were presented as a download link within an NFT.

The discourse surrounding NFTs (in both comments and private messages) was focused on 3 main areas:

1. Presenting NFTs as merchandise (containing digital artwork) with the hope of building an online 'eco-system' for fans to display and trade their NFTs (similar to the principle of Rarible)
2. Using the NFT to deliver exclusive content such as a video and other complimentary content from the artist
3. Using the NFT to deliver exclusive access to musical works (i.e. 'one off' or 'limited edition' musical compositions available only to the holder(s) of the NFT)

The first idea offers the most promise as it ties into merchandising which has been seen to be one of the better streams of income in the music industry in recent years. However how a financially successful ecosystem can be built upon digital assets that have no physical presence (or inherent use or value) and cannot be accessed outside of the specific platform they are issued in is perhaps doubtful when we consider what it is that draws people to merchandise. This is certainly the physical presence of the object and the experience of interacting with it as illustrated in the demand for boutique physical formats (such as the demand for the VHS release). Secondly, merchandise such as apparel is desirable for the cultural cachet that is attached to the ability it lends the wearer to visibly express their appreciation for a certain artist/band, and it's hard to imagine how a digital asset like an NFT alone with such limited accessibility could replicate this with wide appeal.

The second and third NFT use ideas, whilst tapping into the attraction to exclusive goods and the inherent potential to store value as a rivalrous good in the form of exclusive audio / media suffer some major problems in my opinion:

Copy protection – There is nothing to stop the owner of the NFT distributing the download link. Also, even if DRM could be implemented (which is generally seen as impractical), the NFT owner could record the music (or other bonus audio content) as they access it and make it into a new and completely unprotected file (the analogue hole) and redistribute it without permission. I raised the issue of DRM and maintaining exclusivity in audio products linked to NFTs with Wavemint in the previously mentioned consultations, their view on this was commensurate with donation pricing logic

i.e. the fans will buy to support the artist and if the music or other exclusive content is leaked then it should not deter many from buying who would have otherwise bought. Which in fairness is something that is in concurrence with findings of the contextual review in terms of the notions that pirates often would not have bought in the first place (2.2,1) and the much discussed benefits of trust / donation based pricing.

Supply / demand - to make this exclusive content a feasible revenue source, musicians would have to either produce a large amount of music / exclusive content (and this would discourage musicians) or sell the music / exclusive content at high prices (which would discourage audiences). This could only really work for someone who already possesses a large fan base rather than a DIY musician. However the fans of such artists are already used to getting the music free on streaming sites so it would only appeal to a very limited section of their fan base.

Too much exclusivity is not beneficial to musical works – After creating music and spending money (or at least expending time and other resources) to do so, artists will want to maximise their earning potential and their potential to engage with audiences by spreading it over as many platforms / formats as is feasible, which this exclusivity will preclude. The exclusive license for a piece of music posited above as part of an NFT also will not help artists build their fan base. The benefit of Spotify and other online less exclusive platforms is that they include music discovery tools so artists can reach new audiences every time they upload. Therefore the exclusivity may preclude the benefits associated with wider dissemination in general as discussed in 2.2.1. This is not to say some level of scarcity is not necessary within musical products if the hope is to in-still value (as discussed in section 2.3 and in the example of live music explored in projects 2 and 4). However as with all things relating to intellectual property, there is a balance to be struck between exclusive ownership and the benefits of wider distribution of music (2.2). I would argue this idea of exclusivity to the point of only one or a few people being able to own access to a piece of music tips the scales too far towards exclusivity and is possibly detrimental to the artists.

Returning to the more promising idea of using NFTs as merchandising, I would argue that the hyper-exclusivity that these NFTs has more to offer in this context than in the context of digital audio. This is because the context of 'art' (as in the visual digital artworks usually contained within NFTs, rather than music as discussed above) is based upon the notion of limited editions and exclusive ownership rather than notions of widely disseminated and reproducible material (as in the context of music). A recent and relatively successful example of this is Strudelsoft's NFT / floppy disk release of *猫シ Corp. - A class in...' CRYPTO CURRENCY NFT FLOPPY DROP'*. This exploits the ideas of exclusive merchandising in the form of digital artwork (shown below in figure 26.) and the allure of the boutique physical format (floppy disk) and the trend of displacement spending (2.2.1). Once the NFT is purchased the owner can unlock a link to a Google document to input their postal address for the physical product to be mailed.

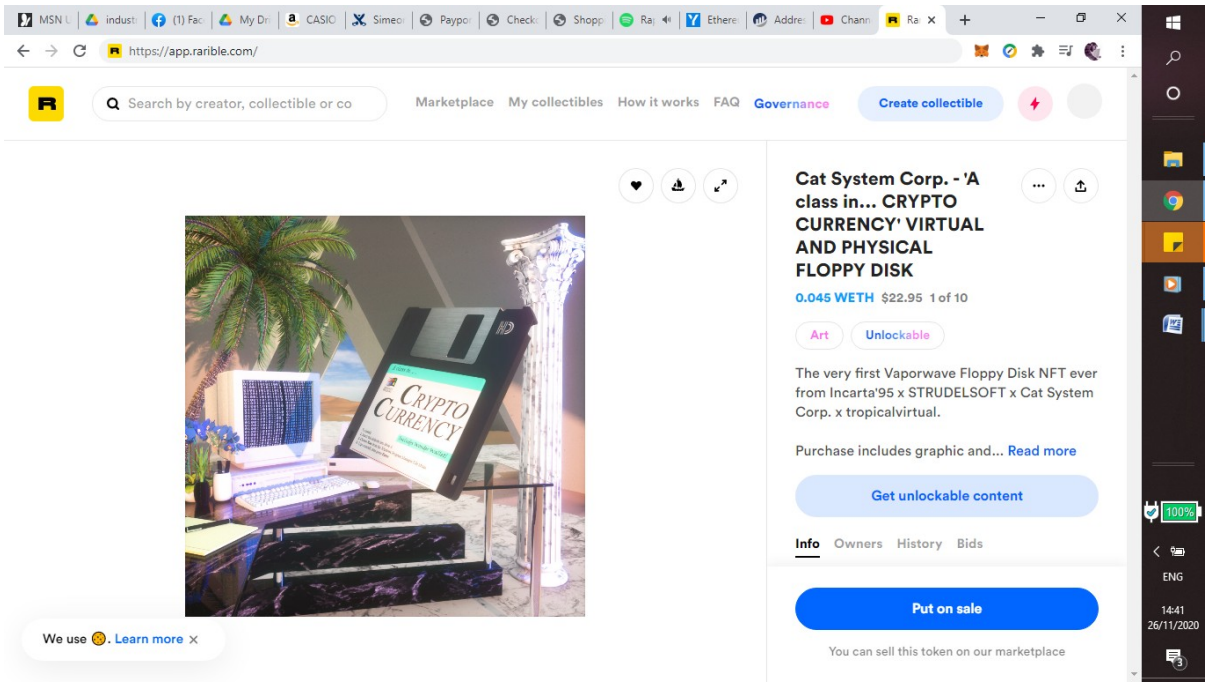

***Figure 26:** 猫シ Corp. - A class in...' CRYPTO CURRENCY NFT FLOPPY DROP' NFT cover art*

The approach applied to Strudelsoft's NFT / floppy disk release of *猫シ Corp. - A class in...' CRYPTO CURRENCY NFT FLOPPY DROP'* is successful in two aspects. Firstly it exploits what I have argued is the most suitable use of an NFT i.e. visual digital art (in this case the animated cover artwork for the release, pictured above in figure 26). Secondly it incorporates the musical work as a boutique physical release (with floppy disk resonating well with the desire for ephemeral media often associated with vaporwave). As the music presented on the floppy disk is 8bit MP3 format (very low fidelity) it seems incredibly unlikely anyone is buying this floppy to listen to the music it contains, therefore this floppy disk represents more of a merchandise item than a musical item / physical music format. This approach will be referred to as 'physical format as merchandise item'.

This use of the 'physical format as merchandise item', rather than digital audio download, circumvents the issues relating to DRM due to the physical nature of the release (and thus its innate scarcity) and as the audio is so low fidelity this will preclude anyone wishing to pirate these files. It also adds value to the NFT as it imbues it with a life beyond the confines of the Raribles website (the only place where Rarible NFTs can be viewed – which had been one of main reservations about NFTs as merchandise). Essentially, this NFT release can be viewed as an exclusive item of digital merchandise with accompanying physical item which lends it value beyond the confines of the blockchain.

This notion of physical music as merchandise is also something that was exploited within the VHS release of project 5, as shown in conversations with some of the buyers who actually had no current means of viewing the tape and were buying it as merchandise item. Also the format (an analogue AV medium) makes it excessively hard to duplicate the material in a high quality digital format, thus inherently addressing some of the issues relating to DRM. 'Physical music as merchandise' can borrow the beneficial characteristics of scarcity from exclusive products and physical goods, whilst still retaining the freedom to be simultaneously widely disseminated as a digital product separately to this and reap the rewards of wider dissemination.

In terms of success of this NFT release, the edition sold out, however it was only an edition of 10 (sold for around $20-25 inclusive of postage/production costs) and one of these 10 NFTs was purchased by me as part of my research. Due to the small number of the edition it is hard to clearly quantify demand, but it would suggest possible utility for context of the DIY musician, as 猫 シ Corp. is a DIY artist, and the label responsible for the release would certainly qualify as a small organisation under the criteria of this research. Larger organisations may also benefit from NFTs if they combine it with the right product. Although it could be argued that the incorporation of the physical products into the blockchain does begin to undermine the advantages relating to the ease afforded by digital products that can interface directly with the blockchain and the much lauded immutability and trustlessness of the blockchain due to the friction between the interaction of blockchain and the physical world which relies on trust relationships again (as discussed in 2.4.2). Also the infrastructural requirements of physical products begin to become an issue both in terms of labour and costs, as in the example of this NFT, due to the borderless nature of the blockchain, the shipping destinations and costs can't be anticipated for (unlike fiat platforms like Bandcamp), and my purchase of this release incurs significant shipping costs for the US based label (Strudelsoft).

Also, Rarible constitutes an intermediary which undermines some of the benefits relating to the removal of third parties. As a result of this, when speaking to the label proprietor during the purchasing process, he explained it costs Ether on the seller's end to process the transactions and send the NFT, which is contrary to the TX fee burden reversal exploited with digital products in projects 3 and 5.

The strong audience engagement with the project 5 release and positive reception of the social media and forum posts regarding it, when compared to the reception of the preliminary release projects and early releases of project 3, illustrate a trend of a greater normalisation of blockchain. This is also evident in the relaxed restrictions on advertising of cryptocurrency products on popular social media platforms. The current market buoyancy of Ethereum and issues relating to scalability also point to wider adoption of the technology. Especially in light of the recent announcement that PayPal is working to incorporate cryptocurrencies into its services in 2021 (BBC, 2020), which would make the technology orders of magnitude more accessible to non-cryptocurrency users and may well be instrumental in moving the technology towards mainstream use.

Chapter 4 – Conclusions

4.1 Reflection on the methodology

One of the main factors that distinguished the action research model as potentially suitable for this project at the outset was the expectation that certain variables cannot be predetermined or controlled but are dynamic and varied, arising from the data and the ongoing research. This gave the practical projects freedom to develop and respond to the findings as they presented themselves. This was important as the research featured an element of the unknown in the form of a new technology. The decision to use informal feedback also proved effective as it lent the evaluative stages agility; the type and method of feedback (as well as social media / web traffic data) could be changed rapidly to that which most suited the project at hand.

The contextual review dealt with qualitative research (in the forms of texts considering cultural factors, musicological works and other qualitative analyses including that of existing blockchain technologies and my own practice) and quantitative data (comprising of statistical research on how consumers engage with music, music industry data and technical information relating to the blockchain). This proved to be a further strength of the methodology as the range of data types helps to provide a better overview of the situation, with the strengths of different data types mitigating the weaknesses of others. This range of sources was also effective as the issues addressed by this research are neither wholly qualitative nor quantitative.

An unexpected challenge of the contextual review was that much of the blockchain related literature was very speculative about the future possibilities of blockchain and unrealistic about what was actually possible, and so there was a need to pick through all the material very critically, and to disambiguate terms. Considering my own practice allowed primary experience to be compared with prevailing attitudes in the material consulted and afforded specific insight from the perspective of a DIY musician and small organisation founder and helped to fill gaps and address inaccuracies in the literature. Involving my own practice also provided ample opportunity to conduct practical projects and provided an existing audience to engage with (i.e. that of Kaneda Records and my own musical projects).

The iterative structure employed in the research worked well when developing the practical projects as it mirrored the iterative approach employed in developing the code utilised within these projects. It also proved useful when completing the contextual review, as with the nature of a new and relatively rapidly progressing technology, it meant that aspects of the contextual review would require periodic updates.

Overall the approach of exploring the blockchain's capabilities by identifying actual use cases, then developing prototypes to suit these situations, proved to be highly effective to test claims made in the discourse / literature and find information that was missing from the discourse / literature.

4.2 Findings in reference to the contextual review

4.2.1 Digital music distribution and the music industry context: piracy, streaming and criticisms of the industry narrative

Filesharing has been widely seen to have negative effect on the revenue generation of recorded music; however the exact level of this is highly disputed. Additionally, the wider distribution afforded by piracy has been seen to be potentially advantageous to independent practitioners, for example, encouraging ticket sales for live works or 'displacing' spending to complimentary products such as merchandise. From my own practice it can be seen in the example of an EP being leaked which resulted in benefits relating to wider exposure as well as download revenue. Also, as transformative works (remixes, edits etc.) and DJ culture are so prevalent in popular music, and that the freedom of access of digital files allows more democratic access to music, it could seen to lead to creative freedom and, as suggested in 2.3, some form of social good.

Wider distribution, due to file sharing, has also afforded new methods of distributing recorded music such as donation-based pricing strategies and direct-to-fan practices, with indications that this 'trust' based pricing is advantageous to DIY musicians and smaller organisations. In concurrence with this, donation pricing has been highly advantageous in my own practice as both a DIY artist and a founder of a small organisation. Streaming also represents another alternative strategy developed in response to piracy. Research shows streaming has been adopted by default by audiences and industry as; for the former it offers a level of utilitarian benefit (i.e. ease of access / use) compared to both legal and illegal purchasing methods; and for the latter a more secure revenue stream. However, it has also likely acted to further reduce downloaded music revenue.

The existing research consulted during the contextual review often does not consider the context of the DIY artist or small organisation specifically. Despite the prevailing trend toward streaming in the broader music industry, experience suggests that download revenue is still important to DIY practitioners and small organisations. More so than for established artists/labels with the mass market mainstream appeal who would expect a higher streaming turnover (to the point of making it worthwhile economically) but who also experience a high rate of piracy due to their wide appeal and the high prevalence of file sharing. These DIY artists also benefit proportionally highly from trust-based pricing strategies that are afforded by digital download as a format, which has been noted in my own practice where approximately a 40% of download income has been generated by people donating or paying more than the minimum price on downloads.

Streaming has also been much criticised, particularly in the media and public discourse, for poor royalty payments. These poor royalties appear to stem, in part, from the increased number of intermediaries necessary for this means of distribution (that greatly reduce the artists share and who have been found to be poorly functioning). Whilst perhaps most noticeable in streaming, this issue of intermediaries reducing artists shares, and possibly functioning poorly, is something apparent across many aspects the existing industry structure and music distribution practice and something that blockchain's decentralisation may help alleviate.

Commercial revenue is much more important, proportionally, for popular, jazz and folk music, as they receive just 8%, 2% and 1% respectively, of ACE music funding (Dugher, 2018),and have historically been much more reliant on private funding. The danger of which being a 'cultural malaise' that seriously threatens creativity in these areas (Fischer, 2008) and for this reason research into revenue streams in these areas is vitally important to the continuation of these forms of music.

4.2.2 Challenges to digital products and the value of live music

The ‘post-scarcity’ world of file sharing threatens profitability in goods and businesses built on scarcity of informational goods, such as the music industry and digital music files. DRM has been experimented with by the music industry to manage this scarcity, although the prevailing view is that this approach has failed at least in the context of digital music files. There is also an underlying tension in all matters relating to intellectual property, such as in the case of music DRM, concerning the notion of limiting access to ideas that should benefit the culture from which they arose as well as the innovator; and the suggestion by some that fewer restrictions on intellectual property may lead to social good with an example of this being the aforementioned transformative musical works, but also due to facilitating greater inclusion in cultural and leisure activities.

Due to peer-to-peer file sharing, and the resulting loss of scarcity in digital music, there has been a cultural as well as financial ‘devaluation’ of recorded music and subsequently there has been a relative ‘revaluation’ of live music due its intrinsically scarce nature (because of its rivalrous and temporal qualities).

There is a wealth of quantitative data indicating that live music remains much more resilient. The tour is seen as the more important economic opportunity when compared to recorded music. This is evidenced in an increase in the number of tours, number of artists on tour and average ticket price post 1999. Performance publishing royalties now also represent one of the most important sources of income for musicians of all categories (DIY, independent and signed to larger labels). This trend is also evidenced in my own practice, where performance fees and PRS performance royalties represent the biggest source of income and events represent generally the surest chance of return on investment.

4.2.3 The blockchain for music

Possible advantages and applications

It was concluded after the contextual review and from experience working as a DIY musician, that blockchain potentially offered advantages for receiving micro-payments over current fiat systems. This is primarily due to markedly reduced transaction fees (and the reversal of fee burden to the buyer not the seller), and essentially instantaneous payment. Smartcontracts offer the ability to efficiently automate complex payment processes such as for example apportioning royalties for collaborative music works where many small payments are received and must be accounted for and distributed to several parties. Lastly, due to the opensource and decentralised nature of the blockchain, and specifically via the Ethereum Web3 API, as explored in practical projects 2, 3 and 5, it is possible that organisations and DIY practitioners can appropriate it for their own use, more so than current ecommerce systems that are wholly reliant on intermediaries, thereby facilitating more direct selling to fans with fewer (or even no) fees.

Limitations of blockchain technology

Blockchain technology is still in its relative infancy and is not accessible or convenient for most to use. It is considered by some to be a highly inefficient way of working when compared to existing centralised systems. Related to this inefficiency there are concerns surrounding the environmental impact of the enormous energy consumption of blockchains and these factors lead some to doubt the longevity of the technology.

There were some indications, during the contextual review, that there was no meaningful market demand for music on the blockchain. This is due to the hoarding behaviour of cryptocurrency investors and is illustrated in the poor sales figures of Heap's (2017) 'Mycelia' Project (Gerard, 2017) and research by others into the spending habits of cryptocurrency users. Also the exchange rates are highly volatile and currencies are relatively difficult to spend and convert to more useful 'fiat' currencies. This makes them rather an inconvenient way to receive money at present. There is also no facility for in-person spending of cryptocurrencies, limiting its usefulness, it would appear, to online spending, at least at present.

There is also much confused reporting surrounding what are actually practical or useful applications for the technology, especially in the narrative surrounding music that often uses misleading jargon (e.g. the scattershot use of the term 'royalties' without proper disambiguation) and false equivalency and there is a lack of rigour in the media coverage of this field and in the white papers of tech start-ups (the rhetoric and approaches are also often politically motivated). Due to this lack of accuracy in the field of blockchain there is a reliance on forum and community social media posting for the cutting edge discourse surrounding technological development, which can lead to some mixed results when applying this discourse in practice. There is also a degree of distrust for the blockchain in the mainstream media and popular discourse that potentially discourages interest in participation in projects exploring the blockchain (although these perceptions seemed to be improving somewhat in during project 5).

It is doubtful if 'trustless systems' can offer any meaningful improvements on current systems of ownership and licensing of intellectual property, as often posited, due to the intrinsic reliance of these systems on trusting actions of people at the points where they interface with the real world, and the fundamental vulnerability of digital audio content to piracy.

A final point of concern is that Facebook and Instagram prohibited advertising that contain mention of cryptocurrency related products or services throughout most of the course of this research. This was highly problematic in the context of popular music as social media advertising is a hugely prevalent tool in music and events. During the course of project 5 however it was found that these restrictions were relaxed (although not totally lifted and such adverts still require special approval) which was certainly helpful in increasing audience engagement for this project and is a step towards moving blockchain based music distribution into the mainstream.

Despite this myriad of negative attributes blockchains both persist. At this moment in time, at current exchange rates (as of 30/12/2020), the market capitalisation of Bitcoin is equivalent value of over 350 billion USD and just over 80 billion USD for Ether. As Fletcher (Fletcher and Kivinen, 2018) observed, at this point it is simply "too big to fail" and therefore is certainly worth further research.

4.2.4 Existing blockchain music platforms

As previously discussed, demand for music accessed via the blockchain seems low, which is evidenced in this instance when considering both download and streaming platforms in comparison to the existing fiat-based examples and revenue generated using these platforms in conjunction with each other during the course of this PhD research. The single from the preliminary music release project and subsequent ako, Badger and Mausoleums releases were uploaded to these blockchain platforms and failed to generate revenue (either download or stream) over the course of the PhD research. There were no downloads at all and very few streams (no more than 20-30 on any release), which generated essentially nil income due to either being 'paid' for with non-fungible coins (Choon) or coins who's value was so low that it could not accrue into any meaningful sum based on the

desultory number of streams (Musicoin). The lack of demand is also evident in the low numbers of artists and listeners using these blockchain platforms.

Whilst it is possible to argue that the artists may benefit from a larger share of revenue earned due to the removal of intermediaries, these benefits are somewhat over stated (as shall be discussed in more detail shortly) and these platforms also act as recentralising forces and therefore undermine some of the benefits of the blockchains 'decentralisation'.

The existing streaming/download platforms also all appear to exempt themselves from PRS/MCPS royalties (unlike Spotify for example) which is of concern especially as prominent examples Musicoin and Emenate pay less per stream than Spotify for master royalties, and like all cryptocurrencies are subject to inconvenient volatility and inconvenience in spending.

This stance on publishing royalties completely undermines their stated aims of paying artists more fairly. Additionally the proprietary tokens ('altcoins') employed on most of these platforms are rather awkward to convert to usable funds, even more so than Mainnet coins such as Ether. There are also no indications yet that there are any noticeable benefits on any of these existing platforms in terms of better management of intellectual property for practitioners and organisations (as posited by Ujo and others) when compared to existing non-blockchain platforms due the aforementioned tension in matters relating to the interface between the blockchain and actions in the real world.

Returning to the issue of the overstated claims of removal of intermediaries, the rhetoric surrounding the formation the commercial platforms tout an idea of 'decentralisation' (i.e. the benefits of direct-to-fan practices and circumventing 'greedy' labels and other intermediaries) which is only applicable in the context of non-independent and non-DIY artist. Artists who already operate in this fashion (i.e. the main target user base of such platforms) will have much less to gain from this 'decentralisation' and the niche nature of these platforms and awkwardness of payment methods renders these platforms highly ineffective in terms of audience engagement and revenue generation. This problematic rhetoric is evidenced in the Choon white paper (Choon, 2018) and the motivations surrounding the Mycelia project (Heap, 2017). In the wider discourse surrounding blockchain music platforms, the term 'royalties' is also often used carelessly and usually without a proper explanation of exactly which royalties are meant, which further undermines the veracity of claims of 'decentralisation'.

Existing blockchain music platforms have a tendency to use private blockchains or custom coins/ICOs which overcomplicates the solution and adds to the difficulty of user experience, and further compound the issues relating to low familiarity with the blockchain. One approach that may alleviate this difficulty to a degree is employing a more widely compatible coin and wallet may help, such as Ether and Ethereum Web3 API compatible wallets, as in the example of Ujo music (and the Raribles platform explored in project 5).

4.3 Summary of findings in reference to selected practical projects:

4.3.1 Project 2 Kaneda crypto stream (summary of findings)

***Figure 27**:* Bert Verso at the Kaneda Records Crypto live stream, photo: Callum Hays (Project 2)

- Live steaming is an effective way for artists and organisations to engage with audiences and explore live music in the context of online/digital music distribution.

- The blockchain is an effective means of ticketing a live stream and the interface proved effective and wasn't prohibitively complex once the blockchain process was demystified.

- Only 2 of the 15 viewers had prior blockchain experience (neither had prior experience with Ethereum) which illustrates the low levels of wider familiarity with blockchain technologies.

- The smartcontract functioned as intended and the artists involved approved of the financial model employed (and the paradigm shift it represented away from models employed in traditional live performance situations).

- The total number of viewers being lower than the previous open-access streams. However this is a more committed audience who view and engage with the stream, and the live music within it, for much longer periods of time when compared to open-access streams. This also creates an experience much more akin to a live event which is beneficial in terms of being able to consider a live streaming as something of similar value to physical live event and

therefore monetise it in a similar manner. This is because it is much more 'scarce' in nature compared to the more 'disposable' sensation of the open access social media live stream. Further value is added by the increased audio and video quality it afforded compared to that of Facebook live.

- Live streaming also offers a potential alternative for live music events in situations such as the recent COVID-19 pandemic, had there been readily available ways for DIY artists to capitalise on this with monetisation strategies that suit the nature of live music performance (such as this project) during the first lockdown this would have helped mitigate loss of income at all levels of the music industry. Post-pandemic audiences will be much more used to the paid / ticketed live stream model, which affords this project potential long term relevance.

4.3.2 Project 3: blockchain singles and EP releases (summary of findings)

***Figure 28**:* Clockwise from top-left: Holy Braille promo photo (credit: Callum Hays), SQUARMS promo photo (credit: Benjamin Scott), Om10 – Range Anxiety EP cover and Linebreak Records Logo (Project 3)

- The cryptocurrency store interface developed for this project had lower payment processing fees during the course of this project than comparable fiat-based methods. This was

facilitated by removal of third parties in the form of card payment processors and music platforms / distributors). There are some caveats to this that are discussed in project 5.

- The opensource nature of the blockchain affords unique opportunity for artists/organisations to code their own online stores; thereby facilitating more direct selling to fans with fewer (or even no) fees or intermediaries.

- Smartcontracts on the Ethereum blockchain offer quicker processing and automated management of royalties after sale. This reduces costs and workload. When interacting with Smartcontracts each internal transaction adds to the total transaction fee, so the greater the number of parties that are paid out from the smartcontract, the higher the transaction fee, a fact that must be considered when addressing the efficacy of smartcontracts. Also there can be some issues with wallets when interacting with smartcontracts relating to correctly estimating the gas amount required. The artists involved in this project all approved of the instant royalty apportioning and payment afforded by the smartcontract, and the higher royalties that the automation and decentralisation afforded during this project. All artists remarked that this approach had significant benefits to existing practices. The smartcontract is also beneficial in situations where income is generated in many micro-payments, such as the current music economy, as manual accounting and apportioning becomes difficult and money often 'falls through the cracks' with more traditional methods. However smartcontracts such as this incur higher transaction fees than simple transactions and due to the scalability issues highlighted during project 5, the costs of interacting with smartcontracts can undermine their benefits.

- Buying music for cryptocurrency has apparently limited appeal in both the cryptocurrency and local music communities (similarly to the conclusions of the live stream conducted in project 2). There is therefore a need to take creative approaches to promoting releases for cryptocurrency (also partly necessitated by ban on Facebook advertising during this project), although this can be advantageous when successful as reaching new audiences is important for developing the profile of an artist. Feedback on blockchain community forum posts often alluded to a preference to pirate music – pointing at the general underlying issue with selling music to wider audiences that has been a recurring factor of the research.

- Concerning the currency itself; those in possession of coins seem to be constantly waiting for the market to improve, rather than actually spending these coins. The general trend is that of hoarding currencies. This is also linked to what could be considered one the largest obstacles to wider adoption of cryptocurrencies which is their extreme volatility

- Music consumption is very much dictated by ease of access. For projects like these blockchain releases to succeed, the payment technology must be as widely understood and used as that used by existing fiat platforms and be of comparable ease. When considering the existing blockchain music platforms in comparison to the methodology and payment interface developed in project 3 it can be argued that this interface offers a simpler and more direct solution than most of the existing platforms considered in the contextual review due to the use of a commonly traded currency and Ethereum Web3 API

4.3.3 Project 4: interactive music (summary of findings)

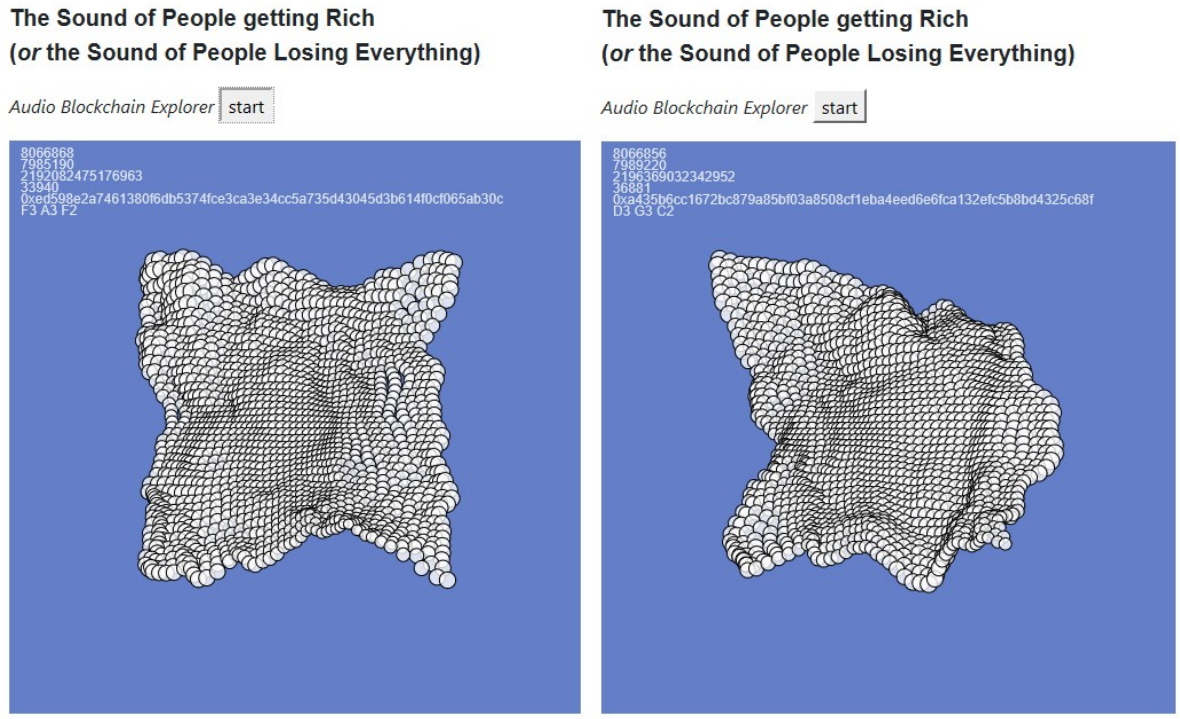

***Figure 29**:* Screenshots from '*The Sound of People getting Rich (or losing everything) – a sonic blockchain explorer'* (Project 4)

- This project was of least interest to Sage as an organisation, but might be relevant to other organisations in the future.
- The browser compatibility issues would need to be solved if considered for an organisation web site.
- Contemporaneously generated algorithmic music can be viewed as 'live music' performance, and therefore has to the potential to tap into 'scarcity' of live music, which is key in its revenue generation potential.
- The general idea of a 'novel' webpage as a way to pique audience interest, as explored in this project and the preliminary interactive music project, as part of a wider music release strategy is also potentially useful (see Project 5).
- The revealing of blockchain systems, as demonstrated in this project, might be an interesting way to educate and engage wider audiences with blockchain and music releases.

4.3.4 Project 5: ako – West Babylon album release (summary of findings)

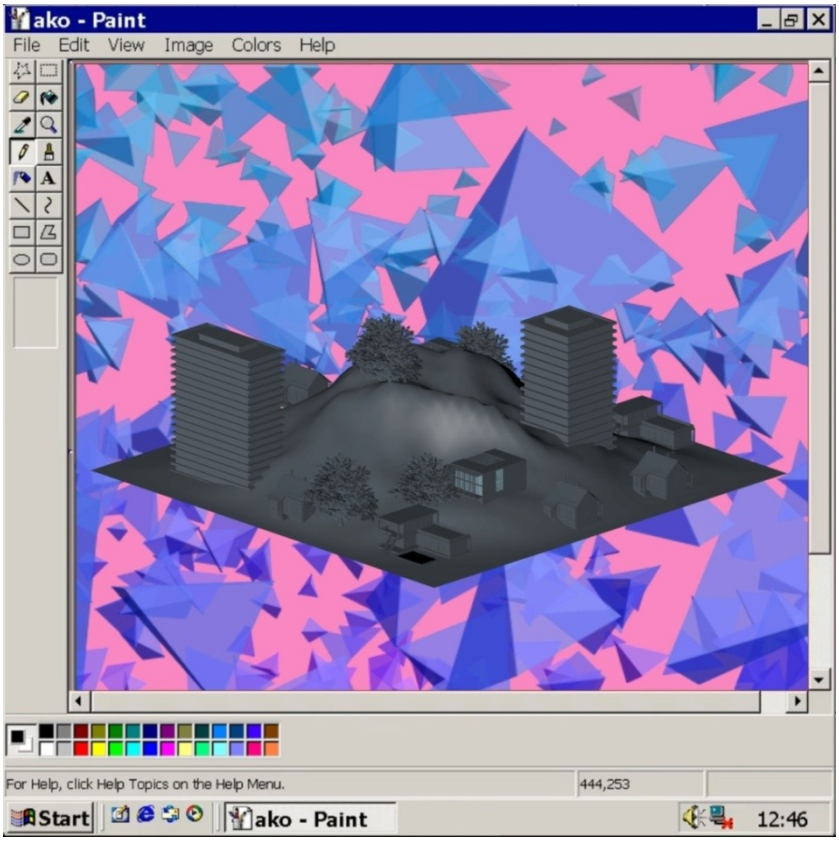

Figure 25: *ako – West Babylon Album cover*

- Transaction fees: sales in Ether were low, despite the market being prices being high, a condition that would lead to predictions that users would be more likely to spend cryptocurrency. This is probably due to the record high transaction fees around the time of this project. This undermines the claims that blockchain offers improved transaction fees. Because the TX fee is passed on to the buyer, the buyer is actively discouraged by high TX fees. This undermines another core benefit of the blockchain which is this reversal of the TX fee burden. The recent increases in TX fees is an indication of high economic activity and the pressure this puts on the network in terms of scaling to meet demand, something Ethereum is hoping to improve in Ethereum 2.0. High TX fees are especially problematic when interacting with smart contracts so it may be advisable for all groups considered to avoid them in conditions where TX fees are high (despite their administrative benefits).

- Donation pricing download: for aiding in wider distribution of the release by creating interest, the donation download store proved to be hugely successful. It received a positive response from audiences and generated traffic to and revenue from the other available formats. The discourse on Reddit surrounding this release also highlighted support for donation pricing format, further supporting assertions made about the positive reception of this kind of pricing.

- Boutique formats, scarcity and exclusivity: the most profitable format was VHS by a slim margin, followed by donation download. As expected, streaming is markedly less profitable. The sales of the VHS format illustrate the trend of boutique physical releases being a strong

income source of the DIY (this also illustrates freely accessible digital music encouraging ‘displacement spending’ on complimentary products). However, digital download still has benefits for artists because it is easier to manage and requires no specific upfront investment when compared to physical formats.

- Non Fungible Tokens (NFTs) were mentioned several times in the Reddit discourse. NFTs offer a means to present exclusive artwork, audio and media and as a form of limited edition merchandise. This combination of tactics of scarcity, boutique formats (as seen in physical release culture in DIY music and physical releases as merchandise), and exclusivity (as seen in live performance and limited edition physical merchandising), might offer economic options which are suited to DIY musicians, small organisations and even to large music organisations like Sage who are interested in less purely commercial music. This is evidenced in the recent Strudelsoft NFT and floppy disk release which was well engaged with by audiences.

- Generating interest in new music: one of the aim of this project to create a novel webpage as a way to promote the release and the resultant standalone cryptocurrency donation store achieved this. The donation download store proved to be highly successful and received a very positive response, generating traffic and revenue from the other available formats. This project, alongside publicising the wider album release, also proved to be a useful opportunity to disseminate the research, resulting in consulting on Wavemint's project and providing code examples for Openculture Agency as well as discussions with several other musicians about how to build such stores.

- During the course of this release project it was also found that Facebook / Instagram has now relaxed its ban on advertising cryptocurrency based products which proved useful in terms of audience engagement.

- The reception of this project, the relaxation of advertising restrictions, the current high economic activity on the Ethereum blockchain and the recent announcement that PayPal is working to incorporate cryptocurrencies suggests there may be a trend towards greater adoption of blockchain and improved perceptions of the technology.

4.4 Conclusions in relation to the research questions:

4.4.1 How can DIY musicians and smaller music organisations use blockchain to distribute music/audio and in what new ways can music/audio be composed, presented and performed?

There are no new means that music/audio be composed, presented and performed that are inherent to the blockchain itself. This is because the blockchain lacks the capability to store and quickly access data larger than a few KB and as such is reliant on the use of external agents and services for this, in the same manner as existing non-blockchain applications. Because of this it therefore cannot intrinsically offer new ways of composing or presenting music. Older forms can be repackaged and there are certain potential commercial benefits for using the blockchain for processing payments. However the exact extent of these benefits is dependent somewhat on context.

As with Heap’s (2017) release project, remix stems were experimented with and were bundled alongside the standard stereo masters. This was an attempt to explore new ways to present music

releases, given the relative freedom of working with a store you can build yourself, as a way of encouraging spending. However, these did not provoke much interest or result in any collaborative works. From experience the distribution of the remix stems is useful in publicising releases, however it works best when they are freely available.

The interest in finding new forms and ways to present music was driven by an attempt to instil scarcity in digital audio media, the importance of which was established during the contextual review (2.3). However blockchain is not a panacea for intellectual property control at least in terms of digital audio download, and offers no inherent benefits in this regard, as was concluded during the contextual review (2.3). If piracy resistance is the goal, we must either look at alternative solutions such as streaming in which blockchain may offer benefits. The promised potential benefits include the possibility to remove intermediaries in terms of payment processing and royalty management and create more intrinsic and efficient networks for the tracking of intellectual property and gathering of royalties. However due to the fact that blockchain streaming platforms are intermediaries themselves, and so far all appear to opt of paying PRS royalties, unlike Spotify for example, and themselves pay less per stream in master royalties than the established fiat platforms, the benefits of blockchain streaming are somewhat doubtful at this stage. Especially when we consider the discrepancy between the discourse surrounding exploitative royalties, often cited as a motivation to establish and adopt blockchain based platforms, and the facts relating to how much Spotify pays in terms of license fees (both master and publishing) compared to these blockchain platforms (and secondly, that the notion of 'exploitative labels' is deeply subjective) . This is compounded by the fact the rhetoric surrounding these platforms, of artists benefiting automatically by working independently, simply does not apply to their target audience (DIY artists) who already operate in this fashion, and in a much more profitable way using established fiat platforms (and the fact that smaller labels are often considerably less exploitative than the larger labels considered in this rhetoric).

Alternatively to streaming, we must accept that the piracy of recorded downloadable digital media as unavoidable and to be providing benefits of wider exposure and displaced spending. Particularly in the case of the DIY artist and the small organisation and move towards donation/trust based payment structures to ensure the artist retains the benefits of wider distribution with income recouped from donations (and merchandise or live music) as was demonstrated in the results of project 5 and my own practice. Even the actual amount of harm that piracy has and will cause is deeply debatable and wider access to music has been said to potentially create social good (more democratic access to culture and leisure) and present new ways of profiting from recorded music.

In the area of digital download revenue it is fair to say blockchain may offer some potential financial benefits, as shown in project 2 and 3, if it were to reach mainstream adoption due to the potentially reduced processing fees and instant and efficient management of royalties afforded by smartcontracts. Although the conclusions surrounding lower processing fees are called into question somewhat by the results of project 5 due to the high TX fees around the time of that project and the issues of scalability inherent in current blockchains that they highlight. With that being said, it is still possible to argue that the artist or organisation is still benefited in the project 5 example, which employed a simple wallet to wallet transaction, as the artist received 100% of the donation and the actual TX fee ($0.20) is paid by the buyer. Also, despite the high average TX fees, this fee was also still in line with amounts charged by fiat-based distribution platforms.

However re-evaluatin g the example of the wallet to smartcontract transactions employed in project 3 in light of the heightened TX fees / scalability issues illustrated during project 5, indicates these kinds of transactions suffer considerable impact (due to the factors of internal transaction for the royalty apportioning functions). As a result, as of 03/12/2020, fees to interact with these smartcontracts were estimated in excess of $2. This is of major concern and at this time it may be concluded that all groups considered by this research may benefit from more from employing wallet to wallet transactions in commerce rather than smartcontracts despite the administrative benefits they offer.

As discussed previously, when considering the example of blockchain based music distribution platforms, rather than the direct-to-fan DIY approach of the stores employed in this research, the advertised benefits of 'decentralisation' are often overstated. In reality these platforms offer less benefit to DIY artists than they claim (due to misleading rhetoric) and these platforms can themselves become the intermediaries they seek to replace.

There is however, some promise in the exploration of ticketed live stream (project 2). Live streamed performance exhibits the scarcity, and therefore innate value, of it's 'live' nature and if further popularised and monetised properly, could play an important part in future music economies. Especially given the popularity of live streaming and the effects of the COVID-19 pandemic on the live music industry which mean audiences are now becoming familiarised with the notion of ticketed / paid access live streaming. It therefore seems rational to conclude that in the wake of this there will be much more widespread exploration of the monetisation of such methods of performance, at all levels of music, especially those that work primarily in the field of live music such as venues like Sage Gateshead, as they are potentially some of the worst affected by such closures and measures imposed during a pandemic. It can also be argued that interactive music exhibits the same potential as a revenue stream within the post-COVID live music economy as it is intrinsically 'scarce' in nature, and offers the same potential for virtual audience engagement. However this aspect of the research is much further from mainstream popularity and is much more complicated to produce. The Blockchain also lends itself well to controlling access to complimentary content and other applications in the context of the larger organisation might be to control access to 'on demand' and other complimentary content, which was something that was suggested by the partner organisation, and again could pose a further revenue stream complimentary to both live and recorded music for all groups considered by this research.

Non Fungible Tokens (NFTs) offer a means to present exclusive audio and media as a form of merchandise as discussed in the conclusions relating to project 5 (4.3.4). This combination of tactics of scarcity, boutique formats (physical release culture in DIY music), and exclusivity (as exhibited in live performance and limited edition merchandising), might offer economic options which are suited to DIY musicians, small organisations, and even to large music organisations like Sage Gateshead who are interested in less commercial music, and are already engaged to some extent with the sale of merchandise, and may be able to capture some of the 'displaced spending' caused by freely accessible digital music.

However, it could be argued that the incorporation of physical goods into blockchain products (as in the example of the NFT discussed above) does begin to undermine the advantages relating to the ease afforded by digital products that can interface directly with the blockchain and the much lauded immutability and trustlessness of the blockchain due to the friction between the interaction of blockchain and physical world that is reliant on trust relationships again (as discussed in 2.4.2). Also, Rarible constitutes an intermediary which undermines some of the benefits relating to the removal of third parties.

A hurdle for blockchain platforms (streamed music / download / live stream / NFT) however is that, as previously discussed, music consumption is very much dictated by ease of access. For projects like the blockchain releases to succeed, the payment technology must be as widely understood and used as that used by existing fiat platforms and be of comparable ease of use and we are still a reasonably long way away from that, as evidenced throughout projects in the low demand (projects 2, 3 and 5) and low prior awareness of blockchain in music audiences shown in project 2. Especially given that the basic principles of an ICO often employed by the existing blockchain music platforms can make for potentially complex and/or cumbersome interfaces at present and serve to add further barriers to widespread use. However, there is hope for a wider degree of adoption in the recent announcement that PayPal is working to support cryptocurrencies in 2021.

There was a tertiary benefit from conducting the practical projects in that they generated interest for the releases, labels and artists involved. From this perspective the various practical projects were worth undertaking, even if the results were somewhat mixed in other areas. It lead to music 'zine coverage, blog traffic, website (including over 13,000 visits to the Linebreak Records website) and social media traffic and opportunities to engage with new online communities with music that would otherwise not reach them in addition to sales and streaming revenue generation on fiat-based platforms. It also led to industry engagement with both my music and research including contact from a researcher at the Recording Academy (the Grammys), Wavemint (a blockchain start up) and an individual working for r0g_ (an international cultural development agency) as well as a number of DIY practitioners (see appendix 14 for a full description of the impact and wider interest in this research). As mentioned, on the face of it Heap's (2017) project probably would not be considered a financial success, but it generated large amounts of publicity (and speaking and other engagements) which can only have been beneficial. This is most evident in the results of project 5, where the novel webpage and unusual nature of the projected attracted a lot of attention for the release and generated revenue in the other formats and generated a wider degree of awareness for the release and aided greatly in the dissemination of the music.

4.4.2 What are the uses for blockchain technology for large music organisations such as Sage, including audience engagement?

Overall the conclusion of this research is that blockchain/cryptocurrencies currently offer the most benefit to DIY musicians and small organisation. This is due to its open source / decentralised nature which allows them to circumvent some of the aspects of existing music industry infrastructure which have a greater prevalence on intermediaries. This allows such artists and organisations to maximise their potential revenue when considering it is generated in relatively small amounts. Whereas, larger organisations have the wider appeal to make such areas with larger amounts of intermediaries, like streaming, financially successful due to the high volume of demand and are much better served by the existing music industry infrastructure in terms of handling this high volume of traffic and can handle the greater administrative load when accounting for this revenue with traditional (fiat) methods.

Large organisations also benefit from centralised IT systems (due to having more money to fund this and reap the reward in terms of efficiency and economies of scale) and will have to contend with the detrimental inefficiency if a move to blockchain was made. Also the smartcontract language is restrictive and functionality is fairly limited at this stage (the limitations on the numerical system alone, discussed in chapter 3 in relation to the development of the payment interface for projects 2 and 3, is highly problematic). These limitations may cause issues in accurately conducting calculations in financial transactions and potential issues in other instances such as administrative tasks (a possible alternative use for blockchain technology). Also due to the immutability of the blockchain there is a certain static nature to the smartcontract, which means updates require constant republishing, whereas with web based solutions updating code is a much more straight forward affair. Lastly smartcontracts can be affected detrimentally during times of high TX fees which undermines the administrative benefits they offer.

All this is despite the claims of the computing power of the Ethereum blockchain and the touting of it as the so called 'world computer' by its founder (Ethereum Foundation, 2015). In reality, as a form of cloud computing, it is inefficient in principal and practice. This is because every time data is processed by a smartcontract, or moved on a blockchain network, it incurs a transaction cost and processing delay (and the chance to fail due to blockchain network issues) so it is hard to argue that it could feasibly offer a meaningful alternative to 'centralised' models already well established. Secondly the data cap of blockchain transactions (and the cost of that data) very much limits the uses for the

data field of a transaction. Smartcontracts are best for managing the movement of coins and most usefully employed in this manner, talk of anything beyond this at this stage still seems rather fanciful.

It was also a conclusion of the contextual review that blockchain solutions relating to logistical operations and supply chain / back office operations (rather than payment processing) offer no intrinsic benefits and are markedly less efficient then existing centralised solutions. This is because of the limitations discussed in relation to using it for cloud computing applications, and in situations such as controlling inventory or the sale of physical goods, for example, the issues with trust and interfacing the blockchain with the real world again become an issue, undermining claims of infallibility.

In summary, “aside from…cryptocurrency there's pretty much nothing that blockchain technology is suited for (and even currency is still ... questionable) that doesn't already have superior solutions using conventional databases” (Chu, 2018).

One such non-cryptocurrency / administrative application suggested in discussions with the partner organisation was the use of the blockchain to distribute program notes to attendees of classical music concerts where program notes are normally provided. However after some consideration it did not seem practical due to the fact that the programme notes would have to stored off-chain anyway, due to the file size and format limitations of the blockchain, and there could be much more efficient ways of achieving digital distribution of these documents using existing applications such as Google documents or emails for example. Not to mention the skills / knowledge gap to be overcame in the audience who in all likelihood would not be familiar with blockchain. Another similar use was for the distribution of, and control of access to learning materials distributed as part of their learning / career development programs, although this again suffers all the same issues as the idea relating to programme notes.

These problems with blockchain in the context of the larger organisations will also be compounded currently with challenges linked to the wider lack of adoption, meaning that staff at such organisations will require training to use these systems incurring cost to the organisation for a very limited return in terms of useful capabilities. Second to this is the fact that larger organisations would potentially need to employ specialised IT support for blockchain applications, which could incur further cost.

Small organisations / DIY practitioners would be equally inconvenienced in terms of training and implementation. However, in small organisations the attitude towards challenges of this nature is to self train / self-develop (perhaps calling upon a wider network of collaborators willing to work unpaid or for token amounts). Therefore these groups are able to offset the inconvenience more readily as it does not cost much (or at all but) opens up potential new revenue sources and both new means to engage with audiences and new audiences to engage with. This links into the opensource nature of the blockchain and the general trend that opensource methods are most readily adopted by smaller groups / independent practitioners, rather than large organisations.

Aside from simple commerce transactions, it appears likely that it would be unsuitable for larger organisations to operate on a public blockchain, due to both the previously discussed inefficiencies and also due to obvious issues relating to privacy and security. They would first have to centralise it in some fashion (private blockchains / DPoS chains). Which, as discussed previously, complicates the possible solution and this level of re-centralisation begins to undermine the benefits of decentralisation, and brings with it an unacceptable level of inefficiency when compared to the methods it would replace.

These factors limit the possible applications, especially in the case of an organisation such as Sage Gateshead where the focus is on traditional understandings of live music, and the associated complimentary spending on merchandise, rather than recorded music. However, one possible use case in the context of the partner organisation might be an NFT related project where the unlockable

content is merchandise or physical music (as with the previously discussed Strudelsoft release) or even, a ticket to access live music (either streamed or in person). This would allow the organisation to exploit the scarcity that blockchain offers in conjunction with the exclusivity of live music and merchandising which are already core to their operations. The limitation of this kind of approach however is that when blockchain technology is used in the context of the sales of physical goods such as merchandise then the advantage of blockchain immutability is undermined. However because of Sage's stature as a large organisation and therefore already possessing a large infrastructure, it could probably manage the additional strain of this interfacing with the real world to a greater degree than a small organisation or DIY practitioner, with limited resources, could.

In general however, when considering any form of selling (physical or digital), the volatility of the currency becomes an issue. This volatility has caused such issues that Steam removed the option to pay with bitcoin in 2017 (Ghosh, 2017). A further barrier to use when considering larger organisations is physical products and in person purchase, there is no simple, reliable means to do this at this time, which is problematic in the context of Sage Gateshead, as part of their operations is based around in person spending.

The conversion of cryptocurrency to 'fiat' currency employed by the rest of the business or organisation is also problematic, relying on the cumbersome process of using exchanges (and their attendant processing fees) and bank transfers, at least currently in the UK. This volatility and difficulty in conversion of currencies undermines the potential benefits relating to payment processing.

Further compounding this are the issues relating to the low saturation, prevalence and familiarity of cryptocurrencies and the 'hoarding' tendencies of those in possession of coins. This means organisations like Sage Gateshead are unlikely to find any meaningful additional market by offering crypto payment options and would be unlikely to be able to offset the costs incurred in establishing this payment method at this time, as evidenced in the low demand for the music releases (project 3 and 5); the work of Khairuddin, (2019), the apparently low sales figures for Heap's (2017) Mycelia project and the generally low adoption of the existing blockchain music platforms surveyed in 2.5. However the warm reception of project 5 and the announcement of PayPal's plans to adopt cryptocurrencies in 2021 do potentially indicate wider use in the near future and offer some hope in regards to the usefulness of cryptocurrencies for larger organisations.

An area that was more promising to Sage Gatheshead when considering the practical projects was live streaming as this was an area they were interested in expanding and an area in which they rely on external contractors. Whilst the solution developed in project 2 definitely shows promise, and a scaled up version could be used to provide in-house ticketed/access controlled streaming services (with applications being virtual attendance at concerts or access to on demand and complimentary content such as videos of past performances and bonus audio content, which is a another use for blockchain ticketing suggested by the partner organisation). The value is being added here not by the blockchain ticketing interface per se however, but more so by the fact that they do not have to pay for a third party to provide the streaming service. In house streaming could be realised without blockchain technologies, and if it used fiat payment it could be conceived that at this current time that it would be more accessible to a wider audience.

However, I would still contend that using the blockchain to ticket or control access to live music and complimentary content is one of the more promising avenues, and even more so in the wake of the COVID-19 pandemic as large organisations could have benefited from this alternative income as much as DIY practitioners / small organisations. This use case is all the more pertinent given the recent increase in the familiarity and willingness in audiences to engage with live music via ticketed live streaming, which is something that may will continue after the pandemic and which lends the project 3 model future pertinence to the operations of a large live music organisation.

4.5 Original knowledge

The research contributes the following areas of original knowledge:

1. **Blockchain in music – real world use cases**: Firstly, the subject area of the PhD itself, i.e. the overlap between music and the blockchain, constitutes a contribution to original knowledge. This is because as practical projects of this specific nature are not found in existing academic literature. The contextual review took a critical approach to differentiate the real world potential of blockchain from optimistic speculation. The practical projects then tested uses of blockchain in DIY music contexts, and the findings might prove useful to others. Specifically, findings are offered in the areas of employing the blockchain for ticketing live music events, as developed in project 2, and selling digital downloads by creating working examples of Ethereum music download stores, as developed in project 3 and Project 5. A particular claim to originality lies in the fact that the crypto live stream (project 2) was the first of its kind. At the time of the stream, there was only one blockchain streaming service (Livepeer) which operated in a similar fashion to Twitch and did not focus solely on ticketed live music events. This ticketed live stream model has also been lent further relevance by changes to audience engagement in live music caused by the COVID-19 pandemic. In summary the contributions to original knowledge are that blockchain can provide an effective ticketing system for live streamed performances and also the use of smartcontract creates a novel paradigm where performance fees are automatically and instantly apportioned. However the increased processing fees associated with smartcontracts in times of high TX fees can be problematic. This project, like project 3 and 5, also illustrated issues relating to low demand for music accessed via blockchain within both the blockchain communities and music audiences, compounded by a marked lack of wider familiarity with the technology therefore making it inaccessible. Further to this the partnership with Sage Gateshead has given rise to original knowledge in the areas surrounding what large live music organisations are interested in terms of blockchain technology and what is useful in that regard, and in both the specific context of live music venues and that particular organisation itself. Specifically, there are potential applications in controlling access to online content such as live streams and additional and complimentary content and engaging with audiences virtually in situations such as the COVID-19 pandemic (alongside which there are benefits in the truly international nature of commerce on the blockchain).

2. **Smartcontracts for DIY music**: Specific practical original knowledge arose from implementing the research to create a working example of a smartcontract, specific to the context of the project (developed over the course of practical projects 2 and 3). It constitutes original knowledge as working examples of this kind of code were not found in academic texts when completing the contextual review. Therefore the smartcontract contributes original knowledge to the areas of blockchain development; blockchain applications / use cases; and the development of smartcontracts and within the field of popular music distribution and the blockchain. Working examples of code at this stage in the development of the surrounding discourse and the technology itself is also vital to develop this field of research. The final version of the smart contract is included in Appendix 6.

3. R**ecord label not music platform**: Existing research on commercial music projects focus on the platform model rather than the record label model, and therefore did not represent the perspective and modes of working inherent within the context of a record label. Music organisations such as Sage Gateshead, record labels and DIY musicians, share commonalities in their modes of working and are a different from mass media platform (such

as the music projects on the blockchain currently), and so this research offers findings more relevant to their ways of working. Linebreak Records afforded opportunities to conduct research that forms a contribution to knowledge. It offered opportunities to test features of the blockchain in a participatory manner and in a format that had not been undertaken prior to this project. Therefore the results of this project form a contribution to the discourse in the area of operating an independent record label on the blockchain. The contributions to original knowledge in summary are that blockchain offers potential advantages in areas relating to payment processing, however suffers from problems relating to low demand for music in this form within both the blockchain communities and music audiences, compounded by a marked lack of wider familiarity with the technology which makes it inaccessible. Therefore it is not practical to run a record label solely on the blockchain at this time, but if good user design, good style design, boutique / scarcity / exclusivity (as posited in 5), and links to open discussion, education, and social media are used, then it could offer future possibilities. Project 5 also illustrated there can be issues relating to scalability of the blockchain to meet demand, that can result in high TX fees which discourage purchasing of musical products and potentially undermine some of the benefits relating to payment processing especially in the context of interacting with smartcontracts.

4.6 Areas for future research

The contextual review identified a gap in the literature in surrounding the music industry context of DIY practitioners / small organisations. In particular in the area of the long term effects of piracy and changes to consumer behaviour and the relative importance and merit of current revenue streams to these practitioners.

There is also a an apparent lack of practical experience present in the existing academic texts concerning the blockchain and it would be useful for researchers and practitioners if more research that exhibited and explored practical applications existed as there would be less reliance on forums and community posting which can produce mixed results

It is also a conclusion of this research that for blockchain to become a viable market place the current volatility is the biggest obstacle and research into alleviating this is needed. Related to this, research into the spending habits of cryptocurrency holders and into encouraging participation in ‘commerce’ is also an important area of future research and this may also help address volatility.

The practical projects left several areas unexplored including:

- Blockchain ticketing for a physical performance event such as a ‘traditional’ concert with audience attending in person as a continuation of project 3’s exploration of blockchain’s possible involvement in live music.
- Ticketed physical event operating alongside a blockchain controlled live stream as a way to further explore blockchain and live music and to test ideas raised by Sage Gateshead about using the blockchain to ticket material complementary to live music events, also as this becoming a more common paradigm due to COVID-19.
- The use of NFTs as either merchandise in their own right or as part of a broader release strategy and this is something that is beginning to warrant attention as discussed in project 5.

All of which would help establish a more definite picture of the current potential for the involvement of blockchain technology in music practice.

4.7 Closing remarks

Despite mixed results during the practical projects in terms of audience engagement and revenue generation, there are some undeniable potential advantages to the technology in terms of removing intermediaries and receiving, distributing and accounting for micro-payments. This is highly promising in the context of music distribution, especially in the context of DIY practitioners and smaller music organisations (although perhaps less so for larger organisations, due to the inherent inefficiency of blockchain networks and the issues relating to scalability that posed an obstacle for the final project). The extent of the market capitalisation of cryptocurrencies and the general sense of wider acceptance of the technology throughout project 5 is also an indication that cryptocurrencies are an important emerging technology and one that warrants further studies in all fields.

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Appendix 1 — Linebreak store page code (project 2 and 3)

```
<!DOCTYPE html>
<?php
//gets exchange rate of ETH to USD
$url2= "https://api.coinbase.com/v2/prices/ETH-USD/spot";
$fileGet = file_get_contents($url2);
$json = json_decode($fileGet, TRUE);
$jsondata = $json["data"];
?>
<html>

<style>

#eth_address {
    text-transform:lowercase;
}

</style>

<head>
    <script src="https://ajax.aspnetcdn.com/ajax/jQuery/jquery-
3.3.1.min.js"></script>

</head>
<!--loads the functions to: convert the dollar value of the single to ETH;
request permision to connect to wallet; and the function to check if the
address is valid-->
<body onload="usdConvert(), ethereum.enable(), metaMaskAddressCheck();">

<div id="container" >

<div>
 <tspan>Range Anxiety (EP) by Om10</tspan>
 <br>buy with ETHER (ETH)
</div>

<div "id="demo5">

Send <input type="text" id="eth" onKeyUp="usdConvert()" style="border:none;
background-color:yellow" size="8";>Ether (ETH) cryptocurrency donation or
more to buy the four track EP and unlock download<br>
<button onclick="metaMask()">Buy with MetaMask (and other web3 compatible
wallets)</button><br><br>
<div>Wait for transaction to be completed and download links will be
unlocked below (you may need to refresh this page):<br>
    download links:<div id="status"><mark id="m3">(download not
unlocked)</mark>
<div><em><a href="index.php" target="_blank">powered by
LineBreakRecords.com<a></div>

</div>


<script>
```

```
//gathers blockhain transaction data for the specified address (the address
of the recieving contract), including a list of all addresses that have
sent transaction to the contract and list detailing if each of those
transactions completed or not.

var data3 = [], i;
var data4 = [], i;
var addresses2 = [], i;
var completed = [], i;
var b = [], i;
var indexes = [], i;
var completedpayments = [], i;
var completedpaymentsSTRING ;
var b = [], i;
var request = new XMLHttpRequest()

// Open a new connection, using the GET request on the URL endpoint
request.open('GET',
'https://api.etherscan.io/api?module=account&action=txlist&address=0x418434
b53504dab1f215850e1f32b6d9a64dc590&startblock=0&endblock=99999999&sort=asc&
apikey=DMVI9FTTB8MT876P7EJ7YBSF56I487GQN2', true)

request.onload = function getjsonda() {
// Begin accessing JSON data here
var data2 = JSON.parse(this.response);
var result2 = data2.result;

 for ( i = 0; i < result2.length; i++) {
  data3[i] = (i, result2[i].isError);
  data4[i] = (i, result2[i].from);
  var addresses2 = data4;
}

}
request.send();

//Checks user is logged in and gathers address
function metaMask() {
  if (typeof web3 === 'undefined') {
    return alert('You need to install MetaMask to use this feature.')
  }
  var user_address = web3.eth.accounts[0];
  if (typeof user_address === 'undefined') {
    return alert('You need to log in MetaMask to use this feature.')
  }

 //sets up transaction in users wallet when the user clicks 'buy', value is
set against exchange rate, in the same fashion as the usdConvert() function
(below), gass value is also set as twice default to make sure enough gas is
included to complete the transaction successfully

  web3.eth.sendTransaction({
    to: "0x418434b53504dab1f215850e1f32b6d9a64dc590",
    from: user_address,
    value: web3.toWei(document.getElementById("eth").value, 'ether'),
    gas: 46000,
  }, function (err, transactionHash) {
    if (err) return alert(':(');
    alert('Thanks');
  })
}
```

```
var account ;
function metaMaskAddressCheck() {
checkAddress(); };

function getAllIndexes(arr, val) {
    var indexes = [], i;
    for(i = 0; i < arr.length; i++)
        if (arr[i] === val)
            indexes.push(i);
    return indexes;
}

///this function checks whether the address has a valid compldeted
transaction into the contract associated with it, if it has it sends value
to a PHP script that will send back download links to the single. If it
does not have a valid transaction associated with it, a message warning the
user of this is displayed. SetInterval refreshes the transaction data and
rechecks the address periodically
setInterval(function(){checkAddress();}, 3000);
function checkAddress() {
var account = web3.eth.accounts[0];
var indexes = getAllIndexes(data3, "0");
var completedpayments = data4.filter((x,i) => indexes.includes(i));

if  ((completedpayments.indexOf(account)) > -1) {
var postdata = data4;
   $.ajax({
    type: "post",
    url: "fetchtestOM10-RANGEsimple.php",
        data: postdata,
        success: function(html){
            document.getElementById("status").innerHTML = html;
    }
   });

            }
            else { document.getElementById("status").innerHTML =
'<i>invalid address / download not unlocked - please check you are signed
in with the correct account and transaction was successful</i><br><br>'}
        }


//grabs exhange rate from PHP
var eth = <?php echo json_encode($jsondata["amount"]);?>
var usd = 1;

//calculates ethereum value, roughly, based on dollar amount (in this case
$4)
function usdConvert() {
    var usdCalc = (usd / eth)*4;
    var usdCalc = usdCalc.toFixed(8);
document.getElementById("eth").value = usdCalc;
}


</script>

</body>
```

Appendix 2 — Linebreak store page PHP file (project 3)

```
<?php

////this receives a value from the store page to confirm if the user
address is valid and has paid to access content

    $addresses    = [];
    $addresses2   = $_POST;

 if (isset($transactions['result'])) {
        foreach ($transactions['result'] as $transaction) {
            $addresses[] = $transaction['from'];
        }
    }


/////checks to see this value has been received, and if so will send the
following div containing the download links to the relevant section of the
store page
if($addresses2 == true){
$paid = <<<EOT
<div id="status">

<a href="http://linebreakrecords.com/om10-range-
anxiety/om10rangeanxietyDL/dtyjgut3456789211linkghsshy211/om10%20-
%20Range%20Anxiety%20(MP3).zip" download>• Download mp3 (320Kbps)</a><br>
<a href="http://linebreakrecords.com/om10-range-
anxiety/om10rangeanxietyDL/dtyjgut3456789211linkghsshy211/om10%20-
%20Range%20Anxiety%20(WAV).zip" download>• Download wav</a><br>
<br>
<br>

</div>
EOT;
echo $paid;
}else {
////if the value confirming the transaction has not be received and the
page has been loaded separately to the store interface, as in an attempt to
access the download links without paying, then the following message is
displayed. As this code is run on the server side it is impossible to
access the links without the correct purchase history, despite being shown
above in the code
echo "this is piracy";
}

?>
```

Appendix 3 — Linebreak live stream paywall PHP file (project 2)

```
<?php

////this receives a value from the store page to confirm if the user
address is valid and has paid to access content

    $addresses    = [];
    $addresses2   = $_POST;

 if (isset($transactions['result'])) {
        foreach ($transactions['result'] as $transaction) {
            $addresses[] = $transaction['from'];
        }
    }


/////checks to see this value has been received, and if so will send the
following div containing the .M3u8 stream player
if($addresses2 == true){
$paid = <<<EOT
<div id="status">

<div id="status" allowfullscreen="true" webkitallowfullscreen="true"
mozallowfullscreen="true">
<mark id="m3">• Watch with player below: </mark></a><br>
<iframe src="http://linebreakrecords.com/hlsport8080exmapletest4.html"
height="400" width="700" style="border:none;" allowfullscreen="true"
webkitallowfullscreen="true" mozallowfullscreen="true">
</iframe>

<br>

</div>
EOT;
echo $paid;
}else {
////if the value confirming the transaction has not be received and the
page has been loaded separately to the store interface, as in an attempt to
access the download links without paying, then the following message is
displayed. As this code is run on the server side it is impossible to
access the links without the correct purchase history, despite being shown
above in the code
echo "this is piracy";
}

?>
```

Appendix 4 — NGINX streaming server configuration file (Windows) (project 2)

```
worker_processes  1;

error_log  logs/error.log info;

events {
    worker_connections  1024;
}

rtmp {
    server {
        listen 1935;

        application live {
            live on;
        }

        application hls {
            live on;
            hls on;
            hls_path temp/hls;
            hls_fragment 8s;
        }
    }
}

http {
    server {
        listen      80;

        location / {


    if ($request_method = 'OPTIONS') {
        add_header 'Access-Control-Allow-Origin' '*';
        add_header 'Access-Control-Allow-Methods' 'GET, POST, OPTIONS';
        #
        # Custom headers and headers various browsers *should* be OK with
but aren't
        #
        add_header 'Access-Control-Allow-Headers' 'DNT,User-Agent,X-
Requested-With,If-Modified-Since,Cache-Control,Content-Type,Range';
        #
        # Tell client that this pre-flight info is valid for 20 days
        #
        add_header 'Access-Control-Max-Age' 1728000;
        add_header 'Content-Type' 'text/plain; charset=utf-8';
        add_header 'Content-Length' 0;
        return 204;
     }
     if ($request_method = 'POST') {
        add_header 'Access-Control-Allow-Origin' '*';
```

```
        add_header 'Access-Control-Allow-Methods' 'GET, POST, OPTIONS';
        add_header 'Access-Control-Allow-Headers' 'DNT,User-Agent,X-
Requested-With,If-Modified-Since,Cache-Control,Content-Type,Range';
        add_header 'Access-Control-Expose-Headers' 'Content-Length,Content-
Range';
     }
     if ($request_method = 'GET') {
        add_header 'Access-Control-Allow-Origin' '*';
        add_header 'Access-Control-Allow-Methods' 'GET, POST, OPTIONS';
        add_header 'Access-Control-Allow-Headers' 'DNT,User-Agent,X-
Requested-With,If-Modified-Since,Cache-Control,Content-Type,Range';
        add_header 'Access-Control-Expose-Headers' 'Content-Length,Content-
Range';
     }


            root html;




        }

        location /stat {
            rtmp_stat all;
            rtmp_stat_stylesheet stat.xsl;
        }

        location /stat.xsl {
            root html;
        }

        location /hls {

        if ($request_method = 'OPTIONS') {
        add_header 'Access-Control-Allow-Origin' '*';
        add_header 'Access-Control-Allow-Methods' 'GET, POST, OPTIONS';
        #
        # Custom headers and headers various browsers *should* be OK with
but aren't
        #
        add_header 'Access-Control-Allow-Headers' 'DNT,User-Agent,X-
Requested-With,If-Modified-Since,Cache-Control,Content-Type,Range';
        #
        # Tell client that this pre-flight info is valid for 20 days
        #
        add_header 'Access-Control-Max-Age' 1728000;
        add_header 'Content-Type' 'text/plain; charset=utf-8';
        add_header 'Content-Length' 0;
        return 204;
     }
     if ($request_method = 'POST') {
        add_header 'Access-Control-Allow-Origin' '*';
        add_header 'Access-Control-Allow-Methods' 'GET, POST, OPTIONS';
        add_header 'Access-Control-Allow-Headers' 'DNT,User-Agent,X-
Requested-With,If-Modified-Since,Cache-Control,Content-Type,Range';
        add_header 'Access-Control-Expose-Headers' 'Content-Length,Content-
Range';
     }
     if ($request_method = 'GET') {
        add_header 'Access-Control-Allow-Origin' '*';
```

```
        add_header 'Access-Control-Allow-Methods' 'GET, POST, OPTIONS';
        add_header 'Access-Control-Allow-Headers' 'DNT,User-Agent,X-
Requested-With,If-Modified-Since,Cache-Control,Content-Type,Range';
        add_header 'Access-Control-Expose-Headers' 'Content-Length,Content-
Range';
     }


            #server hls fragments
            types{
                application/vnd.apple.mpegurl m3u8;
                video/mp2t ts;
            }
            alias temp/hls;
            expires -1;
        }
    }
}
```

Appendix 5 — NGINX streaming server version information (Windows) (project 2)

```
nginx-rtmp-win32
================

* Nginx: 1.14.1
* Nginx-Rtmp-Module: 1.2.1
* openssl-1.0.2p
* pcre-8.42
* zlib-1.2.11
```

Appendix 6 — Final release smartcontract (project 3)

```
//initialises and declares which solidity version is in use
pragma solidity ^0.6.1;

//creates and names contract
contract om10rangeanxietyCONTRACTv2{

//logs the address and value (amount received) for incoming transactions
event senderLogger(address);
event valueLogger(uint256);

//function to receive funds and then apportions 80% to artist and 20% to
label
fallback () external payable {
emit senderLogger(msg.sender);
emit valueLogger(msg.value);
//calculates label's(20%)share transfers to recipient address
0x445b5f277D463122a2Aaeac8B77d8f60865156Dc.transfer(msg.value - ((msg.value
/ 10)+(msg.value / 10)+(msg.value / 10)+(msg.value / 10)+(msg.value /
10)+(msg.value / 10)+(msg.value / 10)+(msg.value / 10)));
//calculates artist's(80%)share transfers to recipient address
0xc4b16B075747BF70bec463BD8D4e3DAcAeAa8D09.transfer((msg.value /
10)+(msg.value / 10)+(msg.value / 10)+(msg.value / 10)+(msg.value /
10)+(msg.value / 10)+(msg.value / 10)+(msg.value / 10));
}

}
```

Appendix 7 — Live stream smartcontract (project 2)

```
pragma solidity ^0.4.15;

//This contract function the same as the contract in Appendix 4, but is
written slightly differently due to being in an older version of Solidity,
this should still function correctly however, as the correct version of
Solidity is declared at the top of the contract

contract livestreamCONTRACT2{

event senderLogger(address);
event valueLogger(uint);

//create and populate variables for collaborators address
address kanedaAdress = 0x445b5f277D463122a2Aaeac8B77d8f60865156Dc;
address artist1Adress = 0x705b4e2D44BE431740b11FA9bA6aCE47Bef8D035;
address artist2Adress = 0x9760Ab40236cF36285209a2E56A2C897d22D7bF3;
address artist3Adress = 0x1c0ecc4EedE23FaFE066e89CBbe8728b052b7F03;

function () public payable {
emit senderLogger(msg.sender);
emit valueLogger(msg.value);

//Label share
kanedaAdress.transfer(msg.value - ((msg.value / 10)+(msg.value /
10)+(msg.value / 10)+(msg.value / 10)+(msg.value / 10)+(msg.value /
10)+(msg.value / 10)+(msg.value / 10)+(msg.value / 10)));
// Artists 1-3 shares
artist1Adress.transfer((msg.value / 10)+(msg.value / 10)+(msg.value / 10));
artist2Adress.transfer((msg.value / 10)+(msg.value / 10)+(msg.value / 10));
artist3Adress.transfer((msg.value / 10)+(msg.value / 10)+(msg.value / 10));
}

}
```

Appendix 8 — SafeMath smartcontract (project 3)

```
pragma solidity ^0.5.1;

///imports safe maths, when published the imported safe math script will be
published alongside this contract as a separate contract
import "https://raw.githubusercontent.com/OpenZeppelin/openzeppelin-
contracts/master/contracts/math/SafeMath.sol";

contract newtestCONTRACT1{

using SafeMath for uint256;

event senderLogger(address);
event valueLogger(uint256);

function () external payable {
emit senderLogger(msg.sender);
emit valueLogger(msg.value);
//label
0x445b5f277D463122a2Aaeac8B77d8f60865156Dc.transfer((msg.value.mul(20)).div
(100));
//artist
0xE0Dac2b105E8511159B76d322d52CEef618F9244.transfer((msg.value.mul(80)).div
(100));
}
```

Appendix 9 — iterative development of project 3 download store

Following the iterative approach of the methodology of this project, the initial release from the preliminary projects was evaluated to form conclusions concerning the limitations and therefore necessary improvements to inform the development of the next iteration.

The final annotated code for the webstore is available in Appendix 1 (the music store page), Appendix 2 (the PHP file to grant access to download links of the music) and Appendix 6 (the final smartcontract).

Several iterations have been made since the initial version used for the preliminary single release including (listed chronologically):

1. Metamask interface

The biggest limitation of the initial iteration was that it relied on the user manually copying first the contract address into their wallet, then setting the amount they wished to pay and then completing the transaction. Once complete the user needed to copy their wallet address into the paywall interface on the webpage to have it checked against the blockchain record of transactions (the distributed ledger).

The main issue is that if a savvy user copied the contract address into a blockchain explorer, such as https://etherscan.io/, they can view the public record of the transactions to the paywall smartcontract's address; then copy the sender's address of an already completed transaction to their clipboard and paste it into the interface (instead of their own address) and gain access to the download page without having to buy the single. This interface is still present on the *ako – Plaintext* release page for reference here.

To address this Ethereum Web3 API was added to the page to allow the page to interact directly with the MetaMask wallet plug-in or any other Ethereum web3 API compatible wallet, web browser or DAPP browser. As the relative reliability of these web3 wallets varies we will primarily be using MetaMask and for simplicity will generally refer to all such wallets as 'MetaMask' throughout.

Operation

When the user clicks to purchase, the page sets up a transaction in the user's MetaMask wallet and pre-fills the amount and the address details using the web3.eth.sendTransaction() function. Whilst the contract address is still accessible to the user, the checking of the user address is now done by directly checking the MetaMask wallet address of the currently signed in user by calling web3.eth.accounts[0]. This means that the user now can't circumvent the interface by copying and pasting a valid address gathered from the transaction list associated with that smartcontract address as with the preliminary release project. It also makes the interface more straight-forward to operate.

The relevant JavaScript is shown in the screen shot below (figure 30). The first function, metaMask(), is activated when the user clicks 'purchase' and checks MetaMask is installed and the user is logged in. It then sends the transaction amount, and contract address to the user's wallet to complete the transaction. The second function metaMaskAddresCheck() is activated when the user clicks 'check address' in the case of the preliminary release and the two subsequent releases (or in the case of later iterations is triggered every 3s by a setInterval() function which shall be discussed shortly) and it grabs the users wallet address, stores it as a variable then calls a function to check that address has a purchasing transaction associated with it, and if so will then allow access to the music. The address checking function is detailed in iteration 5, and later updated to its final form in iteration 7.

The method employed to gather the transactional data from blockchain will also be covered in iteration 5 and iteration 7.

```
<script>


function metaMask() {
  if (typeof web3 === 'undefined') {
    return alert('You need to install MetaMask to use this feature.')
  }
  var user_address = web3.eth.accounts[0];
  if (typeof user_address === 'undefined') {
    return alert('You need to log in MetaMask to use this feature.')
  }
  web3.eth.sendTransaction({
    to: "0x761527498cA8BC8f91EC6A30d54bEC8836679Ca4",
    from: user_address,
    value: web3.toWei((usd / eth)*2, 'ether'),
  }, function (err, transactionHash) {
    if (err) return alert(':(');
    alert('Thanks');
  })
}

function metaMaskAddressCheck() {

        var account = web3.eth.accounts[0];
        document.getElementById("eth_address").value = account;
        checkAddress();
       };
```

Figure 30: Functions [metaMask()] and [metaMaskAddresCheck()]

2. Embedding in Kaneda website

One of the issues with this project was that it proved more difficult to promote using social media than 'traditional' digital releases due to the ban on Facebook advertising and the apparent low demand for music access with cryptocurrencies. To help increase website traffic and overall visibility it was decided to embed the store directly onto the Kaneda Records website. Wix.com, the host of the Kaneda site, is very restrictive about what scripts and content can run on their sites so the solution was to create versions of the release pages hosted on the Linebreak server, and then load them in iframe widgets on the Wix sitebuilder.

3. Privacy settings (allow wallet to connect)

After the first release MetaMask wallet was updated to include a new security / privacy feature whereby a page wishing to connect to the wallet must first request permission from the user or the page will not be allowed to interact with the wallet to check addresses and set up transactions etc. To address this the 'ethereum.enable()' function of the web3 API must be called to prompt the wallet to ask the user if they wish to connect, this function is now called on page loading prompting the wallet to ask the user to grant permission for the page to connect to it.

'ethereum.enable()' is called on page load (example below), and can be seen in context in Appendix 1:

```
<body onload="usdConvert(), ethereum.enable(), metaMaskAddressCheck();">
```

4. Maths and burnt gas

The original contract used simple multiplication and subtraction of base 10 numbers (standard decimal numbers) is shown in figure 31, the first screenshot below, however due to limitations in the number system this can risk funds being left 'stuck' or 'burned' within the contract. Ludwig (2018) explains in his post to my question on stack overflow regarding improvements to the contract used for the releases:

> *"We're limited to 5 digits with no decimals in the code, but we interpret the number as 3 digits of number and 2 of decimal.* [in the example of the number 125.25] *To divide 125.25 by 10 in Solidity is to shift every digit to the right and add a 0 at the front.*
>
> *This makes 125.25 / 10 = 12.52 and 12.52 * 9 = 112.68' but 12.52 + 112.68 = 125.2 with .05 left in the contract untouched. Over time this may build up, but either way is burnt ether as you didn't include a function that calls theselfdestruct()* [a function that destroys the contract and releases funds to the creator] *function."*

He suggests the correct way to conduct this mathematical operation is to calculate either 90% or 10% then subtract the result from the total to provide an answer with no remainder, or use the SafeMath script in the contract to make sure remainders are not lost.

This is issue is evident when viewing the contract from the first release on a blockchain explorer as it shows the contract containing a small balance (the sum of all the lost remainders from completed testing transactions) of 2 wei that cannot be retrieved therefore is effectively lost.

Contract and balance viewable at this address:
https://etherscan.io/address/0xa383a2E97127254c198F7847445D95AE5cA31297).

The approach taken in the later contracts is that of sequential subtraction and addition of 10% increments of the total value (this is shown in the second screenshot, figure 32, below), which is essentially a version of Ludwig's (2018) first suggested solution. This does work and no remainders have been left in the balance of these contracts however this seemed to be a rather messy solution so it was decided to attempt the implement the other suggestion made above of using SafeMath.

browser/Untitled.sol

ContractDefinition linebreakCONTRACT

```
1  pragma solidity ^0.4.15;
2
3  ////Creates and names contract
4  contract linebreakCONTRACT1{
5
6  ////events to gather address sender and value
7  event senderLogger(address);
8  event valueLogger(uint);
9
10 ////sets up variables (things to store values), one for each collaborator
11 address kanedaAdress;
12 address akoAdress;
13
14 function () payable {
15 senderLogger(msg.sender);
16 //// Records the total value of payment recieved
17 valueLogger(msg.value);
18
19 //// Firstly, this stores each of the collaborators wallet addresses
20 //// Secondly, it divides  the total value recieved to pay the collaborators
21 /// 10% and 90% respectively
22
23 kanedaAdress = 0x8d916EF7aFc56a335607417E55D238c77EDC8d5E;
24 kanedaAdress.transfer(msg.value / 10);
25
26 akoAdress = 0xC0BB3c8362628E152f70b602de4B7CFB41516618;
27 akoAdress.transfer((msg.value / 10) * 9);
28
29 }
30
31 }
```

***Figure 31**:* The original smartcontract for the preliminary blockchain music release project

Home | hbcontract1.sol

```
1  pragma solidity ^0.4.15;
2
3  contract holybrailleCONTRACT1{
4
5
6  event senderLogger(address);
7  event valueLogger(uint);
8
9
10
11 address kanedaAdress = 0x445b5f277D463122a2Aaeac8B77d8f60865156Dc;
12 address artist1Adress = 0xE0Dac2b105E8511159B76d322d52CEef618F9244;
13
14
15 function () public payable {
16 senderLogger(msg.sender);
17
18 valueLogger(msg.value);
19
20
21
22 kanedaAdress.transfer(msg.value - ((msg.value / 10)+(msg.value / 10)+(msg.value / 10)+(msg.value / 10)+
23 (msg.value / 10)+(msg.value / 10)+(msg.value / 10)+(msg.value / 10)));
24
25 artist1Adress.transfer((msg.value / 10)+(msg.value / 10)+(msg.value / 10)+(msg.value / 10)+(msg.value / 10)
26 +(msg.value / 10)+(msg.value / 10)+(msg.value / 10));
27 }
28
29 }
30
```

***Figure 32**:* New contract using incremental addition used for Project 3 (blockchain music releases)

Below, figure 33, illustrates a contract with SafeMath implemented (this code is also available in Appendix 8). Line 2 shows the importing of the script itself, line 6 enables its use and lines 18 and 20 show the SafeMath multiplication mul(), and division div(), being used in place of the * (multiply) and / (divide) previously used. However when published this contract still presented the same issues of burnt gas as the original contract and SafeMath seemingly did not function as intended despite apparently being implemented correctly as the instances of the SafeMath functions (mul() and div()) within the contract do function, although with remainders.

Second to this, to use an imported script in such a way, means that when the contract is published in effect you are publishing two contracts, firstly the main contract and secondly a contract containing the SafeMath script which increases the contract publishing costs (at the time it cost $0.56 to publish, which was double the cost of publishing a contemporaneous contract without SafeMath). It was decided to return to the previous and more successful method of incremental subtraction, albeit updated to function in the newest Solidity update at the time creation (0.5.1 in the example), shown in figure 33 below. The approach shown in figure 34 is also similar in principle to Ludwig's (2018) later suggestion of calculating the percentages first and then deducting from the total to ensure no remainders, although realised with incremental addition. All further release projects used this contract, updated in line with the contemporaneous version of Solidity at the time of each particular release. The final version of the contract is in included in Appendix 6, updated for Solidity version 0.6.1.

Figure 33: *Smartcontract implementing SafeMath, code available in Appendix 8*

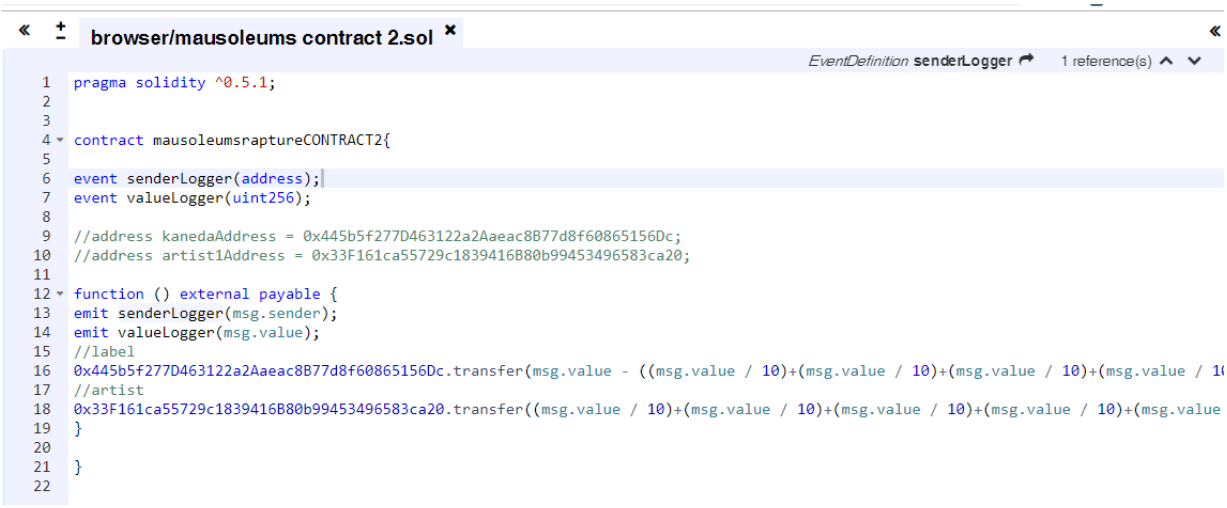

***Figure 34**: Latest smartcontract updated for Solidity v. 0.5.1 (used in Project 3), the final version updated for 0.6.1 is available in Appendix 6*

This issue with the efficacy of SafeMath, the scant reference and help materials, and the unreliability of community discussion also highlights a conclusion of the literature review i.e. the quality of writings and technical materials available is, at times, rather poor, although this is to be expected due to the opensource nature of Ethereum development and its infancy as technology. It was a stumbling block during the early phases of the project and it is a minor aim of this research to try and help address in some way.

One of the other suggestions made by Ludwig (2018) was to include a selfdestruct() function to retrieve burnt gas however this is not particularly suitable in this instance as, whilst calling this function would return burnt gas to the contract creator, it also destroys the contract in the process, and thus does not solve the problem of making a contract that runs in perpetuity without burning gas. A solution that involves publishing the contract with a function included that could be called by the contract creator to retrieve burnt gas can be envisioned and would follow this basic syntax: address.send(this.balance). However this is in opposition to the project's goals in two areas: firstly, of creating a totally autonomous system for apportioning royalties (as future interaction is required to retrieve burnt gas); and secondly as this is no longer a totally fair treatment of royalties (the label/contract creator will be in a position to claim the burnt gas thus increasing their share at the detriment of the artist's share).

5. Rejecting wallets that have not successfully completed the purchase transaction

A further drawback of the preliminary iteration and the first 3 releases of project 3 was that the interface could not distinguish between completed and failed transactions. Failed transaction would also be listed amongst the transactions list, meaning that if someone had tried to send the transaction and it had failed due to the 'gas' being too low they could still access the download page.

As with the initial iterations, the updated interface uses PHP to make an API call to Etherscan to download and store the full transaction list for the smartcontract each time the page is loaded this data is stored in a PHP array called $transactions. This is shown in the PHP section of figure 35 below. In the original iteration of the page the 'from' category of the array, which lists the addresses of all parties sending transactions into the contract were then selected and stored in the $addresses array. This list of addresses sending transactions into the contract was used to compare to the users currently logged in MetaMask address to ascertain if the logged in user has paid to access the

content. However the issue is that this list of 'from' addresses also contains failed transactions too and the page had no way of distinguishing between the completed and failed transactions.

To remedy the issue of not being able to reject wallets whose transactions have failed two arrays are now created $addresses and $iscomplete, the first is populated with the 'from' array of the transaction list array gathered by the API call which is the list of all addresses that sent transactions into the contract (buyers) – in the same process as in the first iteration. The second array, $iscomplete, is populated with the 'isError' array from the API call which indicates whether each transaction was successful or not, both arrays are arranged sequentially from oldest to newest.

These two arrays ($addresses and $iscomplete) are then used to populate equivalent JavaScript arrays. Then by filtering the JavaScript equivalents of $addresses down to only the addresses whose index position correspond sequentially to the index position of completed transactions within the JavaScript equivalent of $iscomplete using a JavaScript function a new array is created called completedpayments. This new array contains only the sender addresses of the successfully completed transactions. This new array of completed transactions is what the user's wallet address is compared to determine if they are granted access to the download page thus meaning that the wallet has to have a successfully completed transaction associated with it. This filtering process is shown in Figure 36. Figure 37 showing the 'source' view of the values of sender address and completion status received and populating the JavaScript arrays discussed above on the 'live' version of the page for reference.

```
<!DOCTYPE html>
<?php
    $apiKey       = 'DMVI9FTTB8MT876P7EJ7YBSF56I487GQN2';
    $url          = "http://api.etherscan.io/api?module=account&action=txl
    $transactions = json_decode(file_get_contents($url), true);
    $addresses    = [];

    $iscomplete = [];

    if (isset($transactions['result'])) {
        foreach ($transactions['result'] as $transaction) {
            $addresses[] = $transaction['from'];
            $iscomplete[] = $transaction['isError'];
        }
        // in php5.5+, this foreach could be replaced with
        // $addresses = array_column($transactions['result'], 'from');
    }


    $url2= "https://api.coinbase.com/v2/prices/ETH-USD/spot";
$fileGet = file_get_contents($url2);
$json = json_decode($fileGet, TRUE);
$jsondata = $json["data"];
?>
```

***Figure 35**:* The API call made to Etherscan to gather the transactional data of the contract stored on the blockchain using PHP and the subsequent creation and population of arrays containing the senders addresses and the transaction failure indicators

```
var addresses = <?php echo json_encode($addresses); ?>;

var completed = <?php echo json_encode($iscomplete); ?>;

function getAllIndexes(arr, val) {
    var indexes = [], i;
    for(i = 0; i < arr.length; i++)
        if (arr[i] === val)
            indexes.push(i);
    return indexes;
}

var indexes = getAllIndexes(completed, "0");


var b = indexes;


var completedpayments = addresses.filter((x,i) => b.includes(i));
```

***Figure 36**: The process of filtering the complete list of sender addresses to only the addresses with successfully completed transactions associated with them*

```
var addresses =
["0x69ef63c7d706e73350d41dbfccd7b3bf03fe59ba","0x445b5f277d463122a2aaeac8b77d8f6086515
156dc","0x445b5f277d463122a2aaeac8b77d8f60865156dc","0x445b5f277d463122a2aaeac8b77d8f6
f60865156dc","0x445b5f277d463122a2aaeac8b77d8f60865156dc","0x445b5f277d463122a2aaeac8b
22d52ceef618f9244","0x9a9713b56816a03948245d5f79673e28e3996975","0x9a9713b56816a039482

var completed = ["0","1","1","1","1","1","1","1","0","1","1","1","1","0"];
```

***Figure 37**: The 'source' view in chrome of the 'live' page with the values of senders' addresses and error indicators populating the relevant arrays. 0 = complete and 1 = failed so the first, ninth and fifteenth transaction are successfully completed transactions and correspond to the first, ninth and fifteenth addresses in the buyer address array.*

6. Estimating the correct gas value

During the course of the testing and development there were often situations where MetaMask, when connecting to the webpage and setting up a transaction, could not automatically calculate the correct transaction fee (gas) required to complete the transaction. In these instances it defaults to a standard value of 23000 gwei, which is enough for a single transaction. However, as the smartcontract has to process two further internal transactions to apportion the royalties this is generally not enough. This means the transaction will generally fail unless the buyer manually adjusts the gas amount to a suitable value. This was evident in the transactions of the purchaser of the Holy Braille single, whose first transaction failed and had to be re-sent.

Gas amount always stays roughly fixed in terms of Gwei unit values, (hence a standard transaction usually defaulting to 2300 in wallets in most instances) however the financial value of the Gwei (and thus actual TX cost) can fluctuate based on market and network conditions. More or less Gwei can be used to speed up or slow down the processing time, but lower amounts of Gwei risk the transaction being ignored by miners (thus failing) or taking a long time to complete.

The simplest approach to solving this issue is to insert a higher than default gas value into the transaction to ensure there will be enough gas to complete the transaction. To do this gas: 46000 has been added to the previously discussed JavaScript / Ethereum web3.js function for setting up the purchase transaction, shown in figure 38 below. 46000 was set, as during testing it was seen that the transactions to the smartcontract would normally complete with around 25000-27000 so it offers plenty of headroom. Also unused gas will be returned to the buyer so there is no concern surrounding over charging for gas.

```
360
361 function metaMask() {
362   if (typeof web3 === 'undefined') {
363     return alert('You need to install MetaMask to use this feature.')
364   }
365   var user_address = web3.eth.accounts[0];
366   if (typeof user_address === 'undefined') {
367     return alert('You need to log in MetaMask to use this feature.')
368   }
369   web3.eth.sendTransaction({
370     to: "0x27e9b9ab1d7995ad0a8fccfc75890ef1d4f26bae",
371     from: user_address,
372     value: web3.toWei((usd / eth), 'ether'),
373     gas: 46000,
374   }, function (err, transactionHash) {
375     if (err) return alert(':(');
376     alert('Thanks');
377   })
378 }
```

***Figure 38**:* Updated purchase transaction function

Another approach to solving this issue, rather than to send funds directly to the contract address, is to call the payable function in the contract itself with the web3.eth.contract object that is present in the web3 API. From experience when testing, when interacting with contracts MetaMask and other wallets can generally reliably calculate the gas required to complete the transaction within the called payable function when using this object. Thus the gas value should be calculated correctly and will track current network conditions.

The limitation here being setting the amount to send (price of the music) in a manner that tracks the current exchange rates. This is because when using this method the value of the transaction would also be set within the contract itself rather than the page code. It is relatively simple to gather the exchange rate and calculate the value of $1 in Ether, for example, on a webpage using JavaScript and/or PHP, however to do so in a smartcontract is much more complicated and at this point it is still not clear from the research whether this is even possible to achieve within the smartcontract itself, it is an issue I have both researched and posted about on social media (Stack Overflow etc.) without receiving any answers. It is also unclear if once the value has been calculated it can be set within the resulting transaction using the web3.eth.contract object, as there does not seem to be a method for this object shown in the help documentation for sending funds. This object seems to be more orientated towards sending and interacting with data, rather than monetary transactions. Changing to this approach would also require a significant redesign of the page so the solution of simply setting a higher gas value in the existing function was preferable, and as excess is returned to the sender in the fix detailed previously, it achieves the same overall result without having to go too far beyond the scope of the project in terms of time spent coding. I also think it is just generally good practice to set a gas amount within the transaction function and the user can always edit it before sending if they would rather try a lower amount.

In practice though this issue of incorrect gas fee does not seem to be too much of an issue as the buyer who bought the Holy Braille single, whose initial transaction failed, re-sent the transaction with

the correct amount of gas and was successful the second time and was obviously aware of the mechanics of gas when sending funds on the blockchain. Users familiar with basic operations on the blockchain will understand the link between fee amount and successful completion and will be able to adjust accordingly. However to streamline the buying process the above discussed fix has been implemented in the latest release and has been added to previous releases.

Also it would appear that the issues relating to correctly calculating gas required when setting up transactions to the contract actually appears to have been a bug in certain versions of MetaMask as this occurred intermittently throughout the series of releases, and would work correctly at times. Also several instances of forum posts concerning reporting this bug were found at various points. As of the last two releases however this seems to have been remedied and now appears to be functioning correctly. To make sure that if the bug reoccurs in the future (or if people interact with older versions of MetaMask) the fix of presetting double the default gas in the transaction has been applied as a redundancy measure.

It is worth pointing out that up until recently the Testnets would complete the transaction and subsequent apportioning transactions for the default amount (23000), but when these contracts were moved to the Mainnet the issue becomes apparent. A lack of a completely realistic test environment is a further hurdle when developing blockchain applications and it is one that was not mentioned in literature consulted regarding working on Testnets. This further highlights points raised about the lack of reliable discourse. This problem is also compounded by the immutable nature of the blockchain, contracts can't be updated after publishing so any changes require republishing each time at a cost and time delay so working directly on the Mainnet when developing is not entirely practical.

7. Using JavaScript instead of PHP to gather the buyer list from the blockchain

As discussed in iteration 5 and depicted in figure 35 (above), previous versions use PHP to retrieve the necessary data from the blockchain and access the relevant arrays within that data and parse it to JSON for use in the 'check address' aspect of the interface. This has one main drawback; it only refreshes the gathered data when the page is loaded / reloaded, as PHP runs on the server side and only runs when the page is initially loaded. This means that once a user has completed a transaction to purchase a release they will need to reload the page to refresh the list of completed transactions for the interface to register that they have actually paid and allow them to access the content.

The solution to this was to move the operations carried out in PHP to JavaScript instead as JavaScript functions can be called at anytime and thus the blockchain data used by the page can be refreshed at any time without needing to reload the entire page. The JavaScript version is depicted below in figure 39 and follows the same logic and principles as the original PHP, with figure 40 depicting the updated address checking function for this new version.

```
<script>
//set up global variables
var data3 = [], i;
var data4 = [], i;
var addresses2 = [], i;
var completed = [], i;
var b = [], i;
var indexes = [], i;
var completedpayments = [], i;
var completedpaymentsSTRING ;
var b = [], i;
var request = new XMLHttpRequest()

// Open a new connection, using the GET request on the URL endpoint
request.open('GET', 'https://api-rinkeby.etherscan.io/api?module=account&action=
request.onload = function getjsonda() {
// Begin accessing JSON data here
var data2 = JSON.parse(this.response);
var result2 = data2.result;
//access isError and senders address arrays from JSON response
 for ( i = 0; i < result2.length; i++) {
  data3[i] = (i, result2[i].isError);
  data4[i] = (i, result2[i].from);
  var addresses2 = data4;
}

}
```

***Figure 39**: JavaScript function to retrieve blockchain data*

```
function getAllIndexes(arr, val) {
    var indexes = [], i;
    for(i = 0; i < arr.length; i++)
        if (arr[i] === val)
            indexes.push(i);
    return indexes;
}
setInterval(function(){checkAddress();}, 3000);
function checkAddress() {
var account = web3.eth.accounts[0];
var indexes = getAllIndexes(data3, "0");
var completedpayments = data4.filter((x,i) => indexes.includes(i));

if  ((completedpayments.indexOf(account)) > -1) {
var postdata = data4;
   $.ajax({
    type: "post",
    url: "fetchtestMAUS-RAPT.php",
        data: postdata,
        success: function(html){
            document.getElementById("status").innerHTML = html;
    }
   });

            }
```

***Figure 40**: Updated address checking function*

Switching to JavaScript also means that process of refreshing the blockchain data and checking the address can be automated using setInterval() (shown in figure 39 above) as the user does not need to refresh the page in between purchase and download. The blockchain data is refreshed and the

address is checked on page load and then every 3 seconds after that, if the user has already purchased the download links will appear automatically on the page. This system is used on the Mausoleums – Rapture of the Beast release here and subsequent releases.

Appendix 10 – Sonification of the blockchain (operation), project 4

This page uses the Infura.io endpoint and API to retrieve live data from the block chain. The data includes: the latest block number, the last transaction hash (number of the last transaction), block difficulty (how hard it was to mine), block size (total amount of data included in that block in bytes) and Gas Used (total gas used by all transaction in that block). When a new block is added to the blockchain the webpage receives updated values for theses parameters. If a change in certain values is detected it triggers a change in both the generated graphics and the music. The code used to retrieve this blockchain data is shown below in figure 41:

```
123
124         function refreshLastBlock(){
125         var provider = 'https://mainnet.infura.io/v3/7bbc43403c60432dbef1a
126         var web3Provider = new Web3.providers.HttpProvider(provider);
127         var web3 = new Web3(web3Provider);
128 var latestBlock = web3.eth.blockNumber;
129
130 var block = web3.eth.getBlock(latestBlock);
131 var gas = block.gasUsed;
132 var gas2 = block.difficulty;
133 var gas3 = block.size;
134 var gas4 = [block.uncles]; //data size of block
135 var gas5 = block.gasLimit;
136
137 var blockhash = block.hash;
138
139 // Last block
140             document.getElementById("showblock").value = latestBlock;
141
142 // difficulty (peerclass)
143             document.getElementById("showpeers").value = gas2;
144 // Last block hash
145             document.getElementById("showlasttx").innerHTML = blockhash;
146 //last block gas
147             document.getElementById("showgas").value = gas;
148 // size (bytes)
149             document.getElementById("showusd").value = gas3;
```

***Figure 41**:* Gathering live blockchain data using Infura Endpoint and storing current block number, gas used, last transaction hash and block size as variables for project 4

The music generation works by selectively moving through tables (or ‘arrays’) of notes, these arrays are shown in Fig. 42.

For block number, it steps through sequentially the notes ['C3', 'D3', 'F3', 'E3'], creating layer 1 of the harmony. Layers 2 and 3 are triggered by changes in Gas Used and Block Difficulty where the code steps through ['F3', 'G3', 'A3'] and ['D2', 'C2', 'F2', 'G3', 'A3', 'D4'] respectively, based on whether the new value is higher or lower than that used previously (remaining unchanged if the value is the same). If the new value of Gas Used is lower than the value obtained from the previous block the note step moves backwards through the array and if the value is higher the note step moves forward through the array. The same approach is applied to block difficulty also. Code for note selection is depicted below in figure 43.

```
242
243  var arr = ['C3', 'D3', 'F3', 'E3'];
244  i = 0;
245  len = arr.length;
246
247  //gas number note array
248  var arrgasnotes = ['F3', 'G3', 'A3'];
249  i2 = 0;
250  lengas = arrgasnotes.length;
251
252  //peer number notes
253  var arrpeernotes = ['D2', 'C2', 'F2', 'G3', 'A3', 'D4'];
254  i3 = 0;
255  lenpeer = arrpeernotes.length;
```

***Figure 42**:* Note arrays for sonification of the blockchain

```
//block difficulty note selection
$('.showpeersclass').each(function() {
  var elem = $(this);
  // Save current value of element
  elem.data('oldVal', elem.val());
  // Look for changes in the value
  elem.bind("propertychange change click keyup input paste", function(event){
     // If value has changed...
   if (elem.data('oldVal') > elem.val()) {
     // Updated stored value
     elem.data('oldVal', elem.val());
      // Do action: step incremetally up because new value is greater
     if (i3 == 0){ i3=lenpeer;}
   pulsesynth2.triggerAttackRelease(arrpeernotes[(i3--) ]);}

   // If value has changed...
   if (elem.data('oldVal') < elem.val()) {
      // Updated stored value
      elem.data('oldVal', elem.val());
      // Do action: step incremetally down because new value is lower
      if (i3 == lenpeer){ i3=0;}
   // send note to synth to play
   pulsesynth2.triggerAttackRelease(arrpeernotes[(i3++) ]);}
  });
});
```

***Figure 43**:* Annotated code for block difficulty note selection. If new block difficulty is lower this will make one step backwards through the array, if higher it will make 1 step forward, if unchanged it will stay at current note.

This creates a situation where each new block mined triggers a sequential movement through layer one, and then depending on the other values included within that block it steps layers 2 and 3 backwards and forwards with a total of 72 different combinations of notes in C Major. The rate of change is directly connected in real time to the activity of people using the blockchain and the type of change linked to their activity, thus creating a sonification (or sonic representation) of the blockchain in the form of aleatoric (chance based) music realised using deterministic methods.

The notes are then played using Tone.js synthesisers, using different waveshapes for each layer (square, sine and triangle) to help further differentiate the layers (shown in figure 44 below), and in certain combinations generate beat frequencies.

```
198
199  gain = new Tone.Gain(0.3).toMaster();
200  gain2 = new Tone.Gain(0.6).toMaster();
201  gain3 = new Tone.Gain(0.3).toMaster();
202
203  const pulsesynth = new Tone.Synth().connect(gain);
204  const pulsesynth2 = new Tone.Synth().connect(gain2);
205  const pulsesynth3 = new Tone.Synth().connect(gain3);
206
207
208  pulsesynth.oscillator.type = 'triangle';
209  pulsesynth2.oscillator.type = 'sine';
210  pulsesynth3.oscillator.type = 'triangle';
211
212
```

***Figure 44**:* Instantiating Tone.js synths, setting volume and waveshape and connecting to the master output (sonifying the blockchain)

The visual aspect is generated using a Processing sketch (shown in figure 45 below) embedded in the webpage using Processing.js (a script that allows for the hosting of Processing code in webpages). It is a version of the 'A Generative System in 24 Lines of Code' by Matt Pearson (Pearson, M. 2011). Modified such that when the values of Gas Used and Block difficulty are passed to it by the webpage (by saving it in a cache text file whose data is loaded via Processing.js) it uses these values to regenerate and seed the noise generator that is used to create the X and Y values used to position the points on the screen and generate the image. Linear interpolation using 'lerp()' is a further modification to the original sketch, and smoothly interpolates between the current and previous seed values, thus transforming smoothly between each generated image. However the effectiveness of this interpolation is compromised by the refresh rate of the page which will be discussed next.

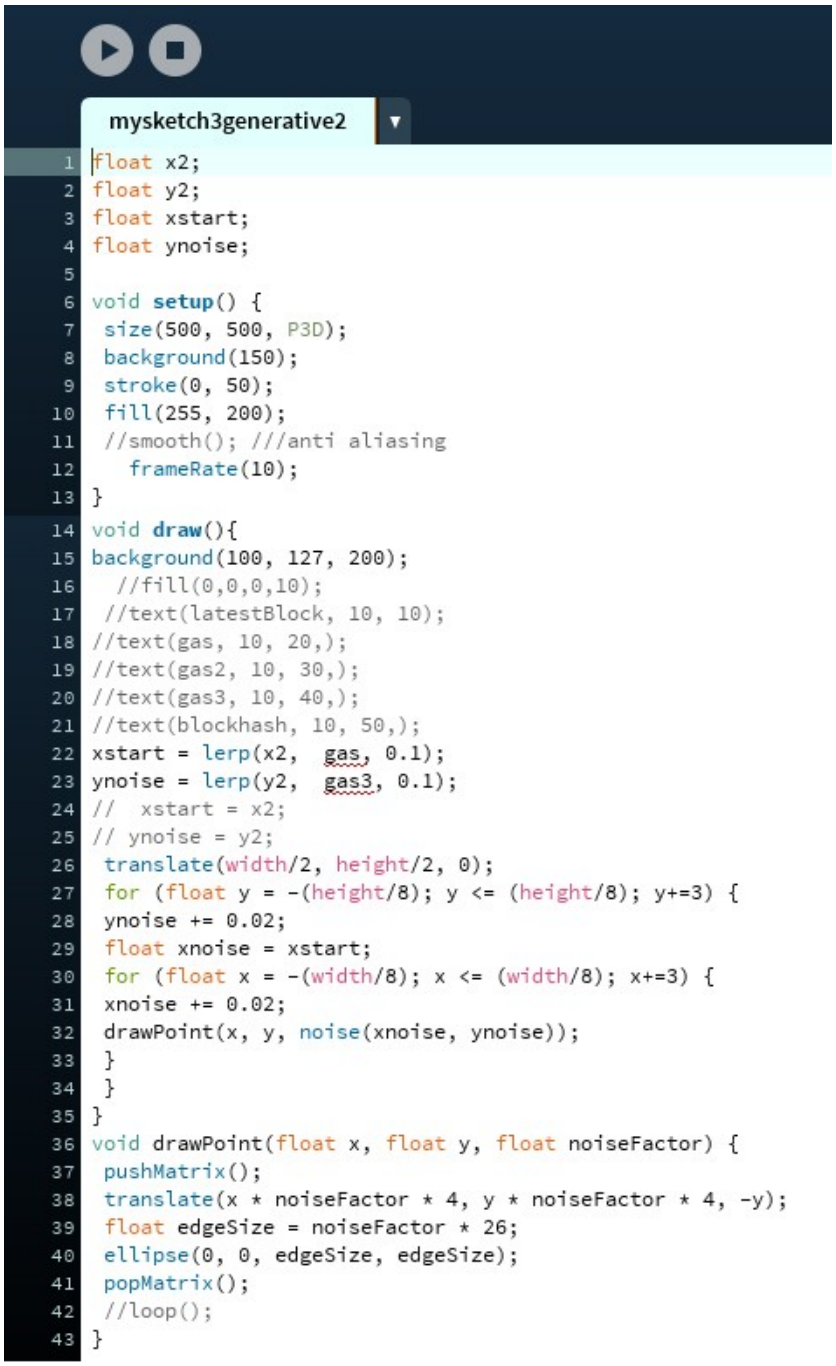

***Figure 45**:* Processing sketch for generative visuals for project 4 (sonifying the blockchain)

To keep the page running in real-time, it has to constantly retrieve data by using the 'setinterval()' function of JavaScript. After a predefined interval of time has been reached this function triggers events or other functions to run, in this case the gathering of data from the blockchain. However, the shorter the interval the more intensive the webpage is to run, and the more data is being downloaded (which can be an issue on slower or metered connections). Second to this and more of an issue for this page, is that every time setinterval() triggers the refreshing of the blockchain data it interrupts the rendering of the processing sketch, thus greatly reducing the frame rate. The sketch used, when run in the context of processing (offline), exhibits markedly different behaviour, there is a continuous frame rate and generated patterns/images move (or 'interpolate') smoothly from one to next as would normally be expected when linear interpolation is employed. As it is, a compromise has to be struck between performance of the webpage and network speed; refreshing values fast enough to create a

more or less real time representation of changes to the blockchain; and lastly the smoothness of the visual rendering. 100ms interval was eventually settled upon, as despite being less than ideal for the visual aspect, it allows a responsive enough representation of changes to the blockchain to approximate real-time without being a restrictively heavy load on computer and network resources.

Appendix 11 — ako – West Babylon store page (project 5)

```
<!DOCTYPE html>
<?php
//gets exchange rate of ETH to USD
$url2= "https://api.coinbase.com/v2/prices/ETH-USD/spot";
$fileGet = file_get_contents($url2);
$json = json_decode($fileGet, TRUE);
$jsondata = $json["data"];
?>

<?php
// define variables and set to empty values for donation amount to be
posted to form handler
$donations = "";

if ($_SERVER["REQUEST_METHOD"] == "POST") {
  $donations = test_input($_POST["donations"]);
  $ethamount = test_input($_POST["ethamount"]);

}

function test_input($data) {
  $data = trim($data);
  $data = stripslashes($data);
  $data = htmlspecialchars($data);
  return $data;
}
?>

<html>

<style>


    </style>

<head>

<title>ako - West Babylon - Linebreak Records - Crytocurreny Record Label
</title>

</head>
<!--enable/connect to wallet-->
<body onload="ethereum.enable()">


<div>

<div>ako_westbabylon.exe</div>
<br><br>
Name your price (no minimum)
<br><br>
<form name="donationform" method="post" action="donation_get_css.php"
target="_blank">
```

```
Enter $0.00 or more to download: <br>$<input type="number" name="donations"
id="donation"  onchange="usdConvert()" onkeyup="usdConvert()" min="0"
step="any" required>
(ETH:<input type="text" id="eth" name="ethamount" readonly>)
<br><br>
<input type="submit" value="Donate">
</form>

<br><br>

other formats:
<br><br>

<table style="width:100%">

  <tr>
    <th></th>
    <th></th>
    <th></th>
     <th></th>
  </tr>

  <tr style="text-align:center; width:100%">
    <td><a href="https://ako0.bandcamp.com/merch/west-babylon-vhs-cassette"
target="blank"><img src="vhs.jpg" width="100%"></a></td>
    <td><a href="https://ako0.bandcamp.com/album/west-babylon"
target="blank"><img src="bandcamp.jpg" width="100%"></a></td>
    <td><a href="https://open.spotify.com/artist/7cKvThgUVJGxl6oCTnugXQ"
target="blank"><img src="spotify.jpg" width="100%"></a></td>
    <td><a href="https://music.apple.com/us/album/west-babylon/1527098479"
target="blank"><img src="apple.jpg" width="100%"></a></td>
  </tr>
  <tr style="text-align:center">
    <td><a href="https://ako0.bandcamp.com/merch/west-babylon-vhs-cassette"
target="blank"><input type="button" value="VHS"></a></td>
    <td><a href="https://ako0.bandcamp.com/album/west-babylon"
target="blank"><input type="button" value="BandCamp"></a></td>
    <td><a href="https://open.spotify.com/artist/7cKvThgUVJGxl6oCTnugXQ"
target="blank"><input type="button" value="Spotify"></a></td>
    <td><a href="https://music.apple.com/us/album/west-babylon/1527098479"
target="blank"><input type="button" value="Apple"></a></td>
  </tr>



</table>

<br><br>

<div><em><a href="https://www.linebreakrecords.com" target="_blank">powered
by:<a>
<a href="http://linebreakrecords.com" target="blank"><input type="button"
value="Linebreak" ></a>
</div>
    </div>
</div>


<script>
```

```
//grabs exhange rate from PHP
var eth = <?php echo json_encode($jsondata["amount"]);?>
var usd = 1;
var usdCalc = 0;


//calculates ethereum value, roughly, based on dollar amount entered by the
user
function usdConvert() {
    var mult = document.getElementById("donation").value;
    var usdCalc = (usd / eth)*mult;
    var usdCalc = usdCalc.toFixed(8);
document.getElementById("eth").value = usdCalc;
}


</script>

</body>
```

Appendix 12 — ako – West Babylon donation handling PHP file (project 5)

```
<html>
<body onload="ethereum.enable()">

<?php
// define variables for donation amount and set to the values 'posted' by
main/index page
$donations = "";

if ($_SERVER["REQUEST_METHOD"] == "POST") {
  $donations = test_input($_POST["donations"]);
  $ethamount = test_input($_POST["ethamount"]);

}

function test_input($data) {
  $data = trim($data);
  $data = stripslashes($data);
  $data = htmlspecialchars($data);
  return $data;
}
?>


<?php
//test to see if donation equal $0 (an if so load download links) or if >$0
generate prompt to confirm donation
if($donations == 0){
//$0: Load the dowload links
$free = <<<EOT
<div id="status" width="800">

<div>ako_westbabylon.exe</div>

<br>
<a
href="https://linebreakrecords.com/assets/ako_westbabylon_download/dl/rterd
tc876787399kjbadjbhkbkj345/ako%20-%20West%20Babylon%20(MP3).zip"
target="blank"><input type="button" value="• Download mp3 (320Kbps)"></a>
<br>
<br>
<a
href="https://linebreakrecords.com/assets/ako_westbabylon_download/dl/rterd
tc876787399kjbadjbhkbkj345/ako%20-%20West%20Babylon%20(wav).zip"
target="blank"><input type="button" value="• Download wav"></a>
<br>
<br>
<a href="https://linebreakrecords.com/" target="blank"><input type="button"
value="powered by Linebreak"></a>
<br>
<br>
```

```
    </ul>
</div>
EOT;
echo $free;
}else {
//this is loaded if donation is >$0, first it gathers logged in wallet
address then sets up transaction when use confirms donation. Once the user
has confirmed the transaction in their wallet the download links are loaded
$paid = <<<EOT
<div id="status" width="800" >
<script>
function dlclick() {
document.getElementById("status3").innerHTML = '<br><a
href="https://linebreakrecords.com/assets/ako_westbabylon_download/dl/rterd
tc876787399kjbadjbhkbkj345/ako%20-%20West%20Babylon%20(MP3).zip"
target="blank"><input type="button" value="• Download mp3
(320Kbps)"></a><br><br><a
href="https://linebreakrecords.com/assets/ako_westbabylon_download/dl/rterd
tc876787399kjbadjbhkbkj345/ako%20-%20West%20Babylon%20(wav).zip"
target="blank"><input type="button" value="• Download wav"></a><br><br><a
href="https://linebreakrecords.com/" target="blank"><input type="button"
value="powered by Linebreak" ></a><br><br>';}
</script>
<script>
//Checks user is logged in and gathers address
function metaMask() {
  if (typeof web3 === 'undefined') {
    return alert('You need to install web3 wallet to use this feature.')
  }
  var user_address = web3.eth.accounts[0];
  if (typeof user_address === 'undefined') {
    return alert('You need to log in wallet to use this feature.')
  }

 //sets up transaction in users wallet when the user clicks 'buy', value is
set against exchange rate, in the same fashion as the usdConvert() function
(below), gass value is also set as twice default to make sure enough gas is
included to complete the transaction successfully
 var donationamount = $ethamount;
  web3.eth.sendTransaction({
    to: "0x445b5f277D463122a2Aaeac8B77d8f60865156Dc",
    from: user_address,
    value: web3.toWei(donationamount, 'ether'),
    //gas: 46000,
  }, function (err, transactionHash) {
    if (err) return alert(':(');
    alert('Thanks');
    dlclick();
  })
}

</script>

<div>ako_westbabylon.exe</div>

<br>
<button onclick="metaMask()">confirm donation</button>

<div><i>(confirm donation and download links will appear below)</i><br>

<br>
```

```
download links:<div id="status3"><br><br><br><br><br><br><br></div>

</div>
<br>
<br>
EOT;
echo $paid;

}

?>

</body>
</html>
```

Appendix 13 – Full list of Reddit posting relating to project 5

https://www.reddit.com/r/CryptoTechnology/comments/izjvfw/cryptocurrency_paywhatyoufeel_music_download/

https://www.reddit.com/r/Vaporwave/comments/izjwzq/i_built_a_paywhatyoufeel_crytpocurrency_ether/

https://www.reddit.com/r/ethdev/comments/izk9i5/i_built_a_paywhatyoufeel_crytpocurrency_ether/

https://www.reddit.com/r/CryptoCurrency/comments/izjpuq/i_built_a_paywhatyoufeel_crytpocurrency_ether/

https://www.reddit.com/r/Metamask/comments/izjr4x/i_built_a_paywhatyoufeel_crytpocurrency_ether/

https://www.reddit.com/r/blockchainmusic/comments/izkb45/i_built_a_paywhatyoufeel_crytpocurrency_ether/

https://www.reddit.com/r/Crypto_General/comments/izk8vw/i_built_a_paywhatyoufeel_crytpocurrency_ether/

https://www.reddit.com/r/BlockchainStartups/comments/izk7t6/i_built_a_paywhatyoufeel_crytpocurrency_ether/

https://www.reddit.com/r/Crypto_Currency_News/comments/izjvtg/i_built_a_paywhatyoufeel_crytpocurrency_ether/

https://www.reddit.com/r/Ether/comments/izjnyt/i_built_a_paywhatyoufeel_ether_donation_store_for/

https://www.reddit.com/r/ethereum/comments/izjn3i/i_built_a_paywhatyoufeel_crytpocurrency_ether/

https://www.reddit.com/r/BlockchainStartups/comments/jkwttm/i_built_a_paywhatyoufeel_crytpocurrency_ether/

https://www.reddit.com/r/Ether/comments/jkwt05/i_built_a_paywhatyoufeel_crytpocurrency_ether/

https://www.reddit.com/r/CryptoCurrency/comments/jkwo61/i_built_a_paywhatyoufeel_crytpocurrency_ether/

https://www.reddit.com/r/Crypto_General/comments/jkwprx/i_built_a_paywhatyoufeel_crytpocurrency_ether/

https://www.reddit.com/r/Metamask/comments/jkwowq/i_built_a_paywhatyoufeel_crytpocurrency_ether/

https://www.reddit.com/r/ethdev/comments/jkwnqy/i_built_a_paywhatyoufeel_crytpocurrency_ether/

https://www.reddit.com/r/Metamask/comments/j7yg5q/i_built_a_paywhatyoufeel_metamask_compatible/

https://www.reddit.com/r/CryptoCurrency/comments/j7yfd1/i_built_a_paywhatyoufeel_crytpocurrency_ether/

https://www.reddit.com/r/ethdev/comments/j7ybhp/i_built_a_paywhatyoufeel_crytpocurrency_ether/

https://www.reddit.com/r/ethereum/comments/j7yaca/donate_with_ether_to_download_my_new_album_or/

Appendix 14 – Impact of the research (organisations and artists with whom findings of the research has been shared)

During the course of the research the findings were shared at various points with various organisations (both large and small) and with DIY music practitioners.

Organisations:

Sage Gateshead

Findings of the contextual review were discussed with them on several occasions, and the results of project 2 were shared with them.

The Grammies (the Recording Academy, USA)

I was consulted by a researcher from the Grammies for an internal document about the possibilities of the blockchain within the music industry in early 2020. We discussed the main findings of the contextual review and projects 2 and 3 i.e. the benefits of the blockchain relating to payment processing, smart contracts and greater decentralisation. We also discussed the current state of adoption of the technology at the time (2019).

Wavemint (Canada)

As a result of project 5 I consulted with Wavemint (September – December 2020), a blockchain start-up based around the notion of artist specific coins. The results of my research where shared with them including the results of projects 2, 3 and 5 as well as research from the contextual review and my own practice about the current industry landscape for independent and DIY musicians. I am also scheduled to take part as an artist in an Alpha trial of their platform which involves distributing my own artists coin, 'AKO', to fans who follow my social media accounts. The recipients of these coins will then be able to swap them from a download of the B-side of a single to be released alongside the coin.

r0g_: Agency for Open Culture and Critical Transformation / Openculture.agency **(Berlin, Germany)**

> "*As a collaborative and internationally networked organisation, r0g_ supports sustainable and hybrid forms of cultural innovation and social enterprise in regions undergoing rapid and fundamental transformation. Following a philosophy of 'open knowledge for open societies' r0g_ acts to put into practice the mechanisms of sustainable open source methodologies using appropriate and community based technologies (i.e. FOSS, OER, Open Data and related Open ICT4D). It sees these as tools for empowering citizens, where exchange, collaborative production and access to open knowledge are of fundamental importance in creating free and open societies. Our particular focus is on how these mechanisms can help enable peace and foster innovation in crisis and post-conflict regions..*" r0g_ mission statement

I provided the code for project 5 (appendix 11 and 12) to an individual working on an Ethereum donation interface for their website (which currently hosts a fiat based donation option).

Music practitioners:

Bert Verso, Om10, Holy Braille, Rohli, SQUARMS, Mausoleums, Badger and **the Potted Wolf** were directly involved in either project 2 or 3 or both (totalling 11 individual practitioners). Results and findings were shared with all involved. **Kaneda Records** has also two other founders, in addition to me, with whom findings were also shared.

In addition to these artists I also provided several others advice in terms of utilising the blockchain in their practice during conversations on social media resulting from the posting surrounding project 5.

While attending **Horst Art and Music Festival Music Lab, Belgium** in 2019 (a week long lab consisting of workshops and seminars with music industry professionals focussing on DIY music and nightlife), I discussed my research and shared findings with other various other DIY music practitioners and industry professionals.

I authored the following music zine articles for **NARC. Magazine,** further disseminating the research to DIY music practitioners and audiences:

FEATURE: KANEDA CRYPTO STREAM #1- MY INSPIRATION
http://narcmagazine.com/feature-kaneda-crypto-stream-1-my-inspiration/

FEATURE: LINEBREAK RECORDS - MY INSPIRATION
https://narcmagazine.com/feature-linebreak-records-my-inspiration/

I also wrote this blog article that was republished by online cryptocurrency magazine 'Data Driven Investor' (https://www.datadriveninvestor.com/), helping to disseminate the research to blockchain specific audiences:

https://medium.com/datadriveninvestor/paypal-for-punks-opensource-money-for-diy-music-d9021ffe9ec

Web presence

Due to the participatory nature of the projects, they were publicised on social media as a well as on the Linebreak Records website. The impact of the social media posting has been discussed at various points throughout this thesis, but the web traffic data for the Linbreak website has been discussed less. Since its inception (early 2018) till the completion of this thesis the (December 2020) it has received **13024 visits.**