Forging Blockchains

Spatial Production and Political Economy of Decentralized Cryptocurrency Code/Spaces

by

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ABSTRACT

Cryptocurrencies and blockchains are increasingly used, implemented and adapted for numerous purposes; people and businesses are integrating these technologies into their practices and strategies, creating new political economies and spaces in and of everyday life. This thesis seeks to develop a foundation of geographic theory for the study of spatial production within and surrounding blockchain technologies focusing on acute studies of Bitcoin as cryptocurrency, Ethereum as digital marketplace, and their conditions of possibility as decentralized autonomous organizations. Utilizing concepts from Henri Lefebvre's *Production of Space*, this thesis situates blockchain technologies within the wider discussion about the political economy of modes of spatial production, dialectical material methods, code/space, and network society through an examination of human and machine relations within their unique and emergent spaces. Combining phenomenological and dialectical material methods with the methodological practice of discourse analysis and systems theory, this thesis explores an understanding of how systemic mechanisms and actant actions driving blockchain technologies are indications of new evolutions in our conceptions of space and place in everyday life of later informational capitalism.

CHAPTER ONE:

INTRODUCTION AND METHODOLOGY

This study seeks to contribute to the new discipline of cyber geography (Curry, 1996; Dodge, 1998; Dodge & Shinode, 1998; Donert, 2000) through an analysis of: (i) systemic mechanisms and the actants driving blockchain technologies, and (ii) how this is changing conceptions of space and place in everyday life. More specifically, it seeks to make at least three main contributions to cyber geography. First, it seeks to understand modes of spatial production from the perspectives of human agents and systemic actants associated with DAOs/DACs. This dynamic is crucial for understanding how the processes of cryptocurrencies and other blockchain technologies are displacing established financial regimes in numerous human geographies. Second, it situates DAOs/DACs within traditional paradigms of capitalist crisis and current systems of neoliberal globalization. These contributions will be addressed from the perspective of Bitcoin as a cryptocurrency[1] system and Ethereum as a decentralized, blockchain-driven market place. Third, this study frames DAOs/DACs in terms of code/space (Kitchin & Dodge, 2014) and network society (Castells, 2004).

In pursuit of the research statement which frames this study, I will start by elaborating on the means by which I arrived at my current course of study. In looking at DAOs, I believe we must first understand the conceptual construct as the sum of its parts while observing the theoretical foundations of knowledge that have affected and could affect their evolutions. As expressions of unique, new geographies, we then see how the foundational work of Bitcoin and the current work of companies (like Ethereum) build an understanding of the actual and potential transformational roles DAOs and DACs play in establishing geographies which are relatively autonomous from humans within cyberspace. This

1 Cryptocurrencies are a form of digital currency using cryptography to secure the exchange. It is not considered to be a ‘virtual’ currency within cryptocurrency social spaces, though it has characteristics of virtual currency and it largely considered as such outside of that social context.

problematic will be explored and explained primarily through an examination of the concept of “spatial production” as defined by Henri Lefebvre (1991).

Research Questions

The broad research question for this thesis is as follows:

How do the systemic mechanisms and actant actions driving blockchain technologies indicate a new evolution in the conceptions of space and place in everyday life?

This larger question was addressed through the following sub-questions:

(1) How does spatial production occur by and with DAOs/DACs from the perspective of human agents and systemic actants? How do these modes of spatial production distinguish these spaces from one another in the scope of currently studied human geographies?

(2) How do DAOs/DACs situate themselves within traditional paradigms of capitalist crisis and current systems of neoliberal globalization? How do processes of Bitcoin as a cryptocurrency system and Ethereum as a decentralized, blockchain-driven marketplace displace established spatial fixes in human geographies?

(3) How do DAOs/DACs fit the models found in Rob Kitchin & Martin Dodge's (2014) code/space and Manuel Castells (2004) network society? How do the similarities and differences between the two frameworks distinguish or inhibit current exposition of the resulting spaces as produced by blockchain-driven technologies?

Study Design

This study used an adaptive socio-technical design method to understand the nexus between processes of spatial production, capital, and its unique expressions in code/spaces and cyber geographies. This design was grounded in qualitative research which is critical in the study of human/machine spaces, their dialectical relations, and their manifestations of code and code/space via those relations. Qualitative

methodologies allowed the researcher to implement data collection approaches that are sensitive to the dynamic and complex natures of the study's subject matters. These methodologies allowed for a robust understanding of human relations, the cultures they produce, and their unique spatial, political, and economic processes in the everyday lives of the people who interact with and depend upon evolving technological systems.

The goal of this thesis was to expose the modes of spatial production within and between the blockchain spaces of Bitcoin and Ethereum through their political economies. Understanding how these systems form, perpetuate, and evolve will help in determining how such spaces, utilizing a mix of human and machine governance, create new spaces for alternate economies, but also harbor potential to replicate existing systems of capital and its resultant contradictions. Qualitative research helps to identify how these tendencies manifest inside the code/spaces and networks of blockchain-based technologies in a manner that is not possible through quantitative means.

Due to the conditions of these systems as new, both in terms of their existence and their study in geography, qualitative research allows for an inductive approach to the studies' data collection, accounting for the broad spectrum of uncertainties that must be considered (Gomez and Jones, 2010). The data gathered from interviews and informal conversations were extremely diverse, but also guided by popular literature, news sources, and figureheads in the Bitcoin, Ethereum, and other blockchain communities. This research also incorporated notions of capital influence and autonomous functionality via narrow artificial intelligence as key elements in their unique modes of spatial production. The social spaces and dialectical relations were examined through a deconstruction of the collective discourses as well as through an examination of the systems themselves: their coded architectures; their functionality; and their respective conditions in relation to their varying forms of governance. Therefore, the assessments and conclusions reached in this thesis focused on the systems, depending on the researcher’s depth of knowledge and the novelty of his framework and approach. The design of these studies captured peoples' varying aspects of, position to, utilization of, and situation within these systems. This allowed the

researcher to assess how the systems of cryptocurrencies and decentralized applications function as well as how the systems act in relation to their utilization.

As this research progressed, the qualitative methods were sensitive to the emergent state of these systems, forming deep and rigorous knowledge around the questions at the core of this thesis. The following research methodology was chosen focusing on the unique aspects of the study that needed to be captured in order to address the requirements of collection and analysis for the study's key components.

These research questions were framed on the basis of the conceptual and methodological tools provided by phenomenology, dialectical materialism, and systems theory. As a phenomenological study, this research focused on the personal experiences and knowledge of the Bitcoin and Ethereum systems from a number of different perspectives ranging from developers to investors and daily users. From the position of dialectical materialism, this study examined the status of Bitcoin as a cryptocurrency and Ethereum as a digital marketplace. This approach situated these new systems in the context of neoliberal globalization as these blockchain-driven technologies potentially bolster capitalist systems while simultaneously exposing their utility as the newest means of production. From a systems theory perspective, this study focused on how the frameworks of code/space (Kitchin & Dodge, 2014) and network society (Castells, 2004) as applied to the relational conditions, architectures, and systems of DAOs/DACs as situated within the context of Bitcoin and Ethereum. The combined approaches of phenomenology and dialectical materialism allowed the study to describe how the underlying architectures were conceived, formulated, and expanded over varying temporal and spatial scales. Understanding the positions and perspectives of key individuals involved with these systems were critical to making sense of the direction of development and in turn, the modes of spatial production for and of these systems as both organic and inorganic parts of their natures. Additionally, systems theory allowed the study to integrate aspects of actor-network theory and software analysis patterns in examining the relationships between non-human actants, human agents, and the systems they depend upon.

Open Conversations

Given the ease of access to user groups within the Bitcoin and Ethereum communities, informal conversations with developers, users, and investors was a key data collection method. This helped to expose the underlying sentiment of mainstream discussions surrounding these blockchain technologies. These conversations were similar to semi-structured interviews, but allowed for a free flow of ideas and opinions based on key questions regarding daily usage of these systems, how long they have been using these technologies, why they are involved with the technologies, how they use these systems today and plan to use them into the future, challenges to usage of and access to these systems, and where they see the technologies headed in terms of the technologies and their applications. Participants' conversations were anonymized to protect their identities and to keep these proceedings confidential. The primary goal was to understand the relations between humans and these systems, relations between humans and other humans in these communities, and how these sentiments vary based on the position of the participant. Due to the relative open nature of these social groups, access and dialogue proved relatively easy. The interviewer met with the participant as outline in the IRB methodology to talk on the main topic areas as outline in the semi-structured interview questionnaire (e.g., history with blockchain technologies, present involvement, perceptions of where these technologies will be in the future, ethics related to these technologies, and accessibility issues). The interviewer would listen intently during the open conversation and following its conclusion, details of the conversation were written down immediately. Analysis of the conversations was performed using formative content analysis in which the conversations were examined for patterns of themes and words within the collective body of data as expressed internal to a group and between different groups in these larger blockchain communities.

Semi-structured Interviews

I also conducted semi-structured interviews with developers, users, and investors in the Bitcoin and Ethereum communities, attempting to acquire insights from key personalities. I led with open-ended

questions in order to observe the participants and listen to what they felt and thought about these technologies. Perceptions, concerns, and motivations were explored through these questions. Variance in experience and intent yielded insights into patterns of thought and ideas that both guide usage and development of these systems as well as how participants let the systems guide their considerations of its applications and embeddedness in their everyday lives.

Due to the distributed nature of the technologies and those who interact with them on a global scale, these semi-structured interviews were conducted via video teleconference (e.g., Skype, Google Hangouts) that allowed for ease of access for both the researcher and participant, reducing the logistical stresses of meeting in person for many key personalities. Online interviews have been shown to be comparable to on-site interviews and tantamount in terms of ethical considerations and non-verbal considerations (Janghorban, Roudsari, Taghipour, 2014). There were also additional considerations in terms of how people would respond due to this medium (Enochsson, 2011), but the rapport building and overall process of online interviews was more than adequate and proved an effective method of communication and data collection (Rayner & Allen, 2013; Shapka, Domene, Khan, Yang, 2016). In-person interviews were also conducted at conferences and in offices based on availability and opportunity.

Documents, Grey Literature, and Other Sources

The use of community blogs, community forums, media in varying forms, white papers, grey literature, the open-source software of Bitcoin and Ethereum itself, and any text providing information or insight into how these spaces function, their conditions and contexts within capital relations, and their manifestations within and due to these blockchain systems, were also used. Aggregation and collection of the data was automated via customized web scraping and text analysis software tools. Web scraping was performed using a modified Pythonic web crawler/scraper framework called Scrapy. The text analysis was performed with custom Python scripts implemented in Jupyter Notebooks where tables, graphs, and other figures were produced for analysis of the text data sets. Any acquisition and use of data from an

online source was verified by the individual publisher or within the guidelines of the End User License Agreement (EULA) for the website or service. For the purpose of this thesis and initial, spatial examination of Bitcoin and Ethereum, software for these systems were viewed as a text at the level of its documentation and pseudo-code functionality.

CHAPTER TWO:

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

Technology is used to accomplish any number of tasks. From the advent of the telegraph to the modern smartphone, we are constantly producing solutions to old and new problematics alike through reproduction of those initial inventive processes. These reproductions are driven by many factors, one of which is the desire of the capitalist to eliminate work. This has pushed technological developments to grand heights while creating a plethora of challenges for globalized societies in which these technologies are utilized. As technologies can affect labor and in turn the employment of people within different scales and strata of societies, this of course raises great concern.

However, lost in the propaganda and rhetoric surrounding incredible technological leaps are the effects of technology on space and time (Harvey, 1990). Technologies, especially within capitalism, are produced with increased efficiency and compression of space/time at the core of their conceptions. While this is done to great success, the results are reduction of human labor requirements and greatly reduced frictions of distance, but with marginal benefit to the human laborers themselves (if not their overt exploitation in order to foster the initial innovation). In turn, certain major technological advances have forced generations of laborers to completely shift their places within societies and in turn societies' expectations for the laborer within their dominant economic system. The resultant spaces, socially conceived through these dialectics and technologically governed through those processes, are fraught with persistent conflict, contradictions, and struggle.

While these processes have been occurring for years, there has been limited examination of their latest incarnations within the realm of cyberspace. From the initial conception of ARPANET to our modern global information and communications technology (ICT) infrastructures, we have quickly expanded our ability to facilitate the above processes at accelerated rates far beyond any other time in

human history. With the spreading webs of fiber, copper, radio waves, and specialized machines, we have created new geographies through our conceptions and evolutions of new spaces. For those who master the dynamics of knowledge/power within these systems, a control over them manifests itself as it has throughout our history in terms of abstracted spaces, territoriality, and class conflict. However, the dangers resulting from a lack of knowledge combined with our growing integration of and dependency on these technologies could have catastrophic effects on global systems at multiple scales. Despite these underlying instabilities, humanity continues to embed itself within these architectures and in turn, these technologies deepen their dominance on everyday lives affecting larger social spaces.

Most recently, the rapid development of the technologies supporting cryptocurrencies has allowed for not only the development of Bitcoin and the like, but has opened the flood gates to numerous applications of these underlying technologies for everything from smart contracts to decentralized autonomous organizations (DAO) and corporations (DAC). The DAO and DAC are of particular importance as they reveal the power of how blockchain technologies and decentralized architectures reinvent the current means and concepts of contracts, currencies, property, and markets. In doing so, they expose new emergent dialectics between technology and capital, capital and everyday life, and everyday life in the context of spatial production. As DAOs and DACs are conceived, developed, and used to augment or substitute operations within existing capitalist entities, they will also change the paradigm by which labor is used and valued within our current capitalist system. Neoliberal actors have been and will continue to be swift in adopting these technologies so long as the profits and efficiencies are produced at the diminished cost of labor. In that instance, the DAO/DAC is conceived in order to further the ultimately false perceptions created by capitalist abstract spaces, homogenizing actions within while concealing their contradictions and destroying (when at all possible) their differences. Capitalism in turn, through redefining current forms, functions, and structures of existing systems, displaces crises to a digital realm where current issues are disguised and new issues erupt (even violently at times). Therefore, the study of these technologies within these frameworks is a critical task. Moreover, these innovations and

their potential have altered not only the ways in which we think about geo-economics, but have demonstrated the potential to challenge multiple constitutive paradigms of 20th century capitalism at all scales. It is with these premises in mind that I will critically explore the nature of decentralized autonomous organizations for we are dealing with the questions of not just current modes of production, but of the numerous modes of spatial production of cyberspace and everyday life for the foreseeable future.

Initial Considerations

I will be presenting the more technical aspects of this discourse pertaining to DAOs and DACs later in this review as it will be difficult to understand their respective conditions without understanding their utility and natures within the following theories' exegeses. However, they are also the most important objects and processes to understand as we explore why they fit into the larger context of ‘cyber geographies’ as analytically and methodologically distinct from 'human' and 'physical' geographies. In this section, I will discuss Henri Lefebvre's theorizations of spaces as well as the time-space compression of David Harvey (1990) and the simultaneities and multiplicities of space as explored by Doreen Massey (2005). I will then apply these theories of space to Martin Dodge, Rob Kitchin (2014), and Manuel Castells' (2004) understandings of 'cyber geography'. Lefebvre's claims, in addition to my review of Harvey's *Condition of Postmodernity* (1990) and Massey's *For space* (2005), are important as I believe they constitute foundational theoretical points for DAOs (in regards to epistemological transition and capitalization within the realm of cyberspace and its associated geographies) as a part of an abstracted continuum of modes of production. Moreover, I will also challenge Manuel Castells' (2004) propositions underpinning his “network society” as a counter-factual argument to test the idea that all geographies require “borders” as a necessary condition of existence and as a basis for their control. As Lefebvre (1991, p. 35) stated: “... in absolute space the absolute has no place.”

Before getting started, we must first address a few key assumptions. Early in his propositions of 'social space', Lefebvre (1991, p. 40) notes that in order to develop an internal understanding of space within, one must do so from his/her body (Harvey, 1990[2]). This is not just the organic process of sensing the world around as a means by which to initiate the evolution of social space, but as a means by which to orient knowledge around ones' physical body, as well as a means by which to understand and identify contradictions and differential spaces (Lefebvre, 1991, p. 62-63). This is a continual process between the body and the perceived/conceived/lived spatial dimensions within social space which I further elaborate through the theories of George Lakoff and Mark Johnson (1999). Their ideas on the embodied cognitive condition round out Lefebvre's (1991) theories of social space. In order to focus on the modes of spatial production as proposed by Lefebvre, I will assume that the epicenter for spatial production is an embodied process as proposed by Lakoff and Johnson (1999), as well as the work of Kellerman (2007) on cognitive cyberspace. However, the addition of Lakoff, Johnson, and Kellerman is in keeping with Lefebvre's (1991) modes of spatial production framework which stems from the Marxist school of thought (1998) dealing with the relation between modes of production and urban and rural landscapes.

Cyberspace

Cyberspace, as both concept and reality, has evolved significantly since its initial conceptions in *Neuromancer* (Gibson, 1984). Even before then, it has been perceived, conceived, and re-imagined in countless ways. Early attempts to understand cyberspace were done so from numerous positions and perspectives. It was seen as a collective, social-cognitive space, a legacy of technological means, a unique architecture unto itself, and a mathematical form of nature (Benedikt, 1994). However, underlying all of this are the human minds and ideas that gave birth to both cyberspace and its predecessors. Social organization on the Internet would not be comprehensible without the deep literature of social spaces nor would the hardware or software frameworks be understandable were it not for the profound work on

2 Michel Foucault also examines this concept

spatial architectonics (Lefebvre, 1991) and the like. Even today, technology is rife with spatial terminology, metaphor, and context.

Presently, cyberspace extends far beyond the Internet, the World Wide Web, and the emerging Internet of things. The world today, especially in urban environments, is layered with copper wires and fiber optic cables. Even the air that surrounds us is saturated with electromagnetic radiation carrying any number of signals that connects people to one another. Smartphones consume our time and attention and in turn catalog our everyday lives in a series of short messages and never-ending activity logs. Cyberspace has gone from being a means of accelerating communication and shrinking of distances to being the new landscapes and mediums in which we exist. In turn, these landscapes and mediums are in a constant state of becoming, at speeds and scales impossible for people to easily comprehend, and are becoming one of the predominant socio-spatial problematics of the 21st century. The implications and consequences of these concepts for geo-economics, geopolitics, and the spaces of everyday life are more salient than ever before.

The cyberspaces considered in this study are the spaces of decentralized autonomous organizations (DAO) and corporations (DAC) due to their unique characteristics and immense potential. As an extension of the modern work on artificial intelligence (AI), these systems require autonomous actants which, by design, have no direct human contact, yet function based on human/machine interactions. More importantly, the resource that both human and machine require within the system (e.g., the blockchain) has not only changed commerce online, but has begun to revolutionize the core of traditional economic entities. The full extent to which these (r)evolutions have been addressed via strategic politics and geo-economic agendas that are shaping these changes is yet to be seen (Bria, 2016).

Overall, the aspects of cyberspace of concern in this study are the modes of spatial production within decentralized networks and blockchain technologies of Bitcoin and Ethereum.

Political Economy of Modes of Spatial Production

Henri Lefebvre's (1991) seminal text, *The Production of Space*, theorized the transition from the mental spaces of philosophers to the social, everyday spaces of people via their material practices. Lefebvre was quick to point out that knowledge of 'space' empowers those cognizant of its condition. This knowledge allows for the control of space and that control could be enhanced by technological means (Lefebvre, 1991, p. 8). This of course was part of his proposed spatial science in which the physical, mental, and social were examined together in order to expose the modes of spatial production (Lefebvre, 1991). Expanding on this point, social space is, therefore, a social product stemming from mental and physical spaces, concealed through various illusions, yet embracing and constituting itself through multiple intersections (Lefebvre, 1991).

This initial consideration brings us to the core trialectic that Lefebvre (1991) used throughout this text. Firstly, material spatial practices of a society cyclically produce their respective spaces which can then be exposed through analysis of those "perceived" spaces. Secondly, representations of space are the dominant spaces of a society in which abstractions are "conceived" via architects, engineers, and the like, playing a part in that society's social practices while also being guided by those practices. Lastly, representational spaces are products of the individual users and their minds' constant pursuit to modify and control their environments within their "lived" spatial experiences. While the spatial practices embrace the modes of production within the limits that space sets, the representations connect themselves to the spatial practices and their imposed order. However, spatial practice and representations of space are subject to the contingent embodiments of social life. This trialectic is key to understanding space as a natural and social product which is tied to the processes of its spatial production and how shifts between these modes of production generate and instantiate new spaces (Lefebvre, 1991).

Having explored the conditions surrounding social spaces, Lefebvre (1991) was keen to expand upon absolute space and how it strips that which is natural, leaving only abstract spaces over time. These abstract spaces are not commensurate with the perceptions of which they consist, yet they project

themselves as the dominant spaces through their conceived forms, functions, and structures (e.g., technological fixes in order to maintain power via control of knowledge). However, as abstract spaces attempt to maintain their dominance, conflicts arise which are then met with social contention and bureaucratic restrictions to hide emerging contradictions. These contradictions both dissolve old modes of production and create new ones (Lefebvre, 1991). The resultant differential spaces are what abstract spaces need in order to create new spaces while perpetuating the concealment of contradictions through projecting the illusion of homogeneity (Lefebvre, 1991).

Keeping in mind Lefebvre's (1991) arguments regarding social space being established via its physical and mental aspects as well as energy, space, and time as inseparable in our considerations of the production of space, he also noted that these elements, in relation to the abstract space (of the powerful and capitalist activity), depend on consensus. This insight is key to unlocking the spatial code of DAO-generated spaces in order to reveal both their modes of production and their concealment. This then leads to the proposition that the production of social space is tied to complex micro-spatial practices, the representations of those micro-spaces, and the representational nature of those micro-spaces within the trialectic of the “perceived,” the “conceived,” and “lived” space. Lefebvre’s (1991) discussion of abstract space resonates with contemporary understandings of how the cyclical production and transfer of value in DAOs reestablishes the system as the basis of consensus within its peer-to-peer network. These ideas are useful for understanding Ethereum, particularly how it differs from Bitcoin, as it continues to evolve the uses of the underlying technologies within a growing number of digital spaces. In this context, Lefebvre’s (1991, p. 60) brief remarks on “technological utopias” demonstrate his awareness that his conceptual framework might be of potential use in developing the spatial epistemology of future cyber geographies.

Spaces of Simultaneous Multiplicities

Expanding on the nature of spatial production, was central to the work of Doreen Massey several decades after Lefebvre. Massey's (2005) thesis is that space is a product of interrelationships as

constituted by social interactions. This means that space is also produced within a sphere of simultaneity and multiplicity (coexisting heterogeneities) and space is under constant construction as a living process. These arguments provide ethnographic depth to Lefebvre's writing regarding space as produced through the mechanisms of lived social experience. In the process of advancing Lefebvre's insight that the production of space is an infinite process, Massey also draws out several distinctions of interest.

Massey's (2005) goal in examining space is to extract its politics which makes the manner in which she does this unique from Lefebvre (despite his cognizance of this condition). She proposes that space does not exist prior to interrelations and through an examination of the relations as embedded practices between entities, an understanding of the world will emerge as the underlying politics of those spaces are exposed (Massey, 2005). These spaces, through their overlapping intersections and coexistent entities, allow for a realm of multiplicity to be examined as actants and actions simultaneously construct space through numerous, open processes (Massey, 2005). Knowledge of these open systems of spatial production is accomplished through a distinction between space as historic time and space as a product of coeval relations within multiple, positive heterogeneous trajectories (Massey, 2005). This is the manner in which Massey strives to understand ordinary social spaces of everyday life and their constructions.

Massey's (2005) understanding of the above processes is first achieved through a deep hermeneutics of “space” stemming, in part, from Lefebvre's (1991) consideration as to how humans have defined “space” through history and into modern day. Through her examination of space as seen through the works of Henri Bergson, structuralists, and deconstructionists, as well as other philosophers and social scientists, she addresses the use of space as a counterpoise to time in order to guide her resurrection of a condition of space and time as implicated in one another (keeping in mind the above ideologues only noted space as a secondary consideration within their primary disciplinary foci). Bergon's arguments surrounding time were critical in Massey's (2005) consideration of his time as tamed, via representation, by space. In this focus on time, a delineation between the discrete nature of difference/multiplicity and its continuous counterpart assisted in the distinction between a process of static, representative space to a

space/time of multiple living processes. Massey (2005) pointed out that Ernesto Laclau perceived the process of representing space as tantamount to submitting that space to a hegemonic regime thus rendering it static. Laclau's work was later compared and contrasted with that of de Certeau in his victory of space over time through representation; a static representation Massey once again moved to replace with that of positive, heterogeneous trajectories.

The later structuralists' arguments furthered this definition of space and time in their observations that one should not convolute or fuse geography and history as these disciplines are distinct via their unique significations and symbolizations of space and time (Massey, 2005). Structuralist averted this conflation through their considerations of each society as unique within the scope of their structures, synchrony, and spaces. However, by equating of all that was not temporal as spatial, they negated time via structure and synchrony and in doing so, furthered the perception of space as static, closed, and synchronic in its structures, robbing it of the possibility of real change (Massey, 2005). This ultimately robs space of its ability to establish interrelations between multiple trajectories. Massey (2005) then notes that post-structuralists (like Michel Foucault and Jacques Derrida) have deconstructed many of these structuralist conceptions in their further examination of space/time while exposing the politics embedded in their definition of power relations, semiotics, and hermeneutics. However, in Derrida's examination of space, Massey still found problematics in its resultant negative heterogeneities and in his defining of space/spacing through the use of negative hermeneutics, thus reinforcing the conception/perception of those heterogeneities (2005).

Massey (2005) then hearkens back to Lefebvre (1991) in her observation that production of space is accomplished, in part, with material practices exposing the sensation of social dimensionality. She then proceeded to examine modernity through the lens of globalization and spatialization, drawing out spatial histories and the multiplicity of trajectories, in which the distinct geographies of control (rule) and of power/knowledge impacts space’s operations and futures (Massey, 2005). Within globalization's tendencies of spatial erasure, there is the occlusion of the underlying economic and technological

mechanisms bolstering its political facades. Globalization, therefore, averts acknowledgment and outward demonstration of the numerous, open multiplicities that produce its many dimensions (Massey, 2005). However, in Massey's (2005) brief exploration of cyberspace, we see that this occlusion of the economic and technological becomes much harder to accomplish as dependencies on the technological expose these connections and their fundamental multiplicities. This is also where she critiques the perceived aspatial nature of cyberspace as the seemingly instantaneous communications can actually exhibit new forms of social division via fractures between cyberspaces' supposed effects and its modes of production (Massey, 2005). In addition to drawing on the works of Kitchin and Dodge (2014), she specifically calls on the work of Stephen Graham (1998) in his models for conceptualizing space and place within ICTs. These roughly fall into the realms of aspatial technological determinism, parallel social production, and mutual constitution of technology and society (in which it is argued we can best understand the processes of spatial production) (Graham, 1998).

In light of the above discussion of space, we see that which has yet to take form in and of itself, or only take form contingently. Moreover, if we take Massey's concepts of the simultaneity of discrete multiplicities into account, we then start to see the processes in which multiple experiences of place, as spatio-temporal events, start to produce space through their interactions which leads to even more multiplicities and simultaneities, ad infinitum. Her persistent comments on multiplicities as discrete also begs interrogation as to the multi-scalar effects of trajectory and position within their positive, heterogeneous interrelations (space/time as fused within processes of continual renewal promote emergence of their condition and politics not just though examination, but through their position to the subjective perception of the viewer and that viewer's position/condition/persistence to and within that space/time). This is an important analytical insight with enormous implications for our understanding of DAOs. Miners produce spatio-temporal events in their continuous construction of the blockchain despite their lack of perception as defined by humans (though dependent on the hardware furnished by humans). The humans creating the infrastructure in which the blockchain and miners dwell surely have a sense of

place in their human geographies and within their spaces and places. This may even extend to the point of transduction by which their actions enter the digital realm of cyberspace, but at what point does our ability to “sense place” have to be superseded by other actants in order to create newer post-human constructions of space?

The answer, or perhaps more apt the questions, may be tied to the definition of place by or for the numerous actants. Over time and throughout various histories, humans have refined multiple meanings and senses of place and these senses vary depending on the spaces in which they occur (whether in nature or in the home). This is further complicated through and by the aggregate processes of individuals' momentary experiences of space as it produces a unique sense of place via contingent perceptions and positions of the viewer (Meinig, 1979). If cyberspace is indeed a space, can humans truly experience a sense of place despite their inability to physically inhabit it? This issue could be explored through an examination of Kellerman (2007), Lakoff, and Johnson (1999) as I believe that humans have to create proxies by which to inhabit and/or experience these spaces, facilitating new forms of spatial creation. However, this could be explained via Lefebvre in that spatial practice through the representations of space can allow for the manifestation of varied representational spaces, human and machine alike.

We then come back to the question as to whether it is human or machine that truly facilitates the representations of space, harboring the contradictions between actants and the resultant differential fractures, ultimately leading to other abstracted spaces.

Space/time Compression in Production

Up to this point, I have yet to address the temporal aspect of the production of space. To do so I now turn to the writings of Harvey (1990) that are pertinent, especially his discussion on time-space compression that was influenced by both Marx and Lefebvre who wrote during very different political economies. Harvey is quick to point out that multiple senses of time are often lumped together causing conflict and confusion while space, prone to the same tropes and in many ways being more complex than

time, is simplified to a point of acceptance and in some cases irrelevance (1990). He then draws on Lefebvre by stating that recognition of the multiplicity of space and time experiences via social practice is due, but through the study of material practices (Harvey, 1990). This proposition is intimately tied to the reproduction of social life as each mode of production embodies a set of spatial and temporal practices. Harvey keeps in mind, however, that different situations can and do manifest these practices in different ways which can lead to conflict (1990). It is here where he draws out the distinction of *becoming* through temporal processes as distinct from *being* in space and place in the course of examining how aesthetic and social theory can be leveraged to understand how such changes occur (through class struggle and the resultant geopolitical conflicts that persist throughout geo-economic processes followed by inevitable uneven development and over-accumulation) (Harvey, 1990). This understanding is then examined within symbolic orderings of space and time as the relationship between the individual and these orderings determine spatial practices and representations (allowing being to emerge from the shadows of becoming) (Harvey, 1990).

Harvey then hearkens to Lefebvre's (1991) trialectic in order to understand and explore the complexities of the above concepts. Though initially taking issue with the vague nature of Lefebvre's dialectics between “the experienced, the perceived, and the imagined”, Harvey expands on them through aspects of spatial practice (accessibility and distanciation, appropriation and use of space, domination and control of space, production of space) (1990, p. 219). In doing so, he draws out not just the dialectics, but the causal natures of these relationships as well as building on how these elements affect frictions of distance and inevitably the compression of space/time (primarily done through his examination of capitalism) (Harvey, 1990). Harvey's examination of social power through domination of space and time are in this vain. Leveraging Lefebvre permits him to exposit on how power is garnered through control of material spatial practices via its forms, functions, and structures (namely, money's command over space/time and how social action is consumed in the struggles of class and politics) (Harvey, 1990). Power is tied closely to constant creative destruction of labor in order to accelerate economic processes

that ultimately influence social actions supporting that power, but not without the emergence of numerous crises (Harvey, 1990). Innovation in this sense has the aim of not only speed-up, but of erasing borders. However, I would argue that in the process of eliminating such borders, newer ones emerge at multiple scales that is in keeping with Lefebvre's (1991) notion of the fracturing of abstract spaces with the ultimate goal of concealing conflicts for the sake of shrinking of frictions of distance while maintaining a visage of homogeneity at the macro scalar. The resultant conflicts in the form of competition and crises accelerate the reconstruction of spaces through devaluation of specific assets (Harvey, 1990). In this context, the production of space is a means by which to increase social power while balancing the equally important dynamic between representations of space and the actual material control of spatial organization (Harvey, 1990).

The above dynamic leads to an important distinction between the mobilities of capital and labor in which accumulation drives expansion while technological fixes assist in overcoming issues related to competition in the process of these spatial reconstructions (Harvey, 1990). This conflict between bourgeoisie and working class interests sees capitalism rise above the spaces of the national while using those very spaces to secure its power over space and time. Even though the working class and counter capitalist movements gain temporary control over place, it is seemingly always at the behest of capitalism's control over the spaces containing these counter movements (Harvey, 1990). This conflict, throughout its long history, is the basis for Harvey's definition of time-space compression defined by accelerating the rate of everyday life while overcoming of borders, ultimately leading to “shrinking” the world.

In this time-space compression, perspectives (indeed multiple perspectives) are essential to perpetuate the constant interplay between coding of spaces and their reproduction allowing for their abstraction, conquest, and ultimate control (initially accomplished through the maps and later through the commodification of the lands they represented) (Harvey, 1990). Harvey again draws on Lefebvre (1991) to understand the politics of space through specific tropes related to the conflict between social and

private utilization of space. Through an examination of the principles of spatial fragmentation, production of space via its political and economic contexts, the interdependence of the political and social, homogenization of space over conception of place, and spaces domination through its production, we then start to see how crisis in representations of space emerges (Harvey, 1990). Therefore, “the more unified the space, the more important the qualities of the fragmentations become for social identity and action” (Harvey, 1990, p. 271). The epitome of these manifestations is expanded upon by Harvey (1990) through his look at the conflicts between the local and global during the modern and postmodern eras.

In the postmodern era, shifts in capitalist modes of accumulation (new organizational forms, production technologies, and intensification of labor) have led to drastic changes in geopolitics, geo-economics, cultures, and societies (Harvey, 1990). This has resulted in laborers having to retrain themselves within increasingly small time-frames to meet the shifting demands in labor needs. The result is increased volatility and ephemeral practices, decrease in the ability to plan strategically, and the production of new symbolic systems to instill the ideals of the bourgeois as aspirational (Harvey, 1990). In turn, the overcoming of spatial barriers has become more important as the means by which the frontiers were originally breached exposes our sensitivities to the larger spaces rendering our understanding of those spaces more critical.

As previously discussed, labor time is central to establishing value (Marx, 1976) and this can be expanded to say “within a set of spaces”. I am specifically interested in addressing the experience of time, as elaborated by Harvey (1990), from three important perspectives: (i) from the perspective of human actors involved in the production of DAO in order to extract “value” in a particular form; (ii) from the perspective of algorithmic actors within the “social spaces” of DAO, pushing outward to deliver a commodity with exchange value; and (iii) from the perspective of algorithmic actors in any number arrangements within the spaces of the DAO in the labor of value creation and competition to these ends. On the last of the three, it is important to consider that due to the decentralized nature of the system, we

could be dealing with an infinite number of “perceived,” “conceived,” and “lived” spaces within the labor process.

Harvey (1990) pointed out a paradox I think is critical to any examination of DAOs in that diminished spatial barriers increase sensitivity of capital to shifts of place within spaces resulting in unstable, fragmented, and uneven development within a now globally dominant economic system. Decentralization of production and money's relation to value are of key concerns to Harvey and is part of the larger examination as to how Bitcoin and Ethereum offer new alternatives to the above tribulations while simultaneously battling within them.

Harvey's exposition of the experience of space and time in social spaces is a framework flexible enough to be applied to all these aspects and could be used to further elaborate the idea that autonomous actants can experience and produce space at speeds that are much faster than those of humans, but no less meaningful in their implications (keeping in mind that his examination was intended for expanding on the nature of postmodernism's relationship to capital accumulation through space, time, and space-time experiences) (1990, p. 201). This is both in terms of the establishment of unique spaces and geographies, and the reinforcement of the fact that these entities do not overcome space and time; they merely transform and continuously shift the perspective from which it is produced. As a result, this study could have immediate implications for discerning capital as process/thing, relations between technology and human labor, and produced spaces of uneven geographic development with the potential to impact many other contradictions (Harvey, 2015).

Bitcoin

The majority of the literature related to the cryptocurrency Bitcoin and its mechanisms, which are central to this study, can be found in a white paper by Satoshi Nakamoto (2008). There is also a vast body of “grey literature” which is being generated by online forums such as Reddit. Phil Champagne compiled the white paper and the bulk of these posts into The Book of Satoshi (2014). However, Nakamoto’s

original thoughts are of the greatest importance as they laid the ground work for how Bitcoin and cryptocurrencies that followed function. Bitcoin's functionality is based on three core concepts: a public ledger of transactions called the *blockchain*; a *cryptographic algorithm* for encryption, authorization, and execution of transactions; and a *distributed network* of computational nodes called miners. Every member of the network shares the open ledger and utilizes an encrypted wallet to make payments and store his/her unique information (primarily a balance). Those same wallets utilize public-key cryptography in order to secure transactions within the network.

Here is the most interesting part. Miners are distributed all around the world and operate the Bitcoin network which is composed of machines via the Bitcoin software framework (which runs the overarching Bitcoin blockchain protocol). They work to verify valid transactions and update the blockchain with new blocks (or pages in the open ledger) approximately every ten minutes. Each miner creates its own version of this block and competes with all other miners to have its specific block added to the globally shared blockchain. Miners compete by seeing who can come up with a solution to a computational problem (in this case, finding a hash value that is beneath the threshold value generated by the Bitcoin network tied to the next block in the blockchain). When a miner finds a solution, called *proof-of-work*, the solution is validated and all other miners move on to work on the next page in the open ledger. The reward for the miner who solved the problem is a number of new Bitcoins (currently 12.5 which is reduced by 50% every 4 years), plus all transaction fees resulting from exchanges between wallets within that block in the blockchain.

In the event that there is a tie, a fork is made in the blockchain (or two ledgers temporarily exist). As soon as the next solution is found, the blockchain branch that this occurred on becomes the true blockchain and the other branch in this fork is orphaned (meaning that miner did not get paid and moves on to work on the newest open block in the blockchain). Moreover, in order to keep the Bitcoin network producing new blocks approximately every ten minutes, the difficulty of the block hash to be solved is adjusted based on the speed of the previous solution which ensures that increases in computational power

thrown at a problem does not upset this tempo in block creation. In effect, miners act as minters of the currency, keepers of the ledger, and regulators of the system, switching roles at different times and speeds during this cyclical process of blockchain renewal (Champagne, 2014).

The implications of the miner network and blockchain generation are great. The Bitcoin network operates as a decentralized autonomous organization (DAO) and if we define Bitcoin as ‘money’ (a medium of exchange value that is representational of social labor) as opposed to ‘currency’ (the socially accepted representation of money), then we can move Bitcoin into the money/commodity dialectic as proposed by Marx (1976). In doing so, we have to ask at what point do we consider these “miners” part of the socially necessary labor time required to create value within and outside the Bitcoin system? Members participating in this peer-to-peer system consider Bitcoin a system unit of value. If miners are in fact part of value creation and transfer, how has this distributed network become a ‘space’ as defined by Lefebvre (1991) from the perspectives of the miners and the humans?

Ethereum

Satoshi Nakamoto's pioneering concept led to the creation of several alternate cryptocurrencies, or alt-currencies, within this initial blockchain framework generally accepted as blockchain 1.0 (Swan, 2015). Blockchain 1.0 paved the way for expanded usage of the blockchain and cryptography in smart contracts. Whereas blockchain 1.0 was built for decentralized money and payments, blockchain 2.0 used its predecessor to accommodate the decentralization of entire financial markets, using a custom programming language as its foundation, which could track transfer activities of not only smart contracts, but smart properties and other DAOs.

Before going any further into the mechanisms of blockchain 2.0, we need to discuss the terminology underpinning these new technologies in order to clearly distinguish between the signifier/signified (Selden, Widdowson, Brooker, 2005) within the online communities still struggling with universally accepted terminology. The set of definitions for the purpose of this study will be derived

from those published by Vitalik Buterin (2014b) through Ethereum's blog. Thus, a DAO is an autonomously existing entity within cyberspace, having internal capital (some form of property having “value”) which it uses to reward certain activities. The DAO has autonomous actants at its core that work within the system to maintain the organization and aside from the initial implementation of hardware, requires no human activity aside from functions outside of the charter governing its predetermined functionality. A DAO can “hire” humans for tasks it is incapable of doing itself (this is the feature by which it is argues Bitcoin is not a DAO) and can make a profit, but it is usually through the actants (machine and human) participating in the organization. DACs are considered to be a subclass of the DAO. The primary distinction between DAO and DAC is in the use of shares which can be purchased or sold and entitle the shareholder to potential returns based on the success of the DAC.

Some scholars and inventors have taken to this concept of DAOs via blockchain 2.0 and are attempting to expand upon it. Vitalik Buterin (2014a) of the Ethereum project proposed a variation to the Bitcoin model and in doing so is expanding the potential of DAOs and their spatial implications within human and cyber geographies. Keeping in the spirit of transparency, the Ethereum project maintains the concepts of a decentralized database (or blockchain) and tokenization (via cryptocurrency) within the system for making transactions. However, a large advance was made when Vitalik Buterin and the Ethereum team applied a Turing-complete language to this environment. To this end, Ethereum uses a featureless blockchain so that the user can define what goes into the open ledger. Currently, this is performed using proof-of-work, but the Ethereum Foundation is currently working to implement the Casper proof-of-stake protocol (which remain in development and has received both praise and criticism as will be discussed later).

Much like an ‘open' app market (such as Google Play), one can join this system, build an application in accordance with a set of agreed terms (a smart contract), and can then distribute that application around the world in a trusted process. A cryptocurrency called Ether is required for any transaction in Ethereum and while individuals (both human and machine) in the network interact with that

app, the miners would work in a similar fashion to those within the Bitcoin network in processing of transactions and validating blocks generating new Ether to be spent.

The interesting part of Ethereum is how it utilizes smart contracts. Smart contracts within this system are programmatic frameworks that are deployed in much the same fashion a paper contract is employed; it sets the terms and costs of transactions within a given function or set of functions ranging from basic monetary transactions to building social network applications and establishing entire DAOs. This results in a system that persists on the generation and maintenance of smart contracts as opposed to the limited purpose of cryptocurrency generation via maintenance of transaction states-of-value as found with Bitcoin. These contracts can interact with other contracts in a completely automated and autonomous fashion if so desired by the originating user (leading to the condition and structure currently used for DAOs/DACs). Even though the contracts in and of themselves are immutable (unless drafted otherwise), they make possible a much more flexible and efficient legal framework to govern autonomous corporate activity within Ethereum and in future generations of blockchain technology.

In less than a decade, we have moved from a conceptual framework of decentralization and currency generation within a functioning monetary system that is perpetuated in large part by autonomous actants within a few cyber geographies to a condition of numerous decentralized organizations operating without human guidance based on smart contracts and cryptographic rule sets (Swan, 2015). In view of this shift, we must ask a number of complex questions not previously asked of Bitcoin. For instance, if we are shifting the dynamic relationship between commodity, value, and money, then what are the implications of a system in which socially necessary labor time is conducted autonomously at near 100% efficiency and produces use value without direct continuous human labor? One could argue, however, that humans maintain and partially produce the physical infrastructure in which these processes occur. But, does that necessarily imply that humans are the only ones supplying the actual living labor to produce value via their creation of this system, or does the introduction of a Turing-complete application via smart contract foreshadow the potential for hyper-reduction of human necessity in value production found in

these new cyber geographies? If the human actants in this system are in fact only providing what Marx (1976) refers to as dead labor in order to reap the benefits facilitated by the miners and DAOs/DACs, what are the implications for existing markets and economies? Does this also imply that these geographies are in large part post-human in nature given the concept of produced “lived” space as perceived by Lefebvre?

The above elements within the modes of spatial production bring out many items for exploration. In looking at the historical transformations between absolute spaces into the realm of abstract spaces (keeping in mind their mental origins), we are faced with the question as to which modes of production are dominant within the context of the blockchain-based DAO. We can see the evolution from absolute to abstract through the utilization of communications and computer technologies in these decentralized networks, but we are seeing multiple parties defining numerous systems in different ways. As the technologies evolve from the blockchain 1.0 and 2.0 into newer generations in terms of technical advancements and innovative applications, we start to see groups with different spatial practices conceive different architectures. Meanwhile, the individuals utilizing these DAOs are experiencing very different representational spaces within those architectures based in cyberspace and through the potential expressions of those spaces in human geographies. However, as previously discussed, there are already very different applications and, in turn, intentions behind the usage of these technologies in cyberspace. These various agendas expose the contradictions within and between spaces as people attempt to extract profit, thus leading to conflict and numerous differential spaces.

In order to explore the topics above and to understand how these systems manifest unique productions of space, I propose three approaches in this endeavor. Each theoretical approach is aligned with a specific research question, but flexible in their ability to make valuable connections to the others. Phenomenological description of the modes of spatial production related to Bitcoin and Ethereum exposes the numerous connections and interactions that form human agents' positions and perspectives towards the systems, ultimately guiding how they approach their applications. Secondly, notions of dialectical

materialism contextualize the human agents within the mechanisms and structures of the systems as their evolutionary processes drive the numerous facets of these hybrid spaces and their potential conditions as spatial fixes within displaced capital crises. Finally, the systems theories of these code/spaces are used to examine the systems from the machines outward, exploring the systems of Bitcoin and Ethereum as their design guides the types and forms of human interaction, but how they are also guided by those interactions in their continued development.

Phenomenology and the Production of Space

A phenomenological approach to the notion of production of space helps describe the conditions of human agents and systemic actants within the blockchain-driven systems of DAOs/DACs. Phenomenology is concerned with the individual's uniquely enacted and defined environmental elements which influence and guide various scales of behavior (Johnston & Sidaway, 2004). In terms of technology, this methodological approach is highly suitable as it can describe lived experiences of humans with technology, assist in understanding formations of world view based on those experiences, and the extent to which these technologies are embedded in the spaces and places of everyday life (Cilesiz, 2011). This technological problematic is seen in the works of Martin Heidegger, both in his early observations of human/technology relations as concretely present and/or tangentially flowing through his later work on technologies' ability to enframe nature as a resource for human exploitation (Hongladarom, 2013). The strength of such phenomenological approaches can be used not only in the immediate consideration of human/technology interactions, but in addressing the conditions of Bitcoin and Ethereum within existent systems of capitalism, globalization, science and technology (Obi-Okogbuo, 2015). Doreen Massey (1995) was quick to point out the dualisms within Western thought between humans and technology as influential in structuring the forms and practices of social relations. This parallels the sentiments of Francois-Regis Puyou and Eric Fay's (2015) application of Michel Henry's phenomenology of life (intentionality and affectivity) in that a laborer's reliance on systems of abstract representations

results in aversion of ethical considerations for those who their action effects via their use of information technologies. As a result, this methodology also aids in the development of ethical considerations within and surrounding usages of blockchain technologies.

There have been numerous considerations in the selection of phenomenology for the purpose of this study. A critique levied by Dominic Smith (2015) pleads for a more transcendental, empiricist post-phenomenology for technological inquiry in line with the works of Michel Foucault, Jacques Derrida, and Gilles Deleuze. Smith (2015) challenges the context of language and the post-structuralist thinkers themselves to move towards a more transcendentally focused phenomenology of technological philosophy. Peter-Paul Verbeek (2008), focusing partially on limits in Don Ihde's analysis of human/technology relations (both mentioned by Smith in his critique of post-structuralism), explores varying blends of human/technology spatial relations within what he terms “cyborg intentionality”. Verbeek's (2008) spectral trilogy aims to re-conceptualize the phenomenon of human intentionality. Moreover, Sana Murrani (2011) challenges phenomenological and cybernetic approaches in exploring the conditions of being and becoming in architectural discourse. This approach takes from post-phenomenology and technoscience (Obi-Okogbuo, 2015) in the development of the discourse which addresses the relationship between humanism, mechanism, and technology.

Lefebvre's (1991) *Production of Space* is foundational in terms of these modes of thought, the systems, their constituent parts, and the human/technology paradigms that are the foci of this research. Given the above considerations of phenomenology and technology, the application of the phenomenological approach will take the human process of space/place construction and apply it to the realm of the human/technology interactions, dialectics, and systematics. As briefly explored above, the manner in which humans have conceptualized technologies and then situated themselves in relation to them has parallels in how Lefebvre (1991) explores the evolution of abstract spaces within the perceived, conceived, and lived experiences of humans and their environments. These interactions are in turn guided by numerous external actants, such as capitalist entities and cryptocurrency markets, that have unknown

effects on both humans and technologies. Therefore, the study of DAOs in relation to human interactions seeks to expand on the latest evolution of space/time relations within technological regimes.

As already mentioned, Doreen Massey (2005) adds significant depth to how place is defined by Lefebvre's space, deepening the rigor of my exploratory framework. This is twofold in its relevance. First, Massey addresses many issues surrounding spatial conceptualization and production resulting from historical reductions of space to time and in doing so, promotes place as locations (Agnew, 2011) of change. Secondly, through her critiques of post-structuralist concepts of space, she develops a framework of mutual constitution between the social and spatial which will assist in forming a phenomenological approach to understanding how humans and technology affect one another to these ends.

Dialectical Materialism and Cryptocurrencies

Dialectical materialism, which is the method of understanding processes of motion, change, and transformation formulated around relations (Harvey, 2010), is a valuable framework for understanding how wide-ranging social, political, and economic processes influence the modes of spatial production in the realm of cryptocurrencies and blockchain technologies. Most of the work in the field of dialectical materialism has focused on capitalism and its modes of production (Marx, 1976). However, since the 1970s, this method has been applied and critiqued in numerous ways making a rich and complex methodology for this initial research path.

There were those, such as Jean Baudrillard (Zander, 2014), who fell away from this school of thinking in terms of symbolic exchange value theory (adding sign value and symbolic value) and later productivism, but the diachronic shift in post-structuralist tones are still heavily dependent on Karl Marx's (1976) methods. Works such as Ben Fine and Dimitris Milonakis' *From Economics Imperialism to Freakanomics* point to the strengths of dialectical social methods in explaining the place of labor value theory in a new, interdisciplinary political economy (McNally, 2012). However, both Par-Ola Zander (2014) and David McNally (2012) point to the historical origins of the dialectical method in consideration

of its modern iterations. David Harvey (2012) expounds upon the methodological restrictions of Marx's political economy in terms of relations to nature, motions of capital, distribution/exchange, and consumption; exposing its ultimate inability to constitute a total theory of capitalist modes of production. Moreover, Moore (2001) frames labor theory of value within the relations between society and nature resulting in metabolic rifts as a consequence of the inherent contradictions of the capital/labor dialectic. Lefebvre was aware of such issues in his assertions (though Eurocentric as they were) on alienation, dialectical humanist Marxism, and transcendent political economy (Kipfer & Goonewardena, 2013). Similar points of issue with the dialectical approach have been raised by J.K. Gibson-Graham (1996) and Doreen Massey (1994) within gender studies. These critiques may further stem from the Hegelian origins of Marx's dialectic in that Hegel strove toward meta-understandings of history. G. W. F. Hegel, in addition to Marx's trans-historical class, were later attacked by Foucault who proposed a regime of historical truth focused on power/knowledge relations (Dorfman, 2005). However, Ben Dorfman (2005) pointed out that Foucault's post-structuralist and post-modernist approaches, among many other thinkers of that era, may be giving way in the recent rise of globalization studies. Pursuant to my research foci, these debates must be taken into account when applying the various forms of dialectical materialism to the study of cryptocurrencies and their associated cyberspace economies.

At the turn of the 21st century, the dialectical materialism of Marx has a new paradigm to consider: digital capitalism and cryptocurrencies. This goes beyond the digitization of existing fiat and credit currencies into the realm of community regulated, decentralized consensus-based currency systems that challenge existing economic institutions (Bek-Thomsen, Jacobsen, Christiansen, Thorup, 2014). Previous to this advent, studies of cryptocurrencies and goods were considered and conducted via virtual world economies such as Second Life (Ke, Ba, Stallaert, Zhang, 2012; Thompson, 2009). Aside from the modes of production within these virtual worlds, the more salient points of conjecture surrounded their impacts and intrusions into real-world economies such as regulatory issues of virtual world commodities (Thompson, 2009). Once Bitcoin established itself as a “reliable” currency (a digital currency that could

sustain and/or exceed parity with the US dollar first achieved by Bitcoin in February of 2011), the same regulatory issues were compounded as they were used for any number of purposes, including purchase and trade of illicit commodities as listed by numerous governments and various international organizations. Even after the genesis of Bitcoin in 2009, US regulators still have no solid plan for cryptocurrencies. This is an extension of neo-class struggles between the vectoralist capitalist class who wish to control the new means of abstract intellectual production and the hacker working class whose labor, works, and information are commodified, capitalized, and ultimately controlled via state regulation (e.g., intellectual property and copyright laws) (Wark, 2004). Hayles (2005) explores these dialectical interactions in rethinking the relations between computation and embodiment as crucial to how the human world is and will be moving forward.

One way to understand these emerging technologies is through the work of Ash Amin and Nigel Thrift (2007). Their proposition of "cultural-economy" not only makes key points about the spatial problematics of socio-economic geographies (e.g., passion, morals, soft knowledge, power, trust), they present these problematics as parts of a larger multiplicity of hybrid entanglements (Amin & Thrift, 2007). Though their goal was to implicate the transforming, urban perspective of this hybrid approach, they touched on the role of participant positionality in these cultural-economic systems. In terms of globalization, space/time still matters as to the position of the individual to the global economy (Shepard, 2002) that in many ways spurred the development of numerous cryptocurrencies and blockchain-based systems. Vili Lehdonvirta (2010) suggests that the social aspects of ICTs are driving new forms of material culture in which post-material ethics manifest themselves in virtual spaces. However, he points out that these propositions ignore the potential for new forms of inequality and exclusion, dependency on offline identity and institutions, and the perception of cyberspace as open (Lehdonvirta, 2010). This can be best understood through Galloway's (2004) exploration of the real, yet abstract, nature of the Internet through its protocols and political economy; decentralization within centralized hierarchies of control systems.

These potential aspects of cryptocurrencies are as promising as they are troubling. Even before the advent of Bitcoin and similar cryptocurrencies, the concerns surrounding digitization of material currencies and properties were plagued by the issue of geographic ignorance of these spaces and the implications of their productions (Kobrin, 1997). This may have had something to do with delineating geographic space and cyberspace as if they were completely different entities. The lack of understanding and defining the “where” of these spaces ultimately led to the assumption that these digitizing systems are space-less and reinforces the perception that classical forms of regulation and territorialization will shape these digital spaces as was done in human geographies.

Therefore, the application of dialectical materialism is critical to exploring how cryptocurrencies, decentralized applications, and DAOs actually function and produce space. Christian Fuchs and Nick Dyer-Witheford (2013) outline several ways in which Marx's works are relevant in the study of the Internet and to which I would add, cyberspace writ-large. They make mention of Marx's dialectic being used to explore the connections between Internet and society, processes of technologies, and the transition from a structuralist-functionalist dialectic to a humanistic dialectic as set in the antagonism between productive forces and relations of production (Fuchs & Dyer-Witheford, 2013). To this end, we must expand the scope of dialectics to blockchain technologies in order to assure their development is pursued keeping in mind the external, systematic influences that neoliberal globalization places upon them.

Systems Theory, Code/Space, and Network Societies

For the purpose of this study, the notion of “systems” is a key focal point in examination of the relational and representational spaces of DAOs and blockchain technologies. In doing so, we must be careful to understand the humanistic origins and uses of these systems for two initial reasons. Firstly, we must understand how human agency co-evolves with these systems and their actants. Secondly, through the understanding of the human/system coeval, we will gain a better understanding of the modes of spatial production that exists between and within each facet of these blockchain systems.

One initial consideration is the concept of knowledge/power in cyberspace (Rowland, Rice, Shenoi, 2014). Unfortunately, there is not a large corpus of literature that is truly applicable to my study and the literature that is available fails to represent a balanced or complete picture of power dynamics within the spaces of human/ICT relations. Jill Rowland's thoughts on cyberspace centered around the common and largely false dichotomy of nation-state and non-state actors' usage of cyberspace are relevant, but they fail to fully demonstrate what the systems' spaces actually are in terms of knowledge/power dynamics while projecting non-state actors in a mostly negative light (keeping in mind that the vast majority of actors and actants in cyberspace are non-state). Similar tones and assertions can be found in the context of 'cyber-crime' (Keene, 2012), as if these activities were unique to digital spaces and that legislation would have any more effect on them than in the 'real world'. However, points made by Rowland et al. (2014) on the growing dominance of multinational corporations and the opportunity for improved geo-economic equality are points that can be agreed upon. Inclusion of human geographic understandings would have made the above argument much more applicable to this study in terms of understanding a more heterogeneous, multi-scalar paradigm of spatial relations (Mauro, 2009). Moreover, such understandings must not be oversimplified via systematization within agent-based models that seek to solidify the nature between humans and systems (An, 2012). Smith and Kollock (1999) are quick to point out that economies of interaction and communication in cyberspace are far different than their in-person equivalents, suggesting strong implications for new forms of knowledge/power dynamics.

Systems theory has been used as a point of discussion and contention between physical and human geographers and has largely failed to establish a bridging effect on points of system definition, process understanding, borders, 'environmental' understanding, and the resulting epistemology (Egner & von Elverfeldt). Heike Egner and Kirsten von Elverfeldt (2009) recommend a resolution of this through abandoning determinism, observing system self-delineation, and pursuing genuine dialogue for a common vocabulary. Trevor Barnes (2009) also proposed a commensurate stance between quantitative and critical geographies, calling on mathematical affinities in Marx's work and resolution through trading zones of

seemingly incongruous societal exchanges of value, meaning, objects, and language. Ron Buliung (2011) asserts the utility of ICT systems facilitates a hypermobility of exchanges, such as those Barnes pointed to, for people and place (yet his point on 'extinction of experience' counters his assertion on digital, metageographic production).

The above points draw out the still on-going struggle within all disciplines' understandings of cyberspace as that which is 'cyber' and that which is simultaneously spatial. In many ways, the discourses seeking resolution between human and physical geographers are much the same arguments I will explore in my discourse between human and cyber geographies. The physical, human, and cyber are all inextricably linked and through a deeper understanding of their inter- and intra-relations, their symmetries and supra-structures will dynamically emerge through continued engagement.

Code/Space

Rob Kitchin and Martin Dodge (2014) examine the relationships between code in its many forms and social spaces. Code/space is the condition in which software and spaces of everyday life produce one another; code/space is neither deterministic nor universal and therefore is inconsistently transduced (Kitchin & Dodge, 2014). Kitchin and Dodge (2014) define four levels at which code is part of everyday life (coded objects, coded infrastructures, coded processes, code assemblages) in order to explore software's modulation of space via transductive processes (these coded parts have the potential to produce collective life with significant and growing levels of autonomy). Software analysis for this course of research would ultimately focus on the origins of code within blockchain technologies, how they effect DAOs, and how these technologies and software affect the social spaces of everyday life (this is in line with Kitchin & Dodge's proposed software studies).

Software, though lacking materiality, functions as an actant within produced economic, political, and cultural spaces (Kitchin & Dodge, 2014). I will argue that software does meet Lefebvre's (1991) definition of matériel. Code as a language bridges the divide in communication between humans and

machines within spaces difficult for humans to comprehend as it constructs a way of perceiving, conceiving, and acting in the world while shaping those spaces through use of its logical structures (Kitchin & Dodge, 2014). Code as a product is a social object within a collaborative effort and, though inherently unpredictable in its conception, manifests as a complex, layered abstraction of numerous discursive relations (Kitchin & Dodge, 2014). Most interestingly for the purpose of this study, code as a process sees software abstracting the humans spaces of the world which in turn starts to follow the regimes embedded in those very abstractions. This aspect of technicity (Kitchin & Dodge, 2014) mediates, augments, and expands everyday life as humans further implement these technologies as coeval in their lives.

Much like Doreen Massey (2005), Rob Kitchin and Martin Dodge (2014) argue these software-effected social relations are inherently spatial and temporal. In this exploration of the history of space, they draw out Thrift's nonrepresentational theory (2008) in which humans' spatial practices are largely instinctive and subconscious, being aided by other actants (such as machines and/or software); this is with the ultimate goal of understanding how software produces space automatically as part of a partial solution to a persistent relational problem (Kitchin & Dodge, 2014). The form, function, structure, and purpose of code/spaces are shaped through software-based activity in which the code is the essential actant, realizing its technicity through the transduction of humans via technologies (Kitchin & Dodge, 2014). In turn, relational problems in these spaces are resolved through software's' condition as a catalyst in the process of modulation between humans and technology (Kitchin & Dodge, 2014).

The above concepts are elaborated in Kitchin and Dodge's (2014) examination of automated management as software has become a primary means by which society and individuals are surveyed, disciplined, and ultimately controlled via technological means. Despite these seemingly insurmountable conditions, there are still those who use software and technologies to create and empower themselves; this is a key aspect in my study of DAOs/DACs. Their sense of everywhere, the concept that code will affect almost all facets of our lives through the availability of computational resources, is examined through the

developmental regimes of empowerment, securitization, and sousveillance (the recording of logs for all surveillance in everyday life) (Kitchin & Dodge, 2014).

Kitchin and Dodge (2014) focus on the software's transduction of space/time via its ability to transfer the means of labor and functionality within human geographies into coded spaces. Though extremely relevant in terms of establishing software studies as a critical focus area within geography, they fail to fully explore how this fits in to a much larger, multi-scalar, conceptualization of cyber geography (only brief mentions are made to Manuel Castells or communication infrastructure as the ecosystem within which ICTs produce their own particular geographies, which in turn reproduce themselves). Their proposed taxonomies, and ontologies, of software are extremely useful as a starting point from which to understand more advanced cyber actants, such as the narrow (or weak) artificial intelligence found in Ethereum. I depart from their assumptions that code is unlike spoken language as this is an unnecessary restriction in understanding how new spatial productions can come into existence and persist past human/code transduction. From my perspective, and as I will explore, communicating to a machine is similar in many ways to talking to a young child or in the case of Don Knuth (1974), an art of poetry or prose. Their mention of collective life via their taxonomy of coded objects could be a starting point for this exploration as could their dialectics regarding the embodied relationship between people, other people, and code, drawing out the nature of these spaces' inconsistent productions.

In this, coded assemblage transitions, the negotiation of spatial production within these coded spaces, the positional states of code/space experience, the human/code scalar contexts, temporal aspects, and the exploitable flaws in these systems are means by which to explore not just how new spaces are produced, but how new geographies derived from this exploration can lead to deeper insights about the spaces in which the code lives. More specifically, Kitchin and Dodge's (2014) dialogue on code and money is applicable to how DAOs are extensions to their ideas. However, DAOs demonstrate an evolution beyond their contextual discourse in that their points regarding virtual abstraction of money and its anonymity are countered through this new means of decentralized market and cryptographic currency,

begging the question as to which systems are actually more secure. In all, Kitchin and Dodge's approach should serve as an invaluable starting point in my examination of the underlying systems constituting DAOs/DACs and the broader blockchain technologies.

Network society

There has been extensive literature generated on numerous aspects of network society. According to Manuel Castells (2004), network society is the arrangement of humans and their social structures within ICT networks, affecting their numerous relations through culturally coded communication systems and structures. The networks are composed of interconnected nodes, representative of various intersections, in which their value varies based on the volume of significant intersections it can efficiently process (Castells, 2004). These nodes must be necessary for the networks functionality (must aid in the network's primary purpose) and if they become redundant or useless, the non-centralized network will shed the node during its processes of reconfiguration (Castells, 2004). In looking at communications networks, nodes act as points of confluence for flows of messages and in doing so, forms patterns in space and time (Castells, 2004). Networks process these flows based on their defined programs (code that assigns criteria for function, valuation, and success/failure) which ultimately affects their outcomes as well as how they compete with other networks through increased efficiency in cooperative capacity with other networks (the more connected a network is with other networks combines with its ability to efficiently process flows increases its overall value) (Castells, 2004).

Networks operate based on the logic of inclusion/exclusion (binary in its basic nature) and within the networks, distances between nodes are considered close to zero as their ability to share flows intra-network are facilitated at high efficiencies (distances are essentially considered infinite unless there is external access and/or the network's program is changed) (Castells, 2004). These networks self-reconfigure numerous complexities to ensure flexibility, sustained relevant purpose, and efficient execution within the operating environment (Castells, 2004).

Castells (2004) then introduces his concepts of “informationalism” (technological paradigm as the material basis for societies in the 21st century) through his exploration of its two aspects; one of which is society as built around and embedded in ICTs. The modern ICT infrastructure allows for self-expanding processes and communication, restructuring within digitization and communications, and distributed flexibility through interactive networks (Castells, 2004). This leads Castells (2004) to purport that all digital networks are global; lacking boundaries as they reconfigure themselves and the affected social structures within a global society. However, hierarchy still exists between networks across the planet and will exhibit domination within that grid of multidimensional, societal networks (Castells, 2004). This begs the question as to how power is known and experienced in these networks via control which ultimately depends on how one interacts with the network (programmers and switchers based on their position in the networks exercise power within network society) (Castells, 2004). However, Castells (2001) must now answer as to how space of flows and timeless time function in terms of his network society. Space of flows refers to the possibility of simultaneity via time sharing sans contiguity, inhabiting the place of nodes and networks through their electronic ICT infrastructures and the flows of information while dissolving time and resulting in an ephemeral structure in which being cancels becoming (these spaces of places are interrelated through their practices, purposes, localities) (Castells, 2004).

Initially, Castells' conceptions might help to explore the means by which Doreen Massey's (2005) constant construction of space occurs within the geographies of DAOs/DACs. However, Castells promotes the idea of human abstraction solely as a means by which to facilitate communication, social organization, and to overcome the friction of distance from within the infrastructural barriers and dependencies of ICTs. Where Castells abstracts humans and other actants to nodes within his terms of social space (to which I would partially agree), I also see this process as a way to utilize networks and actant abstraction to create cyberspaces that are also uniquely social within their own political economies via a multiplicity of their perceived 'natural' states. This is facilitated both through aggregate

reconstitution of personal space/time conceptualizations of self-propagated abstractions using programs, both autonomous and human dependent, in an effort to establish social space via the transduction of place.

The flows become important when considering how these different abstractions interact with and within the spaces of the DAOs/DACs and how value production via labor time is constituted within human and cyber geographies via these network societies. Nigel Thrift's (2008) views on flows is divergent from Castells (2004) as his flows of subjectivity, with increasing numbers of actants and their activities, cannot be seen as merely transactions between nodes as these acts in and of themselves exhibit manifestations of empowerment. These hybrid assemblages (collections of puddles and flows) give all components of the network equal consideration as these interactions, through their mutual consideration, generate new forms of power (Thrift, 2008). Thrift (2004) sees how these technologies are changing everyday life through the re-conceptualization of global models, inscribed in code, but does so through biological terms (viewing of code and technologies as companion animals) and through those entities' potential agency while drawing out the question of ethics in the process.

However, I find the use of social and spatial network analysis, and by extension graph theory, restrictive in its effectiveness to expose the totality of network activity and social exchanges, human or not, as it limits the extent to which the qualitative context of social space is presented and explored through the concepts of Henri Lefebvre (1991) and how it truly manifests itself within experienced space/time as presented by David Harvey (1990). To that extent, looking at nodal structures as indicators of true spatial conditions is questionable outside a very explicit set of environmental definitions. It is probably more appropriate to see nodes as metaphors for understanding how the processes of spatial production takes hold as in the case of the decentralized nature of DAOs/DACs. Castells' (2004, p. 39) mention of a "culture of protocols of communication" does lend itself to the possibility of extending the above ideas to a more dynamic perspective of DAOs and its actants. This still leaves much to be expanded upon in regards to the true dialectic of spatial production in human geographies and the complimentary spatial production within cyberspace.

Stephen Graham (1998; 1999; 2002a; 2002b) is quick to point out that the above processes of Castells' “network society” are occurring in very uneven ways. In fact, his critique is an indictment of the “geography erasing” network infrastructures as their true implementation is yet another means by which to create new borders in cyberspace; the very ones they purport to be erasing between nation-states and cultures while simultaneously exploiting both their distinctions and similarities. This unevenness, both in space and place, is seconded by Gustavo Buzai (2013) in his examination of the exclusionary and restrictive geographies of cyberspace in Latin America. Despite the aim to produce a decentralized space by which to share research and knowledge via the Internet (and other cyberspaces), the structures and institutes constituting the Internet have become very centralized both in terms of infrastructure and control mechanisms (Buzai, 2013; Froomkin, 2000) (e.g., ICANN). Borders can also be seen in the work of Michael Collyer (2003) on the effects of online websites on offline national and migrant identities and the superimposition of those borders onto cyberspace as well as the work of Dean Riddlesden and Alex Singleton (2014) on the disparities in access and performance of broadband access and connectivity.

Stephen Graham and Nigel Thrift (2007) proposed further examination of the underlying 'invisible' mechanisms driving and defining societies (cyberspaces' materially embedded and constantly evolving condition as one of the key aspects of this analysis). However, Thrift (1996) was keenly aware of the historical precedent of technological determinism and what that might mean for cyberspace in the 21st century. Emmanouil Tranos and Peter Nijkamp (2013) posited that physical distances and relational proximity guided the formation of cyberspaces infrastructure and this dynamic can be observed in terms of understanding data and information storage within the larger cyberspace (Gorman & Malecki, 2002). Reactions to this understanding, both technically and socio-spatially, have been questionable legislation regarding cyberspace as property via metaphorical 'place' (Lemley, 2003) and further concerns over individual data privacy (Curry, 1997) within the software/hardware layers of the underlying networks. Researchers and academics have attempted to situate how these technologies affect individuals and societies through studies of ICT dependencies in scientific research (Barjak, Eccles, Meyer, Schroeder,

Robinson, 2013) and geographic information technologies as conditioned for practical applications for society (Sheppard, Couclelis, Graham, Harrington, Onsrud, 1999). Marshall Van Alstyne and Nathaniel Bulkley (2004) suggest that the resultant information generated through such observable changes would actually aid more than just research efforts, but shift productivity in society as a whole. Given the rapid development of ICT infrastructure and the more recent formulation of cyberspace as a concept (Adams & Warf, 1997), it is of the utmost importance to understand key aspects of cyberspace, both from its internal functionality and external influences, so that DAOs and their blockchain technologies are fully comprehended as unique, evolving systems within larger, dynamic architectures. The ideas and conjecture surrounding Castells' network society will guide the considerations of how those systems are contextualized in this research.

Lefebvre (1991) suggests these spatial relations can be exposed through examination of form, function, and structure within these unique spaces. In looking at the production of space and DAOs, these points must be addressed and resolved in order to move forward. It is true that the world is becoming more connected through cyberspaces, and in turn cyber geographies, which facilitate amazing leaps in space/time compression for those with no previous access to the “network society”. However, this “society”, its infrastructures, concentrations, and the ultimate utility through spatial penetration is called into question when it is controlled by those with the money to invest in them which is driven by much more than erasing the friction of distance for human interactions or providing open access to what is now becoming the global store for all human knowledge. These networks and cyberspaces are in many ways still dominated by geopolitics and geo-economics that have existed long before their conceptions and in this lies the call for alternatives through alternative cyberspaces. Forms of these struggles, as framed by McKenzie Wark (2004), can be seen in the persistent net neutrality contestations between those who own the infrastructure and those who use it in the dynamic complexities of everyday life (reminiscent of the dynamics between Marx's means of production and the productive forces) (Harvey, 2010; Marx, 1976). The question then becomes how to develop a plethora of alternatives within these 'alternative' spaces that

present viable options to existing and persistent regimes of control and power while resisting the tendency to manifest territoriality within cyberspace. Perhaps part of the solution lies in the egalitarian forms, functions, and structures of blockchain technologies.

CHAPTER THREE:

RESULTS

Open Conversations and Interviews

The period of data collection for interviews and open conversations began 1 June, 2016 and ended 23 September, 2016. The proposed goal of conducting 20 semi-structured interviews and 30 open conversations fell short, resulting in five semi-structured interviews and 16 open conversations. Throughout this period, introductory and follow-up emails were sent to desired interviewees. Of the 20, four responded to opt-out of the study and one quit responding to my requests for an interview. The five participants who volunteered for the interviews were quite responsive and extremely forthcoming with their time. In the course of the interviews, responses stayed within the core intent of the IRB approved questions, though I did allow them to interpret some of the language within the questions as their situated perceptions as developers, investors, and/or users would lead to responses that were contextually relevant to the intent and rationale for this study. There were some early technical issues with the audio/video hardware used in the video chat medium, but these were resolved by the third interview through the use of a better microphone. Additionally for participants who were outside of the USA and in locations with ICT connectivity issues, quality of the interview sessions did vary resulting in repetition of questions and answers to ensure the correct understanding was established. These technical issues had no noticeable effects on the participants or their responses.

The response to requests for open conversations was much better throughout the collection process in terms of willingness to participate. These requests were posted in the Ethereum and Bitcoin subreddits and was promoted weekly in IRC, Skype, Slack, and Gitter channels frequented by these respective communities. Ultimately, 16 participants completed the open conversation process out of the

23 people who confirmed that they would like to participate. The abbreviated format of the conversations followed the submitted questions for this study, but were presented in a fashion that expedited their responses to a much smaller time frame. Though the requested time of 10-15 minutes was stated as being more preferable to the 30-45 minutes requested for the semi-structured interviews, both semi-structured interviews and open conversations ended up lasting approximately 45-60 minutes from beginning to end of the call (this included reading, obtaining, and clarifying the verbal consent required for the study).

From the 21 participants in this study, 17 were from various locations in the USA, 2 were from Canada, 1 was from Southeast Asia, and 1 was from Europe. This distribution may be related to the materials and notices for the open conversations being only in English as well as how Reddit provides content regionally based on the IP address of the person accessing the website. Within both the Bitcoin and Ethereum spaces, 13 identified as developers (2 of whom also saw themselves as investors) and 8 identified as investors (only one of whom stated s/he actively attempted to use a cryptocurrency (e.g., Bitcoin)). 3 of the 21 participants stated they tried to use Bitcoin and Ethereum, but only as a secondary consideration to their initial developer and/or investor status. Additionally, only 1 of the 21 participants was a women.

LibreQDA (Muñoz Justicia, Bria, Alonzo Fulchi, Freitas, 2013) was used in the course of coding the interview and open conversation data which is a free, open-source, qualitative data analysis (QDA) program developed in Python. In the course of selecting QDA software, I wanted to ensure anyone who wished to validate my research could do so using the same tools at the lowest cost possible. This software was free to download and build from source; the developers of this project were easy to get a hold of and were very eager to assist me in setting up, using, and contributing to the project. There were some issues related to older Python libraries when building this program from its source code, but the process did not take more than an hour. Once LibreQDA was built and functional within a virtual Python 2.7 environment, I proceeded to code and annotate the semi-structured interviews and open conversations

with 28 unique thematic codes which I then analyzed through 9 complex Boolean queries related to the topics and question with the interview questions (see Appendix A).

History with Blockchain Technologies

Current employment & education background

Of the 21 participants, employment backgrounds varied greatly. Investors generally had business backgrounds or business mixed with some technical education. Developers generally had some sort of technical training related to ICTs. Thirty eight percent of the people interviewed were currently involved with Bitcoin, Ethereum, or some variant blockchain technology as their primary source of income. Their educational backgrounds also varied from high school diplomas to graduate degrees. Due to the relatively new and rapidly diversifying nature of variant blockchain technologies, many people learned about them while directly or indirectly involved with a blockchain project. Education and employment were stated as a minor part of the reason participants decided to consider blockchain technologies in terms of investment, development, or other utility.

Path to Bitcoin/Ethereum and initial goals

Amongst all participants was a mix, to varying degrees, of financial and social reasons for being involved with blockchain technologies. Some were more motivated by the social justice implication of using these technologies while some saw it as a framework by which to build other systems. The participants who saw themselves more as investors were more prone to use blockchain technologies, via their cryptocurrencies, as a way to diversify their investment portfolios. Though the developer and user sentiments also reflected this, it was to a far lesser degree then those pursuing these technologies solely for investment. Developers saw these technologies as a new form of more egalitarian infrastructure, but were mixed in terms of approaching these systems as revolutionary while also seeing them as merely another form of technology they have to master for future employment.

Some participants mentioned issues related to technological divides when getting started in these spaces. This entailed access to blockchain and cryptocurrency-based systems both technologically and geographically. It also related to cultural acceptance of such technologies as viable concepts for both investment and everyday use. Many saw the applications being developed in these spaces as immature and not to the point where the general public could easily use them which added to their interests in and involvement with these technologies. Others were interested in issues of regulation potentially associated with these technologies and cryptocurrencies. One participant saw drastic differences in how US and EU-based entities regulated these technologies from both a business and currency-based perspective. Other participants were more broadly concerned about the potential abstraction and legal restriction of proliferating these technologies via their currency-based functionalities. Some participants pointed to historical precedents of fiat currency manipulation by governments as reason for advancing a libertarian approach to these blockchain systems. This wariness towards potentially impending regulatory measures was related to perceived restrictions on individual economic freedoms, the security of economics assets, and the larger security of social freedoms related to these ICT-based systems.

For participants more focused on blockchain 2.0 technologies, the smart contract and DAO are largely still a developmental goal instead of a distinctive reality as promoted by many blockchain specialists. Investors saw smart contracts and DAOs as critical pieces of infrastructure in the evolution of the markets related to earlier cryptocurrencies as they move beyond their initial economic applications; they were more than willing to invest in related projects as these were seen as inevitable trajectories for these technologies. In terms of those trajectories related to smart contracts and DAOs, developers were in agreement. The expanded functionality of smart contracts and DAOs were stated as providing numerous use cases previously impossible, allowing for increase in user opportunity and utilization. However, many participants agree that much of the continued success of DAOs, smart contracts and blockchain technologies also depends heavily on solving long-standing issues of scalability for various aspects of

systems' infrastructures (this is in terms of the software, hardware, and human dynamics of these systems).

Within the many paths participants took towards their current blockchain-based projects are the underlying and dominant social spaces. For investors, a number of meetings and conferences were credited for their historical path within blockchain spaces. Every participant found out about blockchain-related technologies through another human being that they knew or had talked to at a social event. They also often credit these social spaces for the massive growth of both Bitcoin and Ethereum. These social spaces are tied to political and/or economic goals. For developers, social spaces, whether in-person or digitally facilitated, are part of the trade. Collaboration in these spaces is expected in order to ensure development is coordinated based on the use cases for a given project. These are largely also connected to the same spaces attended by both investors and potential users interested in these technologies.

These interactions also led to many of the participants' involvement in activities centered on code/space related issues. Many participants saw political, economic, and social spaces being effected by these technologies (the context for changing the political and economic were grounded in the dialogues established in social spaces). They saw augmentation of political spaces being forwarded through issues centered on governance, decentralization, immutability, and censorship-resistance which ultimately related to issues of freedom (both economically and socially), security, and deregulation (economically via politics). Due to the proofs-of-process that had been established in the development of blockchain 1.0 into the era of blockchain 2.0, participants largely saw the realm of blockchain 3.0 being the phase of movement beyond the economic decentralized application into the political and social realms.

Current Involvement with Blockchain Technologies

Current involvements, relations, and considerations

Many of the participants' primary means of income was through labor on or for blockchain technologies. While some people trade on the currencies, most are developing various systems, either in

terms of businesses or software frameworks. They are paid with a varying amounts of equity, digital currency, and cryptocurrency depending on the particular relationship or project. Though some are developing and consulting on these technologies by themselves, most are working with groups that assist in supporting the development of the software/hardware/business in addition to promoting the concepts and systems' growth. In the course of the interviews, participants would often mention or recommend talking to other key figures in related communities of developers and investors that they knew personally or through conferences/business networking. These relations would often be those that supported a certain type of development or investment to which they themselves adhered.

Their ethical considerations also varied broadly. Investors would not consider engaging with activities that were traditionally seen as illegal within the context of national and international laws. The developers and users were a bit more open in discussing how these technologies should be used to challenge current paradigms of control and access even if that disruption was perceived to be illegal by their respective legal systems. In terms of regulation, some participants did see a need to have reputation systems and legal integration in place to some extent for these systems in order to ensure some form of recourse for people with significant holding in these systems. However, this often comes into conflict with their liberal economic sentiments that are often regulatory-adverse. In terms of security, most participants saw the liquid nature of cryptocurrencies as a plus, especially in terms of regulations surrounding taxes, tariffs, and international portability/fungibility. However, most people with cryptocurrency assets also have them as part of a diversified portfolio of other investments (such as gold, land, and other properties). A few participants pointed to the proliferation of exchanges for cryptocurrencies as symptomatic of this tendency to play cryptocurrency markets like other markets (e.g, speculation, flash trading, etc.).

Participants did see varying degrees of the technical divide. Those who had more exposure to development of these technologies saw these systems as easier to use and to expand, but all agreed that these systems are largely not user friendly despite the large leaps made in accessibility and user interfaces.

Both investors and developers are focused on promoting these technologies to non-technical audiences; this extends to those who cannot run or access physical infrastructures (e.g., mining hardware, computational resources). Bridging this divide largely depends on solving issues of scalability, which all participants agreed was the primary requirement for all developers and were optimistic that this could be accomplished. It was also stated that many developers and investors are coming into these spaces with a focus on blockchain 2.0 and 3.0 applications. These participants and others are being compensated to build the requisite infrastructure that boosts the utility and ultimate productivity of a given blockchain framework (e.g., development of key software, investment towards development, maintenance of existing infrastructure). However, there is still the persistent concern regarding the implications surrounding proof-of-work for people entering blockchain spaces.

All participants are heavily engaged in persistent contact with their social circles. Developers collaborate and socialize largely through the use of chat rooms and forums. Investors are largely the same way with an increased emphasis to meet in person, often at conferences or periodic community meetings. Within these spaces, participants often suggested that these provide a forum for persistent project funding. There is often a pressure for developers to not only develop towards a use case, but to also develop towards a viable product that could be commodified for sale (e.g., a proprietary derivative product from an appropriately licensed open-source project, enterprise service contract for an open-source projects, supporting applications for an open-source project). The fervor for this kind of social space is often compared to the early days of the modern Internet. However, in terms of these code/spaces, developers are still perceived as the dominant party in guiding the technologies' evolutions and the resultant relations to infrastructure and varying scales of social space.

Politically, there is still a large focus on how government regulation could affect the development and evolution of these technologies. Overall, the concern is directed at the currency aspect of the system as investment. Additionally, there is the related concern of business development via compensation for developers and users and return on investment for investors. All participants suggested that user-focused

applications are becoming more common and as true users of these systems increase, so will the applications accompanying political force. However, all participants have stated that there are no great or revolutionary user applications currently available; applications are still largely developer and investor-centric[3]. The overarching sentiment across all participants is that these systems should be used to help people. However, the definitions and context of help varied from case to case, largely depending on their position as a developer or investor and their political, economic, and/or social perspectives.

Exposure to smart contract and DAO concepts

All participants were aware of smart contract and DAO/DAC concepts and were eager to see where they would go in the near future. Developers were far more optimistic about the implication whereas the investors were a bit more apprehensive about such systems where loopholes could be found and exploited, ultimately draining their assets and collapsing the system (Mt. Gox[4] and theDAO hack[5] were mentioned in reference to these security concerns). All agreed that this specific form of the blockchain implementation needed to be researched and developed much more before it actually meets the current expectations and market hype. There are an increasing number of social spaces that are emerging to support both the development and investment aspect of smart contracts and DAOs. However, there are still concerns about the viability of these frameworks as they currently stand and their legality within current jurisdictions around the world. A few of the participants are actively involved in developing a DAO at this time and agreed with the above considerations in the course of their work. As mentioned before, many of these projects are key infrastructural pieces related to larger blockchain frameworks, but participants did point to a few user-level projects currently under development. In both

3 To expand on this, I understood participants responses towards this as applications that exist today replicate existing applications or have been developed via investment in some key piece of blockchain infrastructure.

4 Mt. Gox was a Japanese-based Bitcoin exchange that was hacked in 2011 and then filed for bankruptcy in 2014 after it was revealed that $480 million USD worth of Bitcoin was reported lost or stolen.

5 theDAO is a decentralized autonomous organization founded on the Ethereum blockchain. Its purpose was to fund commercial and non-profit ventures. This DAO was hacked in June of 2016, resulting in a loss of 1/3 of its total holdings (approximately $50 million USD). This resulted in a hard fork (implemented in July of 2016) that reversed the hack of theDAO. Those who disagreed with the hard fork split from the new canonical blockchain from Ethereum, opting to mine the blockchain form which maintained the hack ultimately resulting in the formation of Ethereum Classic.

cases, investors are extremely eager to support and invest in these projects (often opting for smart contract and DAO-based projects over more traditional alt-coin, cryptocurrency-based investments).

Future Plans and Predictions

Areas of impact

Many of the participants saw these technologies and their related cryptocurrencies as a disruption of existing economic systems. Investment and development of these technologies and the people who use them are essential to their aim of moving away from existing fiat- and credit-based systems of digital currency/finance towards a means of peer-to-peer exchange based on their sentiments of value. Some participants were convinced that current national and regional fiat currencies and the current economics systems were going to fail and in turn they stated that this was a way to ensure their net worth was somewhat hedged (even if it is only within their communities related to these technologies). There are great concerns around exactly how value is defined and eventually traded between other forms of value. Participants pointed to development tooling and user interfaces being keys to solving these issues from present into the future. However, these have to be related to applications that expand decentralization beyond the economic into areas of data storage, different forms of consensus, and other blockchain 3.0 applications.

Participants also saw the use of these technologies being critical in forwarding certain types of social change, such as increasing democracy via voting and making access to these blockchain systems more simple through consultancies and tailored solutions based on the blockchain. It was pointed out that these technologies will continue to be increasingly disruptive in many economic and political arenas without signs of slowing; many see these technologies becoming increasingly important in grassroots-based efforts.

Guiding forces

Geopolitical and geo-economic instability drove most participants towards these alternative economic/political/social solutions. Because of the distributed nature of these architectures, they were concerned with keeping the power in the hands of the people writ large via their direct involvement with these technologies. However, they were unclear and/or unsure as to whether knowledge could easily foster trust in these systems as an alternative to fiat- and credit-based systems despite the implicit need for public trust and public access to these systems. Many saw these technologies as a new field of development and investment based on business models that form around them for various customer bases (many of which are still emerging in areas of finance, government, and Department of Defense applications). They were also unsure of what other forces were ultimately going to guide these technologies and what direction those forces might be headed in. Many saw the people (whether directly or indirectly involved with the systems) as the primary force driving the forms and paths for these technologies via their use cases. However, looming uncertainty surrounding regulatory frameworks from governments around the world was stated as being a key concern for how business and development efforts would evolve moving forward globally.

Technologically, the biggest guiding forces are the issues of scalability and consensus. Due to the manner in which blockchain frameworks are constructed, participants felt there may be issues related to the current proof-of-work paradigm and the related hardware/software issues developers are currently working to solve. Some developers have started to move towards private/permissioned blockchain projects due to these issues. Regardless, immutability and trust of data on the blockchain is one of the most attractive features mentioned by participants; economic rationale was the most dominant guiding force mentioned during the interview process. The goal of many investors toward development projects is reduction of volatility, such as that seen in Bitcoin (despite it being the most demanded cryptocurrency). There was a sentiment that over time, frameworks were geared towards applications that were increasingly stable in their processes and that would be more appealing to invest in/utilize. Everything

from notary applications to data storage, proven functions that are made vastly better by blockchains, are seen as far more appealing than the creation of a cryptocurrency. A few participants pointed out that there is possibly an internal contradiction in that proof-of-work requires some sort of token to function and therefore the blockchain as currently conceived in any form cannot be separated from some form of cryptocurrency. I also observed investors reference the volatility of these systems, along with their inherent risks, in terms of fiat currencies (even in terms of future economic considerations). Overall, developers were focused on providing solutions to current use-case challenges while investors were focused on finding places within current economic and political paradigms for which blockchains would provide a solution to a customer (even if the customer was them).

Accessibility

Almost all participants stated that access and involvement in any number of blockchain systems has become much easier over time (this was considered by all to be a very rapid shift from 2009 to the present). This was thought to be due to increasing participation and investment in these systems by a vast array of people. Everything from simplified wallets to online exchanges have made access much easier for the newcomers which helps new developers and investors see these technologies as an increasingly solid investment of digital monies and time. They all stated that there is still no good answer for how to get these technologies in the hands of existing disadvantaged communities, but they were also equally confident that these technologies held the potential to solve existing inequalities found in current economic and political systems. There is still a wide divide in understanding of what these technologies are, even amongst some developer and investor communities around the world. This makes even the use of established cryptocurrencies like Bitcoin difficult (these are related to persistent considerations of volatility in these spaces). User interfaces are seen as the primary deterrent for new users of these technologies as these spaces are still seen as developer-dominant.

Ethics

This was by far the most difficult concept for the participants to define in terms of how these technologies should be used, invested in, and developed. Regardless of where the participants fell in terms of categorization as a user, developer, and/or investor, they had varying thoughts and pauses regarding ethics in the realm of blockchain technology. Most ideas congealed around two main areas: how one defines value; how one views people and their time. The overarching, yet fairly nebulous idea, is that current economic systems do not preserve people's value or their time, yet they had a difficult time explaining how these new systems would do any better. There was hope that DAOs, once beyond their current problematics, would foster new forms of trust in economic systems that would be geared towards people helping people, but the near term path for that has yet to be found.

Due to the developer dominance in these spaces, ethics will largely manifest in the code they write per use case. The complication of user interfaces per these use cases will complicate that paradigm as it touches back on previous points related to a technical divide and the scale of the systems. Some participants focused on their social spaces to ground an ethic; whether that was for their family's welfare, a particular agenda of activism, or an economic/political paradigm. However, these same people also depend on other people/organizations with money to pay them for a service they are willing to buy. Some participants identified numerous balances in this socio-economic bifurcation between investment and development within several aspects of these systems given a particular implementation. Many participants relegated their ethical consideration to staying within their respective regional legal frameworks. Others stated they had no real ethical consideration as it is people using the systems that decide the ethics; the frameworks in these cases are seen as having no implicit politics. However, it was also stated this becomes harder to say when applied to smart contracts and DAOs. Participants pointed to automation, democratic DAOs, personal freedoms, intellectual property, patents, trust, transparency, anonymity, whitelisting, blacklisting, libertarian sentiment, corruption, privacy, malicious hacking, censorship,

technological limitations, and weaponization as current and future ethical considerations, but few had any answers as to how these could be avoided via actions on the part of developers, investors, or users.

Gray Literature and Other Sources

Initially, this process proved challenging as the Reddit EULA had numerous stipulations regarding scraping and use of published data. Attempts to use the Python Reddit API Wrapper (PRAW) library with the Beautiful Soup library produced retrieval of the records structured as desired for analysis, but these records were often random and the subreddit would have to be queried numerous times, returning no more than 100 records per request and possibly exceeding the limitations of Reddit's user agreement. This process of requesting and de-duplication of the chronological publication history for each subreddit proved difficult and never yielded more than 1000 unique records. Due to restrictions on the number of records that can be pulled from Reddit, I opted to analyze the top 1000 posts over the lifetime of three subreddits (3000 total records): /r/ethereum; /r/Bitcoin, and /r/EthereumClassic. This data was gathered for the last time on 26 December, 2016 using the Scrapy Python library. The web scraper was setup in compliance with the Reddit EULA and robot.txt file, pulling the public-facing data from each subreddit. This data set contained the following initial schema per subreddit: title; author; relative time of publication to date (26 December, 2016); date-time group of the subreddit post; tagline; and number of comments. All figures in the results section were created by the author with the exception of Bob Summerwill's dependency diagram (Figure 16b).

Ethereum, Bitcoin, and Ethereum Classic Subreddits[6]

Once the data was obtained from the scraping process in the aforementioned format, I needed to parse out the expanded date-time group into its individual components and convert the comments column into an integer value. The schema following the competed ETL (extract-transform-load) process is:

6 The tools I developed (including the scraper, Jupyter notebook, test data, and images) to analyze the subreddits can be found at: https://github.com/joeblankenship1/thesis_blockchain

author; tagline; time_rel (relative time of post from date of viewing); comments (' comments' removed; now an integer value); title; dow (day of the week 3-letter); mon (month 3-letter); day (1-31); time (24 hour clock); year; tz (timezone); dtg (date/time group as ‘yyyy-mm-ddThh:mm:ss+hh:mm’ with the final +hh:mm as time zone from UTC). Since this was a data set of 3000 records from all three subreddits, it was easier to parse the date-time information pre-analysis. However, in larger data sets, date-time functionality within the Pandas library would be used on the sample data within the ETL process. To perform the analysis, I used Jupyter Notebooks with a Python 3 kernel and all of the following graphics were produced using the matplotlib Python library. All software projects used for data collection and analysis are open-source which are free to download for validation of my methodology and results; the Jupyter Notebook and other documents can be viewed directly on GitHub.

I began my data exploration with a focus on the authors. I graphed a count of posts per unique author in each subreddit (Figure 1a, 1b, 1c). This was done in order to establish which online entities had published the most top-rated threads in the subreddits history. I then proceeded to explore and plot the number of comments received per author post from the top 1000 posts. These were sorted from most to lease comments received for a single post along with the author’s name and the title of the post (Figure 2a, 2b, 2c). I then added the total number of comments received per unique author in each subreddit (Figure 3a, 3b, 3c). The above methods were performed to assess if one or more entities in these subreddit communities could be seen as ‘leaders’ in the sense that they persistently post and have the ability with those posts to draw participation (via the number of comments) amongst people in that community. We can then look at the titles of these posts to see if they are addressing or participating in key discussions in the history of their respective communities.

I also want to examine if authors from one subreddit community are involved in discussions from another subreddit. I first obtained a count of unique authors from each subreddit (Figure 4). The Bitcoin community had, as expected based on the length of time since the community’s conception, the most diverse number of contributors, followed by Ethereum, and finally Ethereum Classic. I then compared

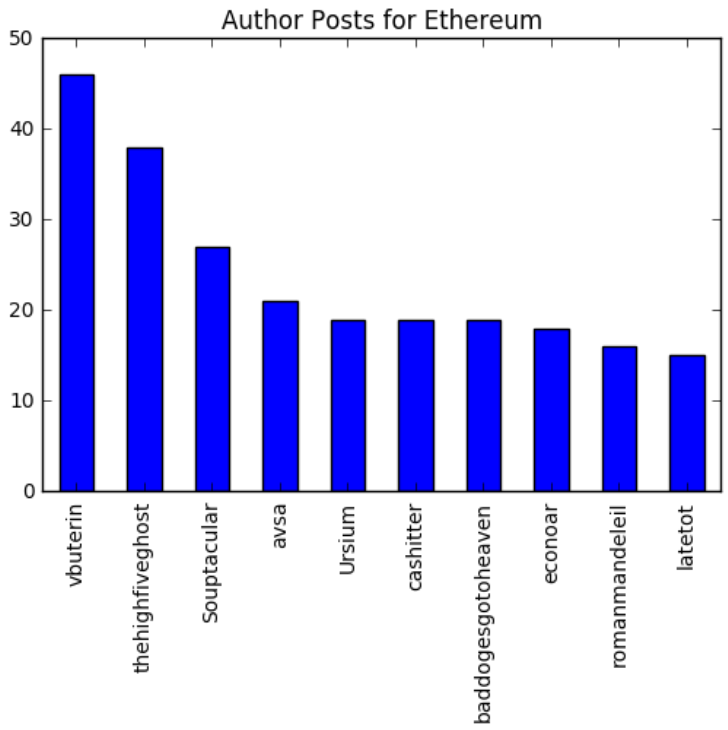

Figure 1a: Author posts for Ethereum

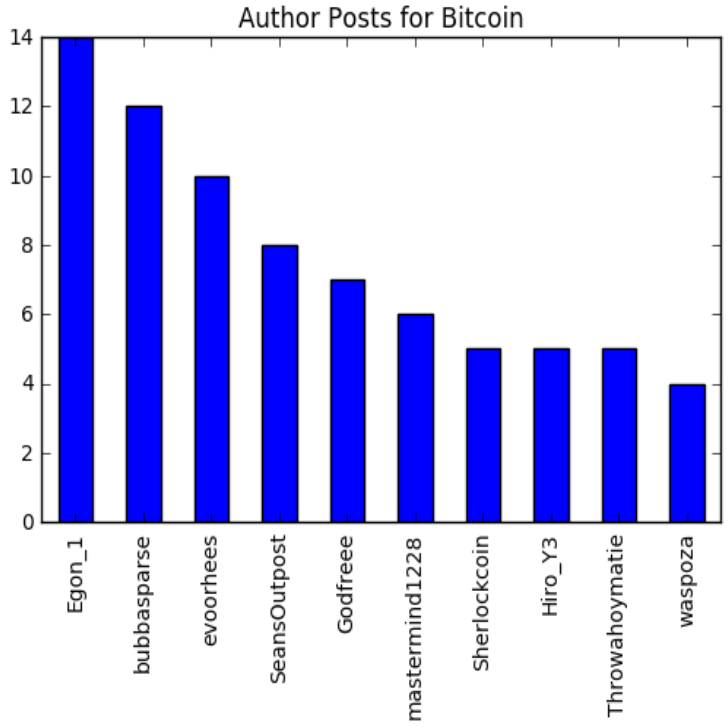

Figure 1b: Author posts for Bitcoin

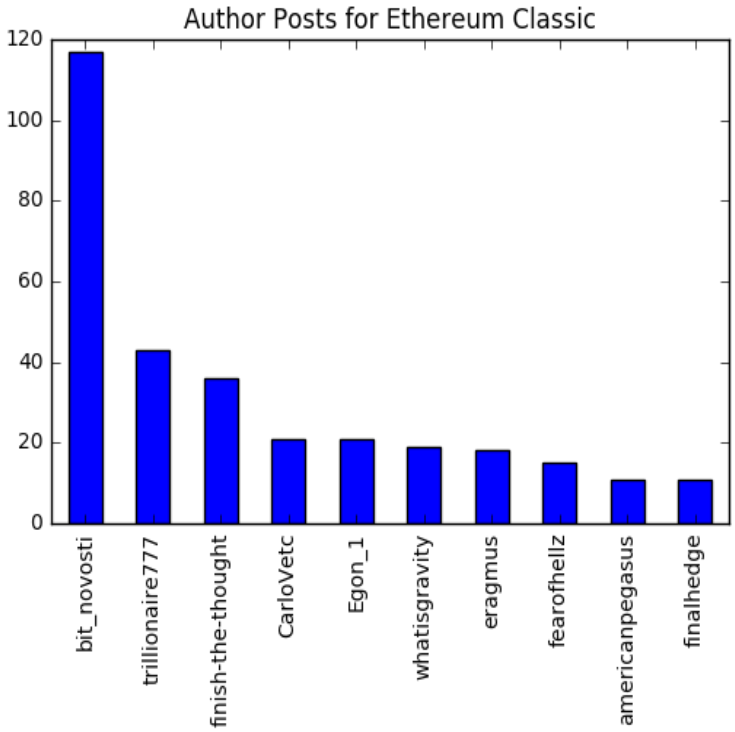

Figure 1c: Author posts for Ethereum Classic

	author	comments	title
36	thehighfiveghost	1006	Critical update RE: DAO Vulnerability
0	vbuterin	843	Personal statement regarding the fork
74	latetot	558	The ability to reverse exploits that violate t...
17	vbuterin	509	The Current HF Status
53	AttaAtta	494	An Ethereum hard fork is not a bailout it's fo...
25	Rune4444	482	A "too big to fail" political hard fork is ver...
168	VoiceOfTheEvolution	392	Devil's Advocate: What incentive is there for ...
10	ledgerwatch	390	I think TheDAO is getting drained right now
42	GloomyOak	374	It seems attacker just targeted the WhiteHatDAOs
148	ProHashing	369	Why Ethereum should fork

Figure 2a: Highest number of comments on unique post by author – Ethereum

	author	comments	title
794	zanetackett	2713	Bitfinex security breach: Trading will be halt...
76	evoorhees	2137	Some words for my friends
410	BenLawsky	2129	Hi, this is Ben Lawsky at NYDFS. Here are the ...
13	hexdump	2100	Silk Road operator Ross Ulbricht to sentenced ...
89	Zomdifros	1843	The Face Behind Bitcoin: Satoshi Nakamoto is.....
366	josiah__Coinsetter	1658	IRS declares Bitcoin as property, not currency
103	SecretCheese	1567	Silk Road website founder Ross Ulbricht found ...
36	l0gz	1511	REAL Satoshi Nakamoto denies being Dorian Naka...
15	evoorhees	1455	Open Letter to Michael Casey - WSJ reporter wh...
238	WeAreMtGox	1400	We are Mt. Gox: AMA

Figure 2b: Highest number of comments on unique post by author – Bitcoin

	author	comments	title
188	ttggtthhh	162	Alex van de Sande (/u/avsa) and the rest of th...
22	jbaylina	144	Follow Up Statement on the ETC Salvaged from a...
59	publius2050000	128	Declaration on the Future of Ethereum Classic
48	slacknation	121	white hat went rogue
9	biglambda	99	Vitalik Buterin says he won't support ETC even...
88	TheRandyMagnum	98	Charles Hoskinson on ETC, "Devs are coming."
179	LGuappo	97	Serious question: What do you guys think the a...
99	Newbium	97	Barry Silbert To Buy ETC Until It Reaches ETH ...
1	bit_novosti	96	Hard fork went smoothly, Ethereum Classic chai...
0	bit_novosti	94	Call for action: What can I do to help Ethereu...

Figure 2c: Highest number of comments on unique post by author – Ethereum Classic

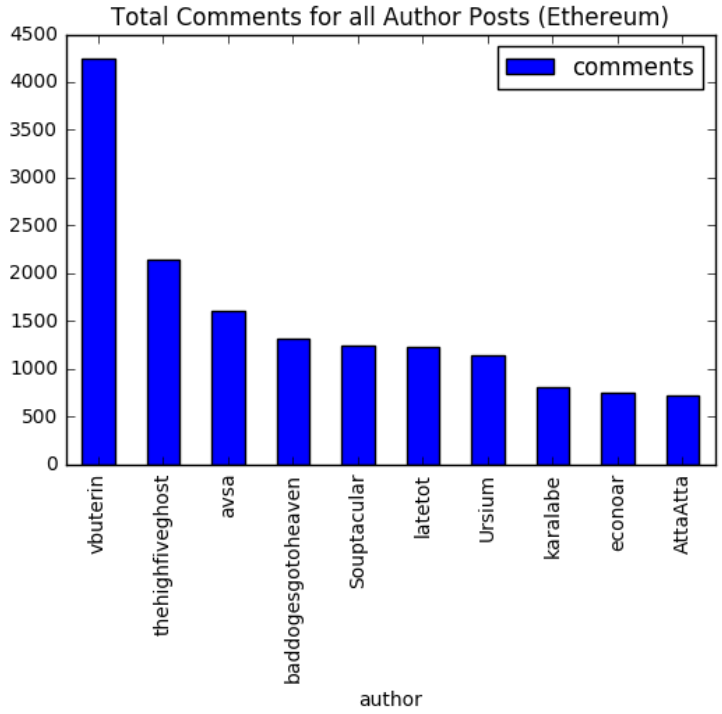

Figure 3a: Total number of comments per author for all author's posts – Ethereum

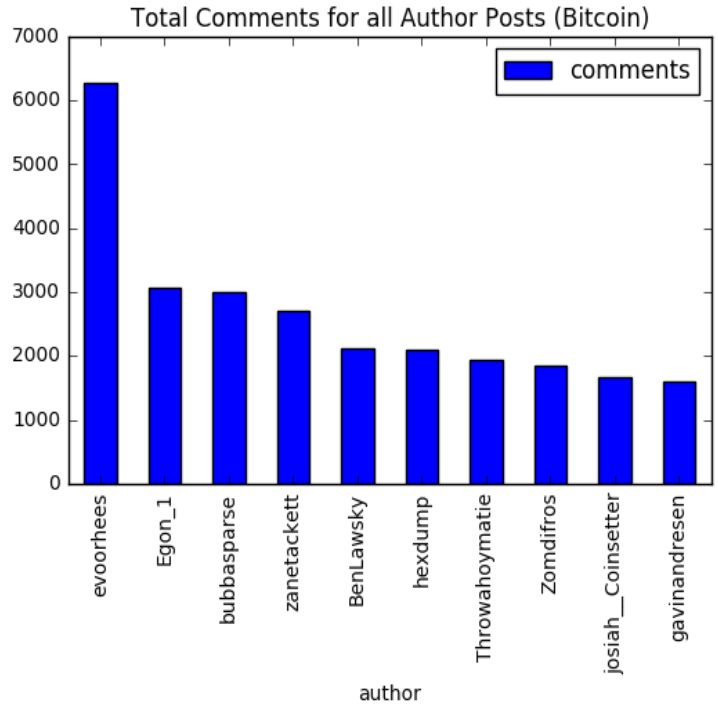

Figure 3b: Total number of comments per author for all author's posts – Bitcoin

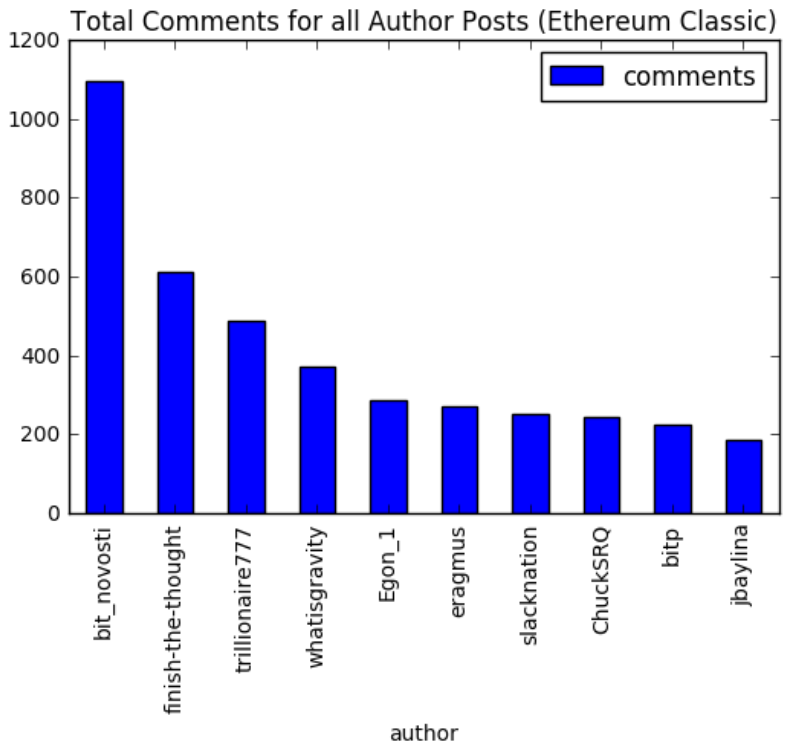

Figure 3c: Total number of comments per author for all author's posts – Ethereum Classic

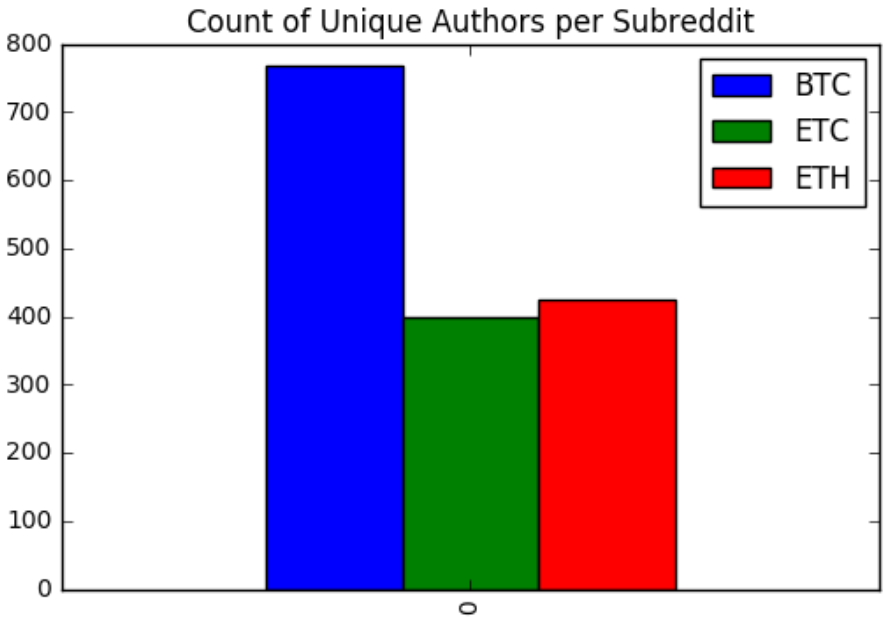

Figure 4: Count of unique authors per subreddit

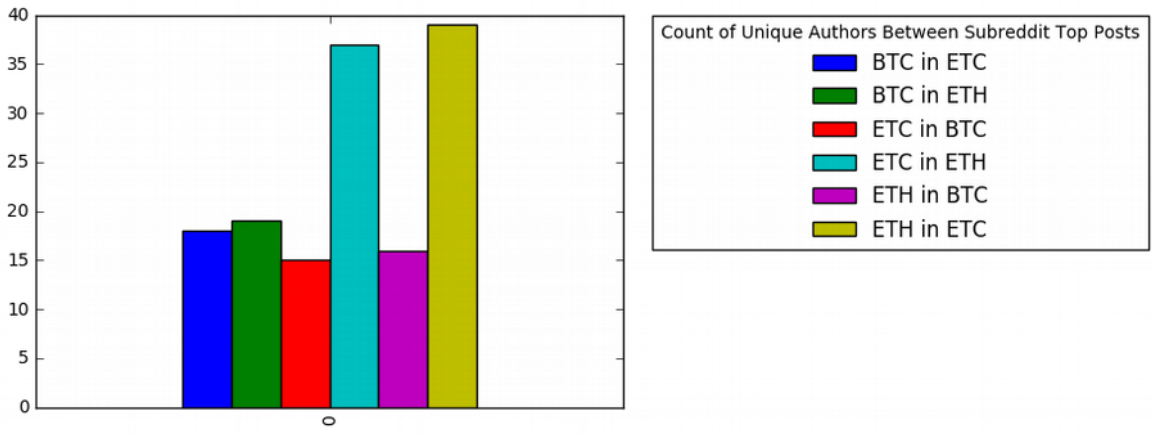

Figure 5a: Count of unique authors between subreddit top posts

	BTC in ETC	BTC in ETH	ETC in BTC	ETC in ETH	ETH in BTC	ETH in ETC
0	18	19	15	37	16	39

Figure 5b: Table - Count of unique authors between subreddit top posts

names	btc_in_eth	eth_in_btc	btc_in_etc	etc_in_btc	eth_in_etc	etc_in_eth
nugget_alex	0	0	0	0	1	1
FredEE	1	1	0	0	0	0
Jusdem	0	0	0	0	1	1
instantether	0	0	0	0	1	1
ChuckSRQ	0	0	0	0	1	1
idlestabilizer	1	1	0	0	0	0
insomniasexx	0	0	0	0	1	1
AroundTheBlock_	0	0	0	0	1	1
Bidofthis	1	1	0	0	0	0
fearofhellz	0	0	1	1	0	0
Joloffe	0	0	0	0	1	1
Tralx	0	0	0	0	1	1
adiiorio	0	0	0	0	1	1
OperationNine	0	0	0	0	1	1
alistairmilne	0	0	1	1	0	0
Satoshi-	0	0	1	1	0	0
finalhedge	0	0	1	1	0	0
bitcoinsberlin	0	0	1	1	0	0
romanmandeleil	0	0	0	0	1	1
evoorhees	1	1	0	0	0	0
drcode	1	1	0	0	0	0
101111	1	1	0	0	0	0
kyletorpey	1	1	0	0	0	0
americanpegasus	0	0	1	1	0	0
Sherlockcoin	1	1	0	0	0	0
jbaylina	0	0	0	0	1	1
BokkyPooBah	0	0	0	0	1	1
raithe1337	0	0	0	0	1	1
bookelections	0	0	0	0	1	1
cap2002	1	1	0	0	0	0
madhatter3D	0	0	0	0	1	1
bitpotluck	0	0	1	1	0	0
lcvella	0	0	0	0	1	1
lozj	0	0	0	0	1	1
CrystalETH_	0	0	0	0	1	1
Ezekial25	0	0	1	1	0	0
vbuterin	1	1	0	0	0	0
Egon_1	1	1	1	1	1	1
bdarmstrong	1	1	0	0	0	0
zanetackett	0	0	1	1	0	0
seweso	0	0	0	0	1	1
aakilfernandes	0	0	0	0	1	1
Crypto_Economist42	0	0	0	0	1	1
hermanmaas	0	0	0	0	1	1
MemoryDealers	0	0	1	1	0	0
BitcoinXio	1	1	0	0	0	0
jespow	0	0	1	1	0	0
zr1trader	0	0	0	0	1	1

Figure 6: Table of authors found in one subreddit who have published in another subreddit

unique authors in one subreddit to those in the other, generating a graph of comparison between the three communities (Figure 5a, 5b). The most inter-community exchange was found between Ethereum and Ethereum Classic which is to be expected due to the recent Ethereum hard fork. There is a slight trend in that authors from newer communities are not seen in the top posts of older communities. This does not mean that authors from one subreddit are not involved in another; this is only in terms of an author producing top posts in each of the subreddit communities. I then produced a table to view all authors who were seen between one or more subreddit's top posts (Figure 6). There was only one unique author that was seen across all three as receiving one or more top 1000 posts.

I then proceeded to explore the temporal aspect of the data through a time series analysis of the date-time information in relation to the other data types from the subreddit data sets. I started with an examination of general time frames as referenced from the date of the final webscrape for the three subreddits' information (26 December, 2016 which from this point will be reference as the date of information or DOI). For Ethereum: the bulk of top posts made in the Ethereum subreddit were made in the last year from the DOI (Figure 7a); this is confirmed by the vast amount of all top posts in 2016 as shown in the visualization of top post per year for Ethereum (Figure 8a); the bulk of all their top 1000 posts have occurred between Jun and August with a significant amount concentrated at the end of the calendar year (Figure 9a); the bulk of top posts occurred during the work week (Monday through Friday) (Figure 10a); in terms of day of the month, there are more top posts that occur towards the end of the month than in the beginning (e.g., after the 15th) (Figure 11a). For Bitcoin: the bulk of Bitcoin's top posts were made over the last three years, but with very few originating in the last year from DOI (Figure 7b); this is confirmed by the vast amount of all top posts occurring in 2014 followed by 2015 and 2013 in the visualization of top posts per year for Bitcoin (Figure 8b); the bulk of all top posts have occurred between November through April of the following year with May through October being noticeably lower (Figure 9b); like Ethereum, most top posts have occurred during the work week (Figure 10b); there is no noticeable pattern for the times of the month for top posts in the Bitcoin subreddit, but the beginning of

the month does appear to be slightly more active with a spike occurring on the 9th (Figure 11b). For Ethereum Classic: Ethereum Classic has only existed since August of 2016, but the bulk of top posts are from around the August-October time frame from DOI which is also reflected in the year visualization (which is only 2016) (Figure 7c, 8c); July and August were the peak top post months for Ethereum Classic (Figure 9c); the work week is also when the bulk of posts are made (Figure 10c); in terms of time of the month, the final week for all the months that Ethereum Classic has existed has produced the largest number of top posts (with a spike on the 26th) (Figure 11c).

The date-time information was analyzed as such to first examine patterns and trends within and between the subreddits top post activity. Secondly, it was done in preparation to explore how temporal effects may influence intra-community dialogues or how these may interact with the other subreddit communities in terms of the authors' posts or community issues that may be shared between these three subreddits in or around the same times. I programmed a tool to examine specific authors within a subreddit given a particular time frame. I was then able to examine the top authors (top author being defined via the number of posts made and the number of comments received for specific posts within the collection of top posts per subreddit)
during the different peaks in activity for the each of the date-time categories available for the data.

Following the brief examination of the authors, comments related to the authors, and the temporal activity within each of the subreddits, I moved on to examine the title content within and between these subreddits' top 1000 posts. For this purpose, I programmed and used two primary tools: word clouds and word frequency tables. I first created functions that parsed all the title text information into a file, removed non-essential punctuation, converted all text to lower case, and then generated word clouds for each subreddit. These word clouds essentially visualize the word frequency found within each subreddit corpus and graduates the word's size in accordance with its count within that corpus. I then programmed functions that would produce word frequency tables and summaries of those tables to compare to the word clouds (a custom stop word list was used). The word clouds and word frequency tables were

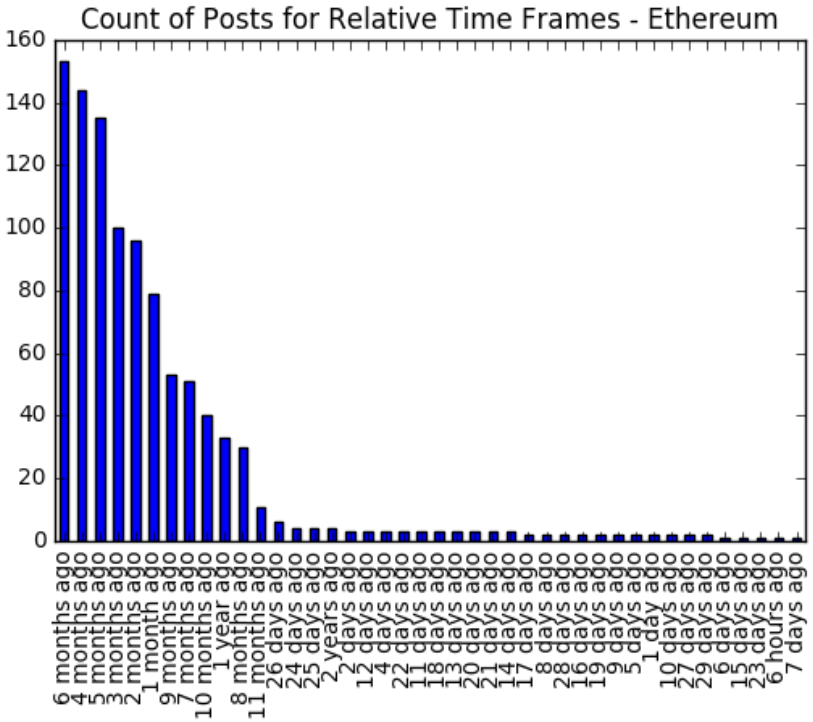

Figure 7a: Count of posts for relative time frames – Ethereum

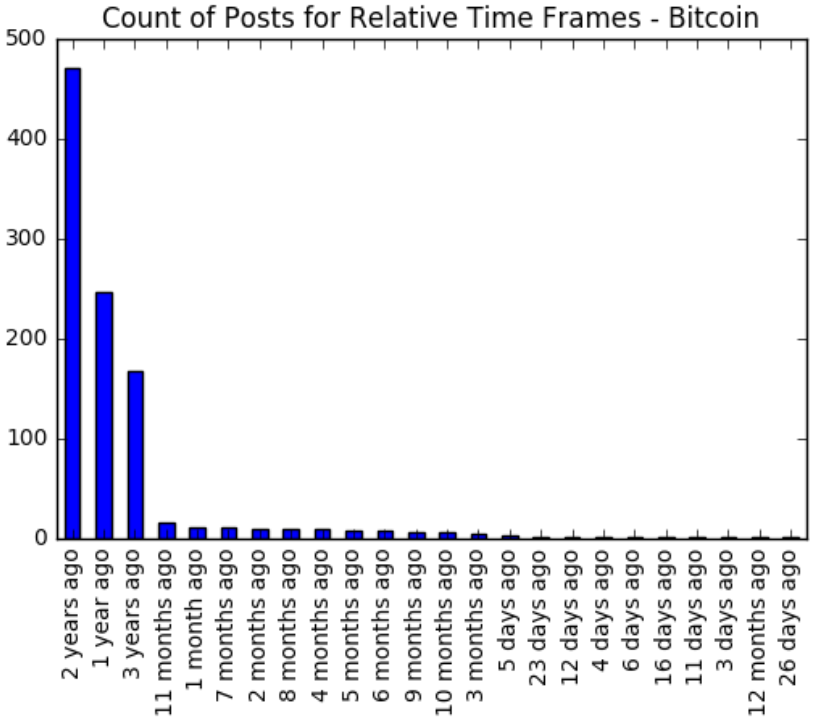

Figure 7b: Count of posts for relative time frames – Bitcoin

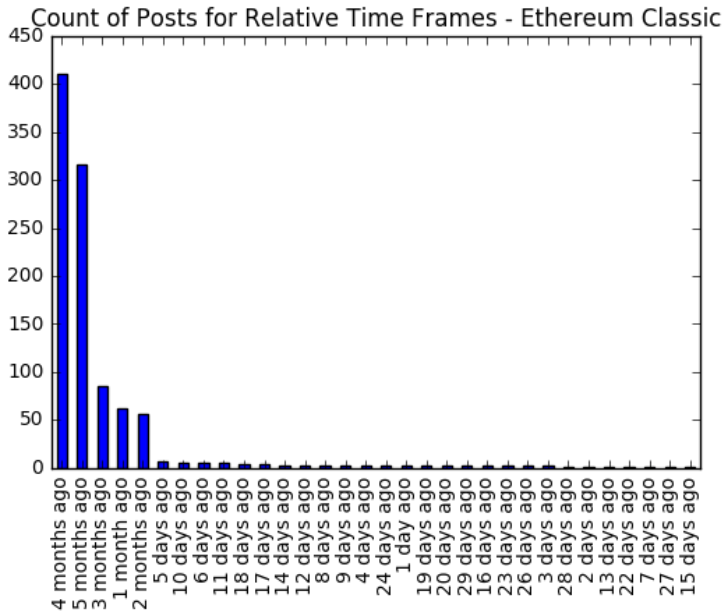

Figure 7c: Count of posts for relative time frames – Ethereum Classic

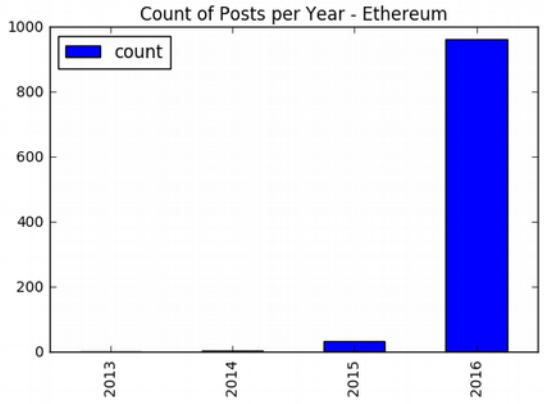

Figure 8a: Count of posts per year – Ethereum

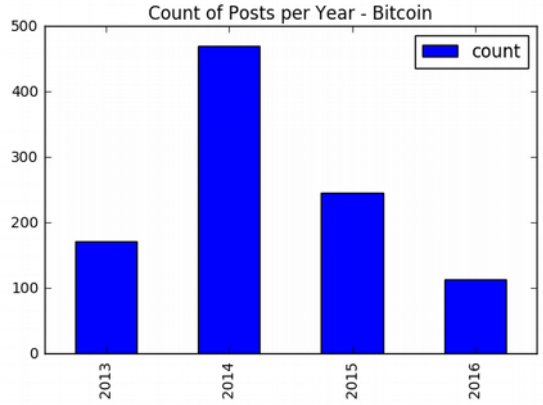

Figure 8b: Count of posts per year – Bitcoin

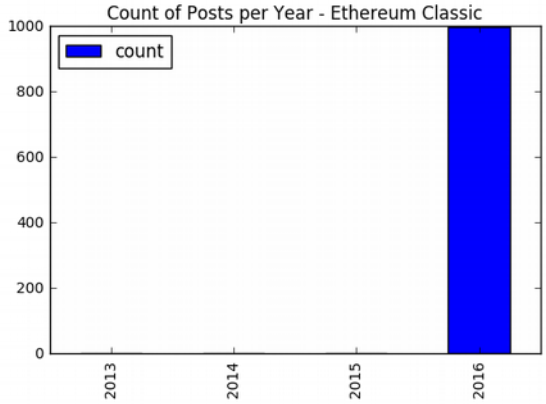

Figure 8c: Count of posts per year – Ethereum Classic

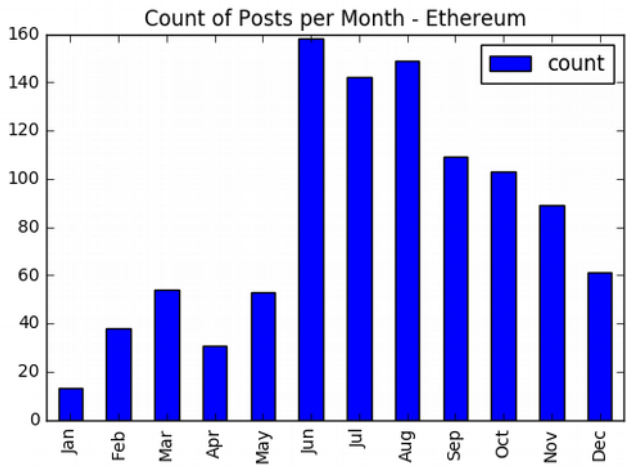

Figure 9a: Count of posts per month – Ethereum

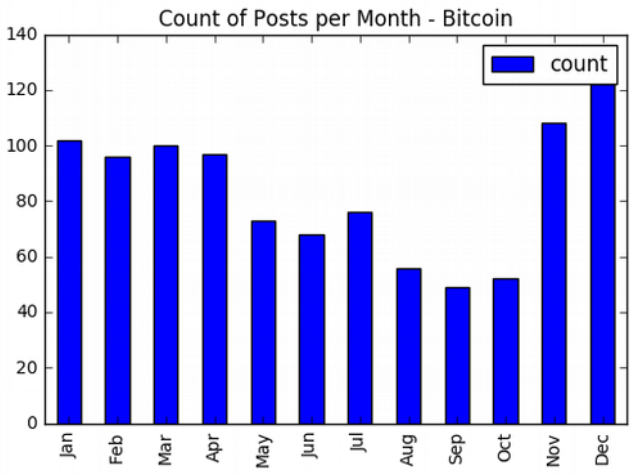

Figure 9b: Count of posts per month – Bitcoin

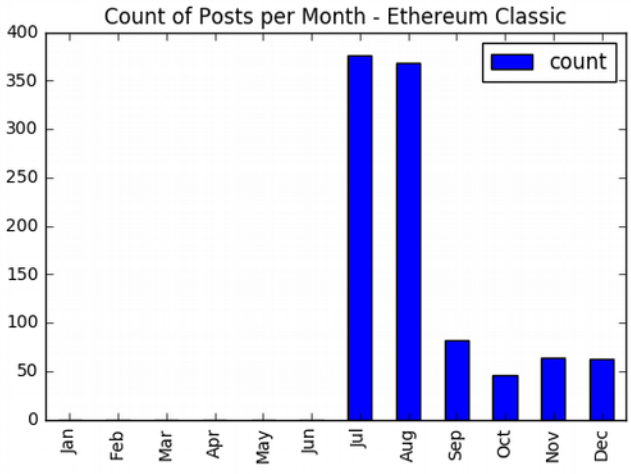

Figure 9c: Count of posts per month – Ethereum Classic

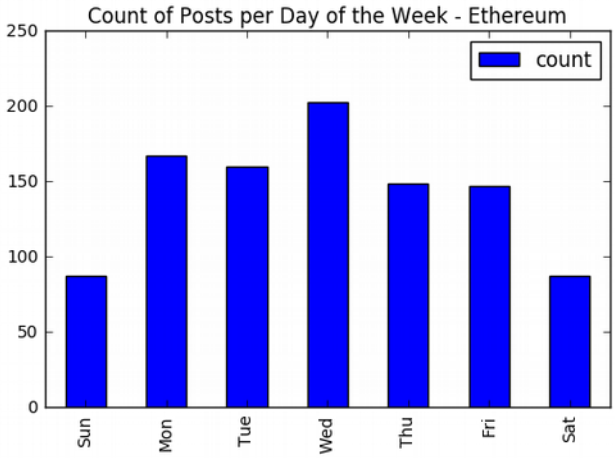

Figure 10a: Count of posts per day of the week – Ethereum

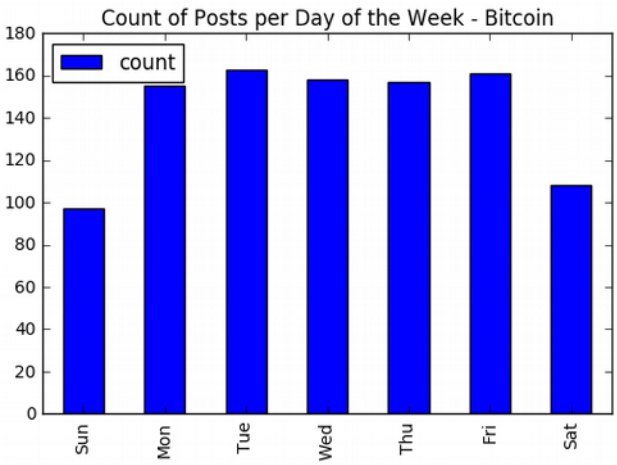

Figure 10b: Count of posts per day of the week – Bitcoin

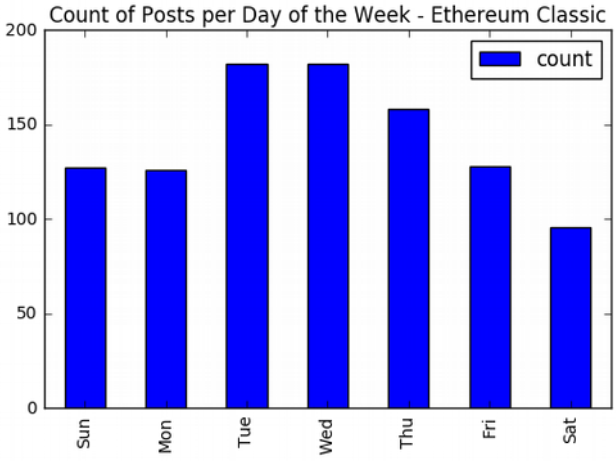

Figure 10c: Count of posts per day of the week – Ethereum Classic

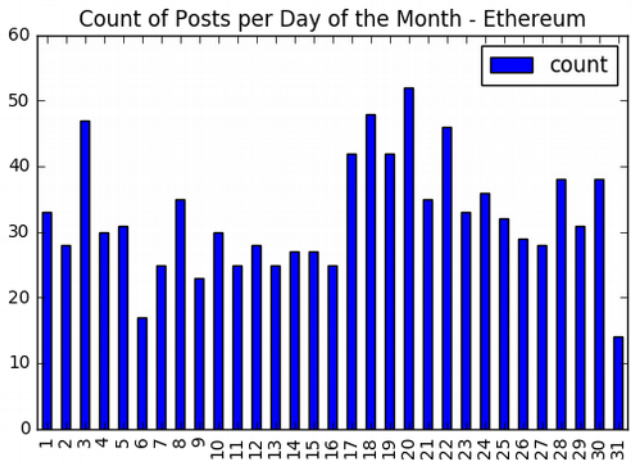

Figure 11a: Count of posts per day of the month – Ethereum

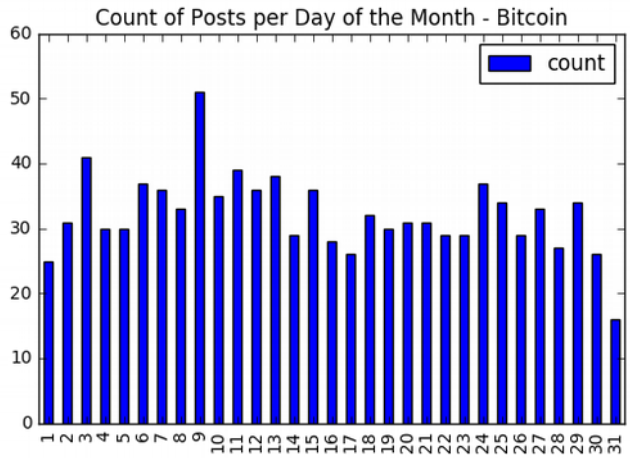

Figure 11b: Count of posts per day of the month – Bitcoin

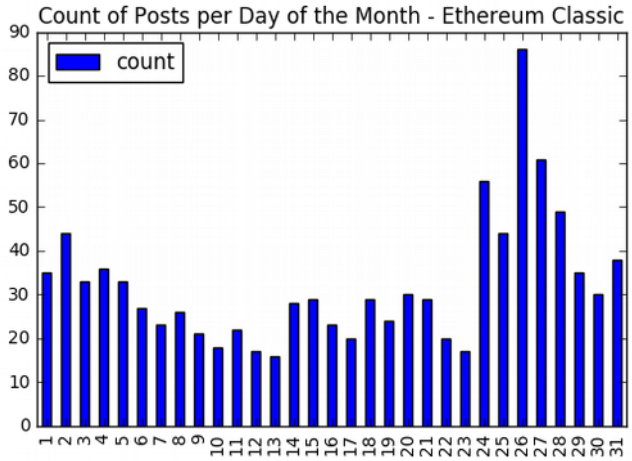

Figure 11c: Count of posts per day of the month – Ethereum Classic

generated in order to gather an overall sentiment of the content and discourses within the collection of top posts within each subreddit community. This allows for a preliminary examination of trends and patterns found in the collection of titles for the most popular topics of discussion between all three subreddits.

To further the interrogation of the subreddits' content, I developed additional tools for their analysis. Using the already generated word frequency tables, I made it possible to remove a selected number of top terms found in each subreddit and then generated a new word cloud to more easily examine the changes in word graduation and potential relations. This was followed by creation of another function that would generate word clouds for a specific author in a specific subreddit with the added option to remove a selected number of their most used words. These were developed in order to ask more direct questions related to the authors, time frames, and the larger communities as they develop intra- and inter-community dialogues on blockchain-related topics. Functions were also developed to examine the top titles for an author in a specific subreddit as well as a word cloud generator for a subreddit's specific element within a specific time frame. Used together, these functions can assist in understanding how a leading author's post may influence other conversations within and between subreddits as well as how the influence may relate to other events surrounding the author's post. At this point, I also thought it essential to develop an interface for comparison of my interview data to the content found in the three subreddits' top 1000 posts. As a result, word cloud and word frequency functions were developed for the interview and open conversation data.

Preliminary results from the above analytic tool outputs and a deep reading of the actual title content for the total corpus of 1000 top posts from the Ethereum subreddit revealed that most posts focused on the hard fork which was performed in August of 2016 to recover the funds lost during the DAO hack which inadvertently created Ethereum Classic (Figure 12a, 12b). There is also a focus on the blockchains application for smart contracts with specific attention on the Geth implementation of the Ethereum framework (and to a lesser extent the Parity implementation). Vitalik Buterin is mentioned frequently (he is also a persistent contributor and has many top posts within the data set). There is also

Figure 12a: Word cloud for all words in subreddit – Ethereum

	word	count
2085	ethereum	387
2586	fork	98
2794	eth	78
2013	dao	76
511	blockchain	74
194	new	71
2308	1	62
953	hard	59
2241	100	42
2766	0	42
2269	geth	41
2132	update	38
1997	just	36
528	4	35
1378	vitalik	35
573	blog	33
2191	t	31
2448	bitcoin	31
302	community	28
694	contract	27

Figure 12b: Word frequency table for all words in subreddit – Ethereum

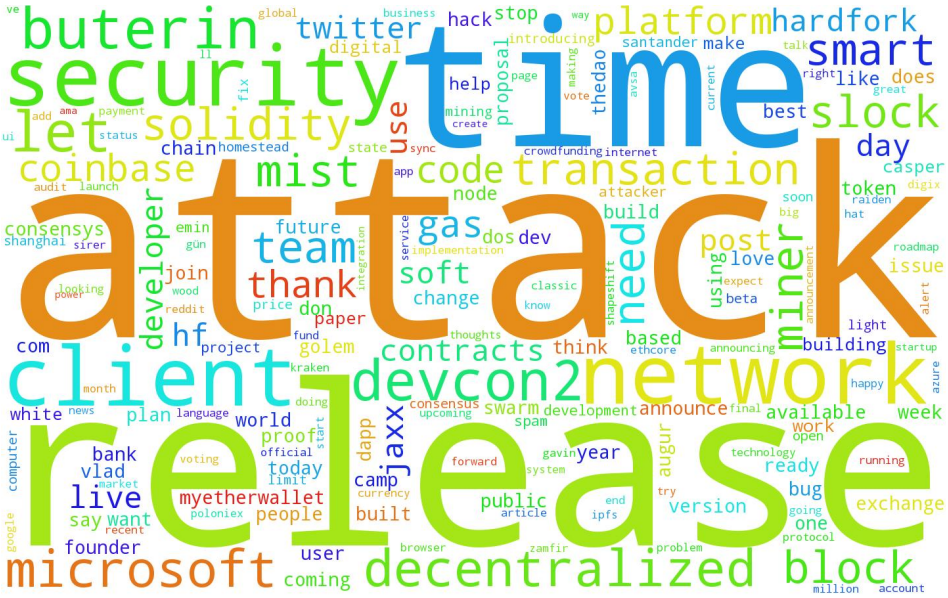

Figure 12c: Word cloud with stop words removed – Ethereum

attention paid to the relationship between Bitcoin and Ethereum as issues related to wallet functionality and various forms of system support, intra- and inter-cryptocurrency community, are of persistent interest to many community members. Removing the top 30 most mentioned words from the Ethereum corpus during generation of word clouds via the word frequency table also exposed frequent mention of concerns related to system attacks/security, the Ethereum foundation, and the larger ecosystem of decentralized applications and developer/investor involvement (developer involvement is indicated through mention of software releases, solidity, developer conferences, and other developer terminology common to the developer documentation expanded on in the following code review section; investor involvement is indicated via mention of exchanges such as Coinbase and companies such as Slock.it, Auger, and Microsoft) (Figure 12c). There is also a less frequent, but present, tone for general users in the topics related to the Mist Browser and various general wallet/contract usage issues (these could equally apply to developer and investor dialogues as well given various contexts).

Examination of the Bitcoin data set reveals an overall focus on the currency aspect of the Bitcoin framework. It was expected that the top 1000 posts for the Bitcoin subreddit would be more generalized as it has existed for much longer (as a blockchain protocol and cryptocurrency) than Ethereum and Ethereum Classic (Figure 13a, 13b). Bitcoin is most frequently mentioned in terms of its relationship to money, where it is accepted, and where one can exchange both Bitcoin and other monies (Coinbase and PayPal were mentioned most often). These are followed by concerns related to banking or banks and currencies. There is also topical mention of OverStock, likely related to their adoption of Bitcoin as payment option, and Bitcoin's relationship to the Silk Road website. Removing the top 30 most mentioned words from the Bitcoin corpus during the generation of word clouds via the word frequency table also exposed frequent mention of concerns regarding wallets, exchange, governments, worth, and the ever present mention of Satoshi (both the identity and the Bitcoin monetary denomination) (Figure 13c). To a lesser frequency, there is a lingering mention of attacks on Mt. Gox and other exchanges. The user and investor language is much more persistent in this community than the Ethereum and Ethereum

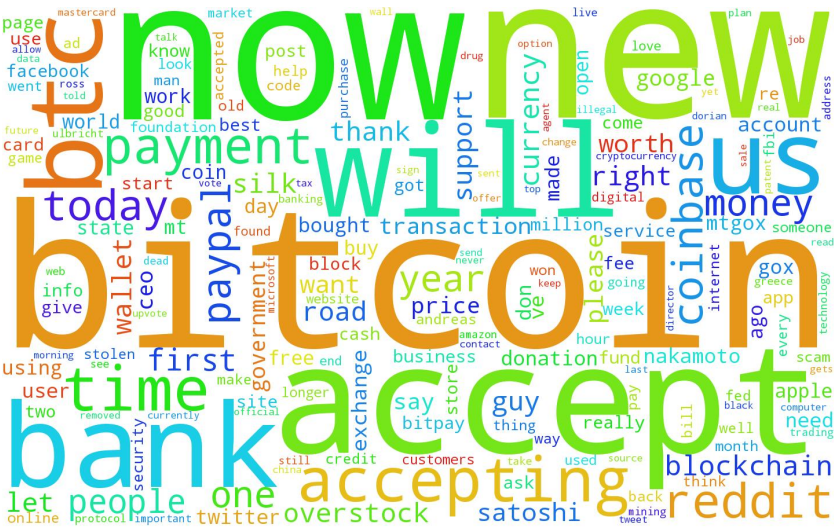

Figure 13a: Word cloud for all words in subreddit – Bitcoin

	word	count
2884	bitcoin	565
2348	just	61
175	bitcoins	55
2577	t	53
224	new	40
52	r	37
2302	btc	35
2391	accepting	34
3130	coinbase	31
2786	000	31
3356	money	31
1203	today	31
1170	reddit	31
1619	time	30
140	paypal	30
2898	one	29
303	people	29
1921	bank	28
1317	com	27
1952	first	27

Figure 13b: Word frequency table for all words in subreddit – Bitcoin

Figure 13c: Word cloud with stop words removed – Bitcoin

Classic communities. This is due to the overall frequency of words centered around corporate language (such as CEO, customers, business, market, and support) as well as a more general language common in the Bitcoin and Ethereum subreddits for users (such as social media sites, wallets, fees, and where the cryptocurrency is accepted). Ethereum Classic is a fairly new community that emerged from the hard fork of the Ethereum blockchain in late 2016. Initial examination of the corpus of its top 1000 posts for the limited existence of the community reveals a focus on the transition from Ethereum to now pseudo-independent Ethereum Classic (Figure 14a, 14b). This includes persistent mention of the hard fork and the DAO hack that spurred it. There was frequent mention of support for this new community and its blockchain framework as well as its relationship to Bitcoin and the wallet functionality in general. Following this, there were concerns regarding who would support development of this blockchain framework, mining, connected markets, trading, exchanges. These top mentions are topics that are essential to maintaining a functioning blockchain system as a lack of participants and interconnections to other blockchain communities can often be seen as lacking viability, both in terms of attracting new developers and new investment into the cryptocurrency system. Removing the top 30 most mentioned words from the Ethereum Classic corpus during generation of word clouds and tables also exposed frequent mention of concerns regarding various forms of attack and hacking (connected to the number of miners participating in a system that still requires proof-of-work and the resulting consensus mechanisms), contracts, funds, mining pools and block generation (Figure 14c). There was also frequent mention of the Chinese in contexts of mining and system investment as well as mention of Vitalik Buterin and Charles Hoskinson (previously of the Ethereum Project who left and is now involved in the Ethereum Classic project). Because of the relatively new status of this community, word frequencies indicate a large swath of interests with main topical areas for that community still emerging as development, investment , and user issues are worked out. There are more mentions of various exchanges, such as ShapeShift and Poloniex, as visibility and trading of Ethereum Classic on this reflects legitimacy within the larger cryptocurrency community. However, the main themes that emerge from this new subreddit are growth

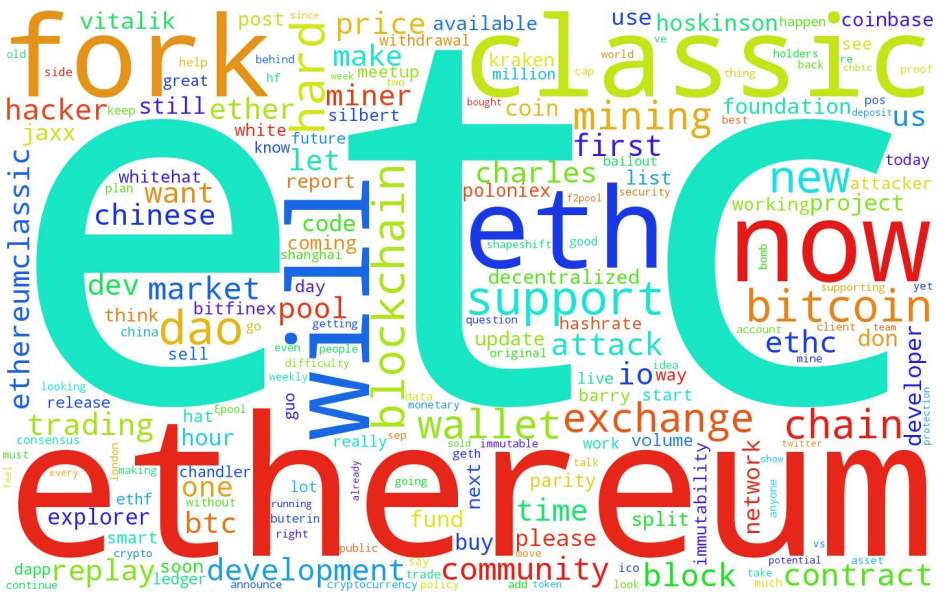

Figure 14a: Word cloud for all words in subreddit – Ethereum Classic

	word	count
2118	ethereum	345
1726	classic	240
2508	eth	122
377	fork	66
1805	dao	54
1349	support	49
860	hard	47
464	blockchain	39
2189	bitcoin	36
2059	1	32
1320	wallet	32
160	new	31
1787	just	31
235	mining	30
1957	t	28
269	community	28
119	chain	27
980	com	25
1510	development	25
955	market	25

Figure 14b: Word frequency tables for all words in subreddit – Ethereum Classic

Figure 14c: Word cloud with stop words removed – Ethereum Classic

and survival in relation to key features that help get investment into the framework and projects that help sustain that investment (both in terms of full-time developers, traders, and decentralized application investors).

Following this overarching assessment of the discourse found in each subreddit, I then focused on the title content for: the top five authors with the highest number of total comments over all their posts; the top five authors with the most comments for a single post; and the top five authors with the most posts to a single subreddit. For Ethereum, these three groups saw many of the same unique authors. The top concerns amongst these authors primarily focused on developer-centric issues related to the functionality of the Ethereum framework and protocol. There is a heavy emphasis on the hard fork for Ethereum and security issues such as malicious attacks in varying forms common to blockchain systems (such as that performed on *theDAO* which was featured prominently in many of the top discussions). Much of the more user and investor related posts were directed at clarification on how the hard fork following the DAO hack would affect them in efforts to quell unrest from those who were liquidating their Ethereum assets due to the event. There were also numerous posts of recent social events for the Ethereum community such as developer conferences which frequently mentioned Ethereum founder Vitalik Buterin (almost all top authors and authors in general have made mention of Vitalik Buterin in their post titles). From the above three focus areas, there is a noticeable trend in two directions: developers sharing their work with additional personal commentary; users discussing general topics related to the larger Ethereum community. Moreover, the topics presented and addressed by the developer-centric posts tend to drive the general discussions within the total collection of posts. In many cases, top authors literally posted news headlines from various news outlets for discussion. Whether titles were published through the unique author by an automated spam bot or manual process is difficult to determine in many cases, though the human interactions within the related discussion threads often hinted as to whether posts by an author were redundant or were more specific to a subjective or personal experience. An author who focuses on developer related issues (who are often Ethereum-related developers) frequently have a number of

champions who promote the author's concepts, ideas, and headlines for a number of reasons ranging from encouragement of other developers to become involved with any number of projects (e.g., learning Solidity, other system and Dapp tutorials, Geth client updates), marketing the larger concepts to potential investors (e.g., simplification of the Ethereum blockchain concepts geared towards business applications), or encouraging general awareness to spur user involvement (e.g., downloading a wallet, buying ether, building community).

For Bitcoin, the discourse is far different than Ethereum. Unlike Ethereum, Bitcoin's top 1000 posts are distributed amongst a much larger group of unique authors. However, each top author in Bitcoin had fewer top posts from the collection of 1000, but with much larger numbers of cumulative and single post comments. There was also a noticeable shift in the tone and overall discourse found in the Bitcoin subreddit. The top five authors overall focused their discussions on topics related to Bitcoin's economic processes. These range from what companies are accepting Bitcoin for payment, who is planning to accept Bitcoin for payment, how to purchase and exchange Bitcoin, and how Bitcoin is going to change any number of business models or industries. There were often discussions centered around mention of Bitcoin in the news or other social media. This led to larger discussions that seemed to foster a larger sense of community for Bitcoin users and investors (often referred to as 'bitcoineers'). Very rarely was there mention of any developer related topics within the Bitcoin data set even if the author is a known Bitcoin developer (a time series analysis of the entire history of Bitcoin posts may reveal if this has always been the case or perhaps how Bitcoin transitioned from a period similar to what Ethereum is experiencing now to its current state today). There were still mentions of Silk Road and Satoshi Nakamoto from these authors, but the focus was centered on the utility, legitimacy, and growth of the cryptocurrency as a currency. Block size and mining have shifted in tone from that of a developer concern (as seen in Ethereum) to one of investors maintaining a business infrastructure for the community of users and investors based on the frameworks sustained stability and legitimacy.

Ethereum Classic is such a new subreddit and community that posts vary extremely in their discourse even within the same author's posts. The most prolific author was approximately three times more active than the second most prolific author. However, this author was not one of the top five authors with most comments for a single post (Ethereum and Bitcoin often had many of the same top authors within all three categories). The top five authors overall for the three categories demonstrated a mix of developer, economic, and community related issues that sound very similar to the discourses found in the Ethereum subreddit. Since this community was born of the hard fork of Ethereum predicated on the DAO hack event in June of 2016, there is often reference to that event, the people involved with the hard fork, and the concerns that surrounded the hack and hard fork events. However, the larger discussion centered on the politics that underlined the system's existence. Aside the mentions of funding, mining, and software development of the system, there were larger discussions on governance, consensus, immutability, and communities that support these ideas. We also see more Bitcoin-esque dialogues emerging in the Ethereum Classic subreddit such as who will accept this new system, how will it be used, who is investing/developing this system, and why one would choose Ethereum Classic over Ethereum. This may be due to the variety of conversations that were happening over the short existence of this subreddit and is not to say that these do not occur in the Ethereum subreddit, they were just more prominent in the Ethereum Classic subreddit data set (as illustrated in previous results on authors between subreddits, there were more Bitcoin to Ethereum Classic authors than Bitcoin to Ethereum authors (these authors were often completely different within the top 1000 post)). The discourse in this subreddit was geared towards mobilizing action in terms of maintaining the decentralized network of miners and their related software framework as well as building and sustaining a community to keep this project growing within its established politic via investment and user involvement. Many of the most commented discussions also centered on concentration of wealth based on who holds the most Ether (ETH) or Ether Classic (ETC) in these systems as Ethereum works towards implementation of proof-of-stake and people wait to see whether Ethereum Classic will maintain the proof-of-work model currently in place for both

(this is also in part related to the DAO hacker, the WhiteHat hackers or Robin Hood group, and their current Ether Classic holdings). The authors with the most posts overall are definitely focused on investor and user concerns as topics focus on the relationship between Ethereum and Ethereum Classic while connecting both to current issues facing the larger cryptocurrency community (i.e., why companies and countries would want to use blockchain and would Ethereum or Ethereum Classic work in those use cases). There is certainly the sentiment being promoted that Ethereum Classic is the "people's Ethereum blockchain" often mentioning various economic and political influences which were seen as negative within the Ethereum project (e.g., key developers leaving Ethereum following acquisition of millions from various investors and now rejoining the Ethereum Classic project, discussion of Ethereum Classic's legitimacy and immutability over Ethereum).

To complete my analysis of the three subreddits, I compared the content of my interview data to that of the three subreddit data sets. I processed all of my interview and open conversation data into a format suitable for deriving word clouds and word frequency tables. I then produced a word cloud and word frequency table for the entire corpus (Figure 15a, 15b). As expected, this word cloud and table reflected sentiments found in the subreddits (the text used combined participants' responses who were experienced with Bitcoin and/or Ethereum). There were many common words cluttering up the initial view, but there were many terms related to developer, user, and investor focus areas in the background. A second word cloud was produced removing the 30 most frequent words (Figure 15c). Here we start to see familiarity in our comparative discourse as developer terms and focus areas emerge from the collected interview and open conversation content. Many terms, such as cryptocurrency, decentralization, application, and project, are prominent above terms common in use among investors and users, such as general blockchain technology common to most blockchain projects, with a focus on the user. A third word cloud was produced removing the 60 most frequent words (Figure 15d). Here we start to see emphasis on terms common in discussion on the larger blockchain 2.0 and blockchain 3.0 projects. We also now start to see DAO mentioned in this third layer along with an emerging topics of economics and

community building. Through all the interview and open conversation clouds so far, the term ‘idea’ drew my attention. During the interview and open conversation process, the participants always came back and mentioned in passing ‘having the idea’ or ‘getting the idea’ (sometimes also related to the mention of varying scales of ‘concept’ which I will expand upon in my analysis). I finished with a word cloud derived from removing the 90 most frequent words found in my interview and open conversation data (Figure 15e). Here we start to see politics emerging in relation to the economic and development aspects of these data sets. Here we see concepts related to token and exchange in relative close frequency with mentions of government topics.

The above methodology was developed to explore and expand an understanding of the overt and underlying concepts and relations found between the semi-structured interview and open conversation content collected for this study and the Reddit content from the larger communities of which the participants belong. The content analysis of both data sets individually and then together revealed interesting patterns and trends found between the participants answers and the common strands of thought within the blockchain-based subreddits. This helped to validate assumptions made during a deep reading and coding of the semi-structured interview and open conversation data regarding the larger communities’ economic, political, and social dynamics that are indicative of processes driving particular modes of spatial production and political economy within these blockchain ecosystems. The automation of the data exploration tools I developed and implemented are no substitute for a deep reading of the material discussed above, but it does assist in developing a more robust set of inferences through which a more directed and effective analysis can be pursued.

A key advantage that emerges from the content analysis of these three subreddit data sets is an awareness that we are looking at three communities that are co-evolving along similar paths. Bitcoin has been where Ethereum and Ethereum Classic are today in terms of establishing its legitimacy as a development project, a secure investment, and a customer friendly product (in terms of its state as the leading cryptocurrency today). Ethereum has just reached a level of legitimacy and has a level of

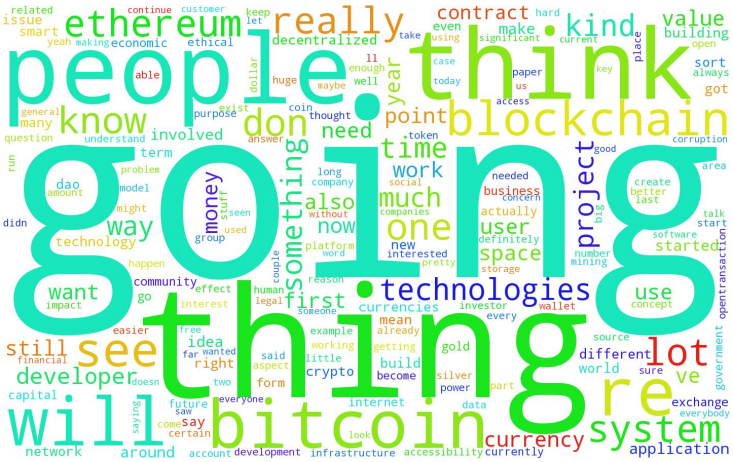

Figure 15a: Word cloud for all words in interviews and open conversations

	word	count
2304	going	133
2914	people	118
1721	think	115
1913	it's	103
780	like	94
2117	bitcoin	91
136	things	74
320	ethereum	73
269	just	71
89	blockchain	70
45	i'm	68
1737	lot	63
873	don't	63
1957	really	57
2255	know	55
1688	one	53
2850	thing	52
317	technologies	52
2612	time	47
2647	kind	47
1635	system	40
2107	value	39
868	money	39
3027	currency	39
2649	way	38

Figure 15b: Word frequency table for all words in interviews and open conversations

Figure 15c: Word cloud for interviews and open conversations without top 30 words

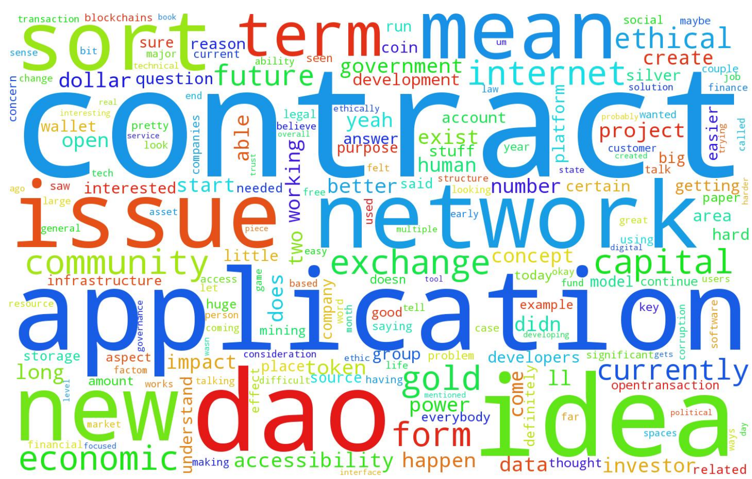

Figure 15d: Word cloud for interviews and open conversations without top 60 words

Figure 15e: Word cloud for interviews and open conversations without top 90 words

sustained involvement from developers and investors, but is still struggling to find key customers and use-cases that make it a viable entity for use in the everyday lives of users (such as the increasing number of common use cases for Bitcoin). Ethereum Classic, given a massive leap as it split from Ethereum after a considerable amount of development and investment was put into the ecosystem, has to start from square one in terms of the developer/investor/user dynamics mentioned above. Examining the content and the resulting discourse of the three independently and then together from the perspective and categories used exposes the unifying forces as well and the departures found within each community and larger blockchain phenomena.

Ethereum Wallet and Browser[7]

Ethereum makes installation of their wallet and browser for users extremely simple as compared to the more developer-oriented activities. This is largely a desktop/laptop based activity, though mobile applications for both Android and iOS continue to be released with increasing functionality and utility. From the Ethereum homepage (https://ethereum.org/), the organization gives the reader a description of what the system is, its functionality and intent (e.g., no downtime, no censorship, no fraud, no third party interference, etc.), and how it received its initial funding via crowdfunding. However, the introduction, menu items, and language are geared towards attracting developers to their projects and investors to put forms of capital into the system and/or the Ethereum non-profit.

The user is initially offered a wallet through the homepage. When the user selects this option, s/he is warned of the risks involved with using this technology. The user is then brought to the software versioning website GitHub to download the wallet software for her/his respective operating system (i.e., Linux, MacOS, Windows). At this point, the user must know how to download the correct software per the hardware specifications of her/his personal computer, install the software using the appropriate tools

7 A note on perspective: I am examining the experience of a new user and/or investor in the Ethereum blockchain ecosystem from that of a Linux user. I did this as most Linux operating systems are free and open for anyone to install and use on their personal computers. Therefore, my perspectives and overall experience can easily be verified, challenged, and/or expanded upon by others in the future.

while ensuring the safety of the downloaded wallet software (this involves validating the download with a SHA-256 checksum), and then start using the wallet post-installation. The GitHub repository is heavy with developer-based language, making the understanding of how versions of the software differ from one another difficult for non-technical users. It is also not immediately clear to the non-technical person how Mist (a decentralized application browser for the Ethereum smart contract network) varies from the Wallet (an application which stores one's cryptographic keys, tokens, and contracts that is now built into Mist).

Once the Wallet application is downloaded, extracted, and installed, one must select the correct executable file for one's respective operating system. The application will launch, asking the user to select which network (the main network blockchain or a test network blockchain) s/he wish to use (the test network is mainly intended for developers of decentralized applications) and to then create an account. The user must then wait for the blockchain to download, but is given reading materials for how tokens, smart contracts, and DAOs of varying types are created while this process is underway. The process of downloading the main network blockchain can take hours or days to version on one's computer system (which is now a node in the decentralized, smart contract network of Ethereum) depending on the specifications of the user's system and her/his ICT connectivity to the Internet and World Wide Web. Once the blockchain for either the test network or main network is versioned locally to the user's computer system, s/he can open the Ethereum wallet application, via Mist, to examine her/his account balance, buy and sell Ether, and create/interact with smart contracts, DAOs, tokens, and other decentralized applications (using the Mist browser) available on the larger Ethereum network (e.g., depending on their selection of test network or main network).

From both the homepage and the Mist browser, the user is then directed towards learning Solidity, Ethereum's primary smart contract language. Ethereum provides the user with Solidity tutorials that include examples of how one would create one's own cryptocurrency token, create a crowd sale for tokens, and how to build a DAO (these are the same examples provided as reading material during the

installation process). For each of these, the walk-throughs are well written, but still require the reader to understand the syntax and semantics of Solidity and how that connects to the written explanations and visual aids in the tutorials. The user is given additional developer resources throughout these tutorials. From the homepage, the user is then directed towards command line tools which are almost explicitly for developers of the underlying Ethereum framework and protocol. I will expand on the more developer-oriented content below. Finally, the user is given community resources such as additional information on how the system functions, system-oriented programming language resources, social networks, and points of contact for the Ethereum organization.

For the non-technical user, the Ethereum organization, via its homepage, ensures s/he can open her/his wallet, purchase Ether, and interact with the larger network of decentralized applications relatively easily given the open-source and distributed nature of the efforts supporting the Ethereum project's development. This means that "everyday" users can buy and sell Ether using Bitcoin or as of recently credit card (via Coinbase and only in the US), but would have trouble with any additional functionality built into the system. This is the same for investors. For any rapid involvement beyond the basic exchange of the cryptocurrency, a developer would have to facilitate the creation of Solidity-based smart contracts for the user and/or investor. This gap is decreased through a fairly large community of connected social networks used by people depending on their situated condition as user, developer, and/or investor. Over the relatively short lifetime of the Ethereum project, people have created many different points of access for inclusion in these social networks, most of which are geared towards the development of software for the core Ethereum project or to a lesser extent, but no less important, funding of the decentralized application software development and its expanded adoption by different consumers. Much of this interaction is sustained in online communities as all three groups of people (i.e., users, investors, developers) are geographically distributed all around the world. However, there are also large gatherings of people via in-person meetups through where more traditional forms of communication and exchange can occur (both in terms of socio-intellectual exchanges and peer-to-peer token value exchanges for

Bitcoin and Ethereum). On the point of peer-to-peer token value exchanges, individuals are largely sensitive towards the legal restraints on these types of economic activities within the jurisdictions in which they are physically located.

I have found these online communities and in-person meetings to be open and inclusive to all people who are curious about these technologies and their political economy or are eager to become involved in their use, investment, and/or development. I have observed that the above pattern of involvement eventually results in a focus on investment and/or development. This means developers and investors are in close communication and collaboration in any number of discussions regarding what these technologies are, what they represent, and how their utility can be leveraged. Leveraging in many cases is connected towards an investor position supporting a business model that would be competitive given the inclusion of blockchain technologies. However, leveraging these technologies from a position of development is largely centered around a set of use cases which may or may not be incentivised monetarily for and by a customer willing to compensate the development efforts.

In order to participate, a user or investor would have to be given Ether via peer-to-peer exchange. This would involve an initial coin offering (ICO), use of an exchange (e.g., Coinbase, Poloniex, etc.), or direct interaction with a holder of the Ether cryptocurrency. While setting up an initial user account or wallet, the user is offered the chance to exchange Bitcoin for ether which is facilitated through the ShapeShift digital currency exchange. Users and investors entering the Ethereum system through exchanges will have to purchase Ether with digital fiat or credit currency which often includes a number of fees. This is a common practice for people new to these economic spaces as mining systems that require proof-of-work are extremely difficult to enter with the expectation to earn rewards without first investing large amounts of money into the infrastructure required to be competitive. This is a perpetual process for the Ethereum system (and many other cryptocurrency-based blockchain protocols) as any action taken with a decentralized application often requires an expenditure of the internal cryptocurrency to perform through to completion.

I will now elaborate on my experience with expanding beyond the user and/or investor experience as described above via examination of the Ethereum Pyethapp code/space.

Experience with Pyethapp[8]

Pyethapp (2014) is the Pythonic Ethereum client implementation of the larger Ethereum state machine (or plainly put, it keeps track of the state of the larger blockchain network and adjusts itself based on inputs from that network as there can only be one true blockchain). The more common implementations of this state machine are the C++ and Go versions of the core software. Pyethapp depends on two major libraries to function: Pyethereum (2013) which is the core library that covers the essential blockchain functionality of proof-of-work and running the Ethereum virtual machine; and Pydevp2p (2015) which is a peer-to-peer networking library for node discovery and movement of services within a multiplexed and encrypted system. There is also use of Pyrlp (2015) which is a Python implementation of the recursive length prefix (RLP) encoding library that Ethereum uses for encryption (this is not immediately apparent until digging through the Pyethapp and Pydevp2p library documentation). Pyethapp interacts with two official Ethereum networks: a live primary network in which real transactions and functionality are occurring; and a test network in which new code is tested without risking one's Ether (i.e., Ethereum's digital cryptocurrency). I will focus my analysis on Pyethapp and its interaction to the core and peer-to-peer libraries within the Ethereum blockchain system.

Initially, Pyethapp assumes that you have installed and configured the software correctly on a hardware client of your choice and that this software then registers with the larger network. This includes the successful installation of the Pyethereum and Pydevp2p core Ethereum system components (along with a number of supporting libraries from the Python 2.7 core libraries essential to the Ethereum

8 A note on rationale: I selected Pyethapp over the C++ and Go clients as I know Python and can use it as a proxy for the other Ethereum state machines; it functions and integrates with the Ethereum blockchain similar to the other implementations. Analysis of Ethereum is chosen (over Bitcoin) as it has: smart contract and DAO functionality in a high-level programming language; it is a popular and relatively new framework; the documentation tools and communities that support development have been easier to access for information and clarification over the course of this study than other blockchain communities.

libraries' functionality). The software must then be able to connect to the larger system; finding and connecting to mining nodes within the network. Once these connections occur, it must then be able to establish a secure, multiplexed session in order to create an instance that uses the designated Ethereum protocol. This allows the node to receive data from the network. Once this system of relations is established, the node can then begin to interact with the larger Ethereum ecosystem in its processes of block generation.

For the non-technical user, this is challenging. One must be able to understand how to obtain the software in order to install it and examine it. From the homepage for Ethereum, one can access the Pyethapp software via the command line tools installation link (which contains the only mention of Python near the end of the page) where one is first warned of the security and legal risks one takes in using and interacting with this system. The Ethereum team makes clear on its command line tools site (https://ethereum.org/cli) that Pyethapp is the library to use for academic research and directs one to their GitHub repository for the project. At this point, the ReadMe file presents an overview of how the Pyethapp client functions as described above. The user must have a knowledge of their specific operating systems (i.e., Windows, MacOS, Linux), Python version 2.7 virtual environments, and the GitHub website. MacOS and Linux users must know how to use the command line interface for their systems; Windows users must run one of these operating systems on a virtual machine.

The first time I attempted building Pyethapp from source was in July, 2015. Despite my previous builds of the Geth (the Go Ethereum client) and Eth (the C++ Ethereum client), this initial setup took a full 8 hours. This included reading documentation and fixing dependency issues between my operating system and Pyethapp requirements. Even at that point, I still received spurious errors and numerous failures when attempting to interact with the blockchain. The developer communities on Stack Overflow were incredibly helpful in resolving issues. It took an additional week of fixing errors to arrive at the point of usage outlined in the Pyethapp, JSONRPC API, and console documentation. My most recent build of this software in December of 2016 was completed in 3.5 hours from source. I spent another 2

hours fixing dependency issues native to my system before functionality reflected that which is in the Pyethapp, JSONRPC API, and console documentation.

Code Walk-through[9]

As mentioned above, developers of the Pyethapp project were very forthcoming with their guidance for pursuing this form of code review. Through my posts on Ethereum's social media, a developer suggested I start with the Pyethapp wiki (2015) for assistance with this part of the study. From the Ethereum repository for Pyethapp, I proceeded to the wiki where you are initially guided to the wiki page that outlines proper use of the embedded iPython console for the Pyethapp client. For those wishing to examine the Ethereum blockchain, this is an extremely useful tutorial for querying various facets of the systems operation. Additionally, Python developers can perform basic and sophisticated analysis of the Ethereum blockchain via the console (e.g., inspecting the blockchain, creating transactions and contracts, automation, blockchain network analysis).

Once Pyethapp is installed and running correctly with a complete copy of the blockchain (there is an option to download a partial blockchain, but the complete chain is the default upon setup of the Ethereum clients) as outlined in the previous section, we are ready to proceed with the code walk-through as provided through the wiki. At this point, Pyethapp goes through its functional processes: receiving and decoding network data; message handling; and processing blocks within the blockchain ecosystem. The wiki has been left open for additional explanation as to the extended functionality of the Pyethapp client, but this wiki currently covers only the process of a block from the network socket (a point in a computer system for sending and receiving data in a network) to one's hard drive. In the process of receiving and decoding network data, Pyethapp looks to peer.py in the pydevp2p library to wait for incoming data and if it sees a message (Ethereum Glossary, 2014) (from on account to another within the Ethereum state machine; not a human or machine transaction), it is added to the session for that node. The Pyethapp node

9 The data files, images, and tools used to perform this analysis can be found at: https://github.com/joeblankenship1/thesis_blockchain

(the computer system that is running the Pyethapp) then looks to muxsession.py to attempt decoding of packets following the nodes handshaking (communication between nodes) on the blockchain network. Multiplexer.py then decodes the message if enough packets were collected from previous steps using a cipher within the RLPx (cryptographic peer-to-peer network and protocol suite used by Ethereum) session via rlpxcipher.py (in the Pydevp2p library using Pyrlp). Decoded packets are then put into a queue and are processed through peer.py via a number of greenlets (small sequences of program instructions that are managed within the processes as defined in peer.py). The packet is then handled by peer.py by passing it to a handling protocol which determines if the packet can be passed along to the ‘eth’ protocol via eth_protocol.py.

The eth protocol is linked to a chain service via eth_service.py which registers callbacks (code that is passed to other code to be used at an assigned time) within the first stage of message handling. The callbacks are called through protocol.py after the packet identity is resolved to a handling operation. Since we are using the eth protocol, the new block we are creating will be passed the packets which will be decoded through eth_protocol.py and callbacks will be handled following identification of the packets through eth_service.py. New blocks are then handled and synchronized via synchronizer.py. The synchronizer checks: if the block is unknown; if the proof-of-work is valid; if the chain difficulty is sufficient; and if the parent exists for the new block. If all of these meet the thresholds of the synchronizer, the new block is added to the queue by eth_service.py. This is once again handled via a greenlet which attempts to push the new block onto the blockchain.

Before the new block can be added to the blockchain (so that it can access its ancestors on the legitimate blockchain and to prove its state-of-value), it must first be stripped of its initial serialization (acquired for the purpose of processing the packets into a block through the initial processes) through eth_service.py and is passed along to become a legitimate block by eth_protocol.py. Pyethereum and Pyrlp are then used to structure and validate the encoded block to prevent errors (blocks.py) before it is

passed along for serialization in accordance with the RLP standard established for the Ethereum blockchain (sedes/lists.py) and the larger Ethereum protocol.

Once the block has been checked, the Pyethereum library is used to update the state of the block through executed transaction (blocks.py; processblock.py). These transactions that are to become a part of the block are validated through processblock.py which then updates the sender's nonce (Ethereum Glossary, 2014) (a meaningless value in a block which can be adjusted in order to satisfy the proof-of-work condition), gas (Ethereum Glossary, 2014) (a measurement roughly equivalent to computational steps which every transaction is required to include a limit of and a fee that it is willing to pay per gas) is processed, and an account message and call data are prepared. Processblock.py then applies the message to the system and the value within the transaction is transferred. The Ethereum virtual machine is then used via vm.py to establish reading and writing of transactions to the Ethereum state and to limit access. Transactions being written to update the block state are cached and recorded as to revert them if they are illegitimate. If a message processed through processblock.py is successfully applied to a state update, it is identified as valid and is committed to the new block via blocks.py. Transactions continue to be applied and validated until the new block is finalized at which point Pyethapp's eth_service.py verifies the new block.

If the new block passes the check via Pyethapp's eth_service.py, we are now ready to add the block to the blockchain. The Pyethereum library's chain.py prepares to add the block by first checking the block's uncles (Ethereum Glossary, 2014) (or ommer: a child of an ancestor that is not an ancestor) and verifying the block's validity once again through checking it's parent blocks. Chain.py then updates the index after checking the blockchain length and work quantity so that the child (our new block) can be loaded with the transaction that occurred during the time the block was being generated. The block is then stored in preparation to be encoded and loaded to the blockchain where it is issued a temporary key for holding its place (refcount_db.py) and shifted into a proper position for pre-entry into the blockchain (leveldb_service.py). The blockchain head (newest blocks indexed on the legitimate blockchain) is then

updated via chain.py which then updates the new block for addition in sync with the head. Finally, chain.py passes this information to refcount_db.py where the blockchain journal and death row are updated for the commit (publication) of the new block.

As compared to many other blockchain projects, Ethereum provides an extensive amount of easily accessible documentation. Though the Pyethapp walk-through ends following the block addition to the blockchain located on one's hard drive, it does guide the developer towards the next domain of knowledge needed for review in the process of understanding the application's scope of function. Developers can also look to the Go and C++ client documentation, as well as the larger community of developers, for expansion on the concepts and functions of Pyethapp and the Ethereum blockchain. Pyethapp also provided information via their wiki on account management, Pyethapp configuration, version control, creating user services, usage of the test network, and other developer-related activities. Related to this, Pyethereum also provides some documentation on development and testing practices through its wiki (these function more as cheat sheets for the developer than a guide for users). All other inquiries on development of this system are directed at the Ethereum documentation (2016), Solidity documentation (2016), Ethereum's GitHub (2016), Ethereum on Stack Exchange (2016), and numerous other publications/blogs written by developers based on their experiences (both by core developers of the framework as well as Dapp developers). Though the official documentation for Ethereum and Solidity are written in an easy-to-understand language by which a user, investor, or developer could read and comprehend the function and intent of the system, the purpose is to assist a new developer in her/his path to creating new applications and framework functionality.

The comments internal to Pyethapp, as well as the larger docstring, are almost explicitly for use by developers and is written for immediate understanding of the following code structures. A user or investor without some knowledge of programming would find it difficult to determine the function of the system or its components from the docstring alone. This docstring is often, as shown in the Pyethapp code walk-through, connected to an external text that further elaborates on the relations of functionality within

varying scales of the Ethereum blockchain code/space. This form of abstraction and layering of obfuscation are effective for the purpose of development, but does potentially restrict those who wish to expose and develop an understanding of the Ethereum state machine's internal functionality. The above walk-through is easily summed up for the user or investor by stating, "this is how you create a legitimate block and then add it to the blockchain," but would require a knowledgeable developer to make that assessment. Much of the documentation I read in the course of this study was in English which could provide unintended barriers to expanded adoption of this system by people already disadvantaged by lack of access to ICT infrastructure and/or documentation in their native language. Much of the documentation mentioned above can be translated into various other languages using software or other means, but outside of the developer context, the user and/or investor could draw false conclusions on the capabilities or intent of these systems. Even within the developer context, a language barrier could negatively effect the social relations often required to collaborate on applications and framework projects; this especially applies in the domain of open-source software. I did find in their glossary and in some parts of their documentation an attempt to maintain a gender-neutral language such as the defining of 'ommer' in elaboration of block inheritance.

In terms of scale in this code/space, the code walk-through and some of the more developed documentation for the larger Ethereum framework subdues the actual immensity of these system's true functional nature. The code walk-through as given in the Pyethapp wiki gives a very overarching, but effective view of how this software functions from transaction to block construction with the inclusion of 4 distinct libraries (Pyethapp, Pyethereum, Pydevp2p, Pyrlp) (Figure 16a). The code analysis of a more experienced developer can produce a more complex set of relations within the software architecture (Figure 16b) (Summerwill, 2017). However, these programs have many internal functions that are generalized or assume by developers within both the primary Pyethereum project libraries used and the underlying Python 2.7 core libraries (as well as any third-party libraries that are used or referenced).

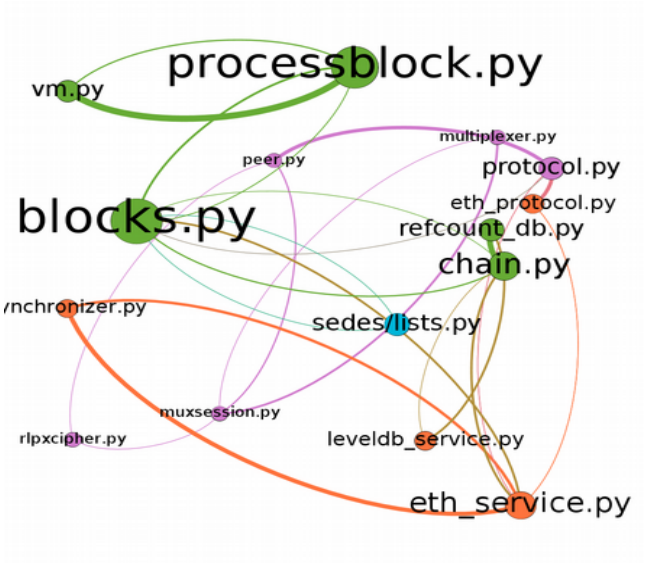

Figure 16a: Code diagram – Pyethapp code walk-through

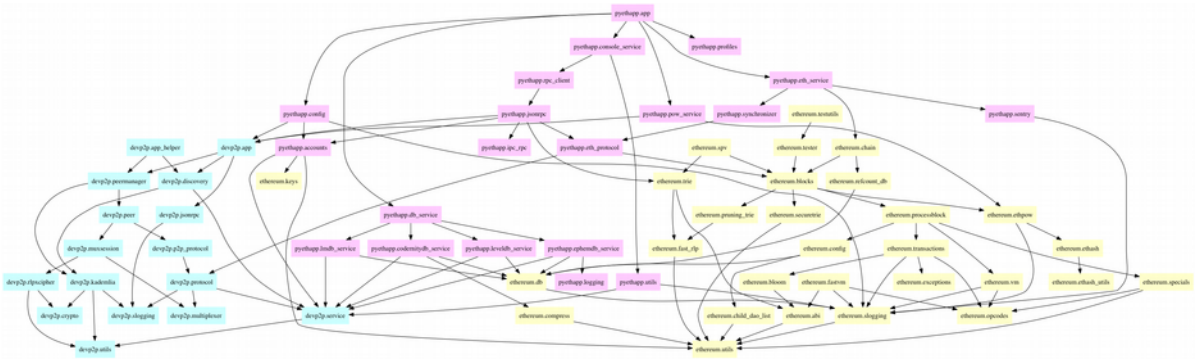

Figure 16b: Code diagram – Pyethapp extended dependencies

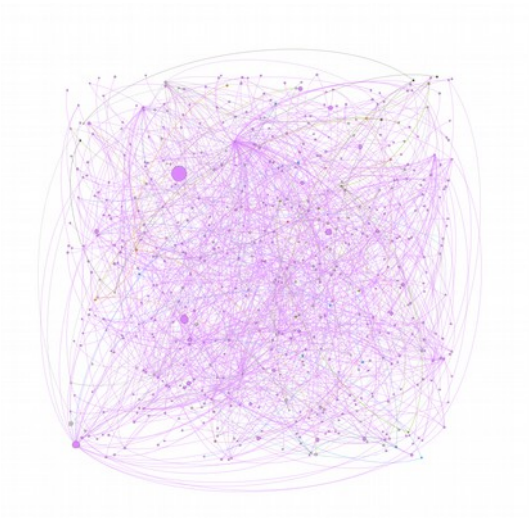

Figure 16c: Code diagram – Pyethapp call graph via internal logic

When the totality of these code/space relations are mapped, they can result in a massive network of interactions, making understandings of distance and space difficult (Figure 16c[10]).

In an attempt to better understand how the technical aspects of this blockchain architecture interacts with the semi-structured interviews, open conversation, and Reddit communities data, I parsed the docstring and wiki content from the Pyethapp, Pydevp2p, and Pyethereum repositories. I then removed comments and documentation internal to all files which were PEP8 (Python Enhancement Proposal) compliant. Upon doing this, I was able to produce word clouds and word frequency tables for four of the five data sources (I had some difficulty parsing the Pyethereum code repository). We can see word patterns similar to those of authors in the Ethereum and Ethereum Classic subreddits. When examining the GitHub wiki content for the Pyethapp (Figure 17a, 17b) and Pyethereum (Figure 18a, 18b), we see many of the same prominent words as we see in the Ethereum and Ethereum Classic subreddit. Examination of the docstring internal to the actual Pyethapp (Figure 19a, 19b) and Pydevp2p (Figure 20a, 20b) libraries reveal a much more logical and systemic language meant to elaborate on the underlying code structures to developers of the software (sometimes these are as much notes on items that need to be addressed as indications of functionality), but could still be related to the wiki information. This is interesting for two reasons. The first is that this method of docstring extraction can be used to determine if the tone and discourse from the subreddits are being guided by developers or being focused on development issues within the blockchain community and the related blockchain infrastructure. Secondly, it gives us an idea of the hierarchy of control within these code/spaces. Looking at the level of language from the docstring, to the wiki, and then to the higher level system documentation and Reddit content, we begin to see that developers are the gatekeepers of a particular form of knowledge/power dynamic. They adhere to an intended functionality forwarded by core developers of the framework through white papers and additional documentation on design decisions. But in order for the investors and users to understand

10 Performed with Pycallgraph library on a ‘pyethapp run’ command terminating in an error. The actual successful ‘pyethapp run’ diagram would be much larger.

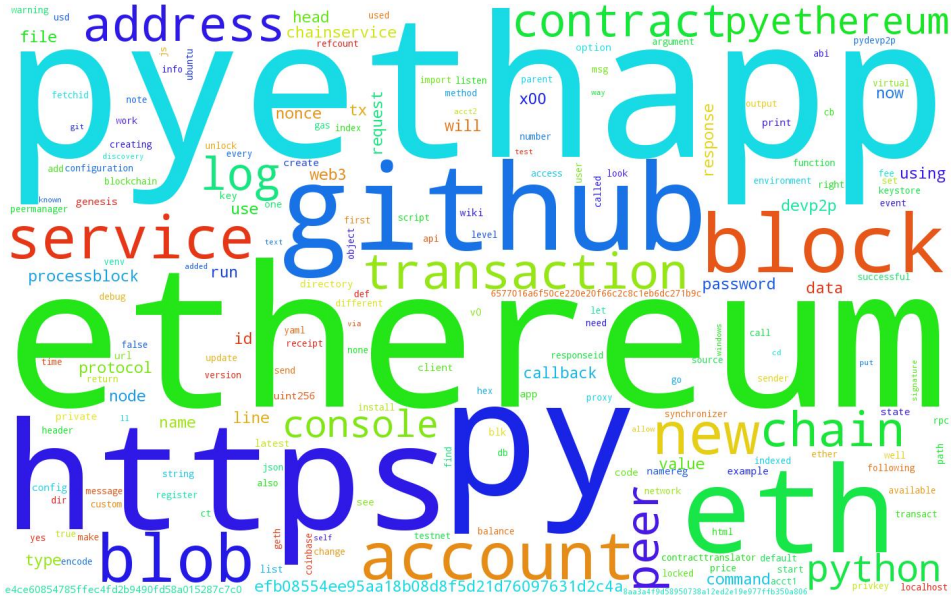

Figure 17a: Word cloud for Pyethapp GitHub Wikipages

	word	count
287	ethereum	246
814	pyethapp	191
794	py	182
240	https	125
913	com	121
1217	github	117
75	eth	113
1130	blob	91
86	block	77
1	account	68
986	new	63
670	address	61
374	chain	60
185	service	53
639	pyethereum	49
1117	python	48
142	console	48
1471	efb08554ee95aa18b08d8f5d21d76097631d2c4a	47
1356	type	43
631	log	42
73	tx	40
777	peer	40
1069	transaction	40
1156	use	39
1026	0	37

Figure 17b: Word frequency table for Pyethapp GitHub Wikipages

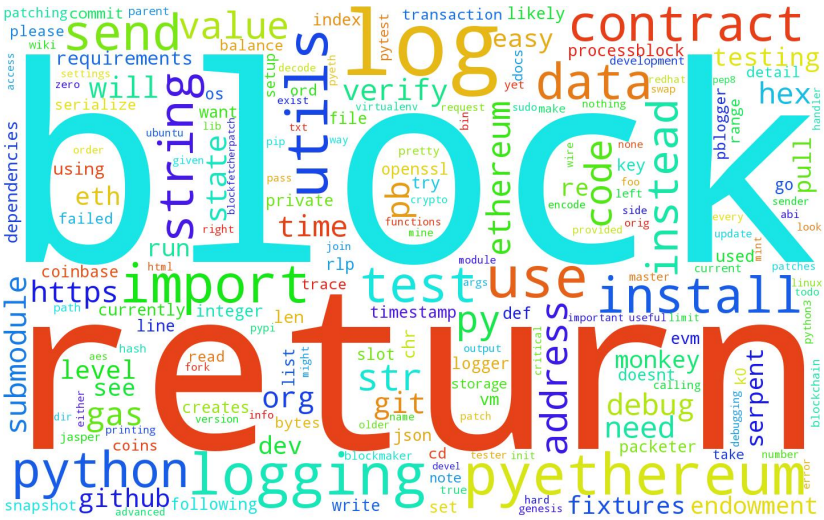

Figure 18a: Word cloud for Pyethereum GitHub Wikipages

	word	count
82	block	20
212	pyethereum	15
190	log	14
292	use	14
86	utils	12
451	logging	12
98	import	11
387	contract	10
112	data	9
511	install	9
422	instead	8
262	address	8
71	returns	8
257	python	8
269	py	8
180	return	8
485	gas	7
52	f	7
80	send	7
517	str	7
499	code	7
324	ethereum	7
403	1	6
355	debug	6
278	https	6

Figure 18b: Word frequency table for Pyethereum GitHub Wikipages

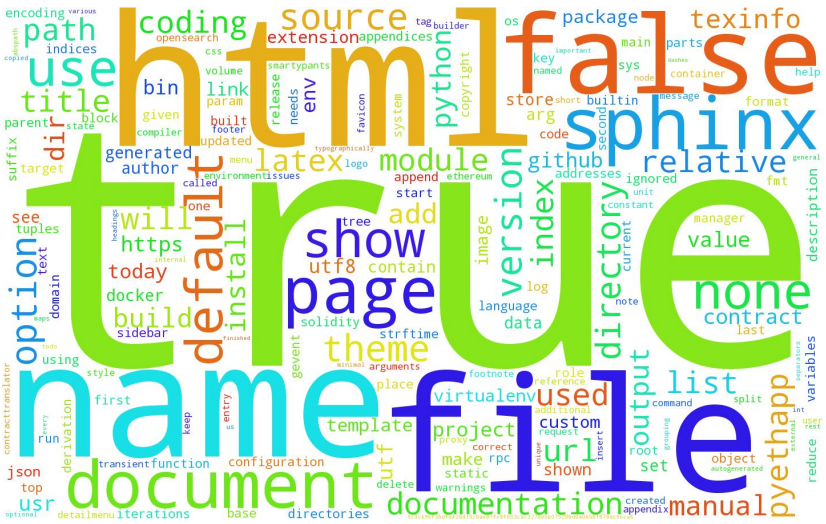

Figure 19a: Word cloud for Pyethapp Docstrings

	word	count
38	html	27
225	true	27
526	file	16
418	false	13
192	sphinx	13
320	use	11
140	default	10
241	coding	9
433	pyethapp	9
67	directory	9
24	version	9
152	source	9
250	module	8
472	index	8
146	files	8
233	options	8
489	used	8
325	list	8
102	documentation	8
401	latex	8
360	output	7
90	title	7
427	names	7
277	relative	7
4	theme	7

Figure 19b: Word frequency table for Pyethapp Docstrings

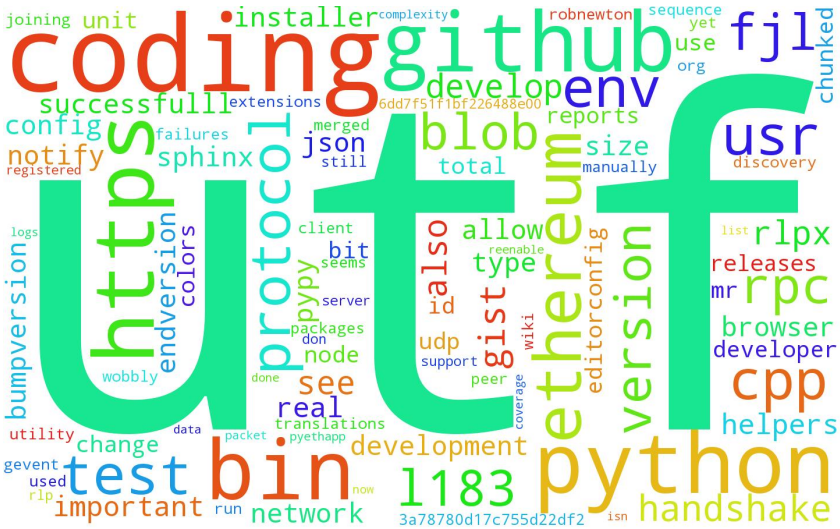

Figure 20a: Word cloud for Pydevp2p Docstrings

	word	count
86	coding	7
76	utf	7
52	8	7
2	com	6
15	python	6
97	github	6
13	https	6
94	usr	5
66	ethereum	5
78	cpp	5
85	bin	5
95	env	4
67	test	4
103	protocol	3
38	gist	2
79	protocols	2
99	handshake	2
56	rlpx	2
104	t	2
17	version	2
60	fjl	2
7	rpc	2
65	develop	2
4	blob	2
87	l183	2

Figure 20b: Word frequency table for Pydevp2p Docstrings

how these systems work, developers have to provide them that knowledge of what can and cannot be done with which systems and why.

CHAPTER FOUR:

ANALYSIS

Toward the end of my data collection for this thesis, I desired to attend the 2016 BitFiniti: the Blockchain Experience Conference in Miami, Florida. The website mentioned many speakers from diverse backgrounds looking to share their experiences with blockchain implementations or to discuss how such technologies would change particular business paradigms. The conference required a registration fee of US$1500 and did not mention usage of Bitcoin or other cryptocurrencies to pay the conference fee. I emailed the organizers to see if they would allow me to attend for a discounted student rate, given my research focus, to which they sent me a discount for $500. Shortly after the conference, their website (Bitfiniti, 2016) was taken down and an email was given as the sole means of contacting the organizers. Due to the price, I was unable to attend.

At the onset of this study, the goal was to determine if and how the spaces and places of everyday life were evolving based on these new technologies and their effects on spatial productions in everyday life, political economy, and the concepts of code/space and network society. To answer this larger question, I will provide three very different answers to the three sub-questions presented in my research statement.

Production of space

The social spaces of blockchain technologies are currently dominated by two positions: the developers of these technologies and the people wiling to invest and sustain funding of particular projects. The interviews revealed that many developers are also investors in these technological spaces. However, examination of the Reddit data and the Ethereum code/space reveal that the developer is the key agent within the dynamics which produce a blockchain space (Figure 21[11]). Investors and those looking to

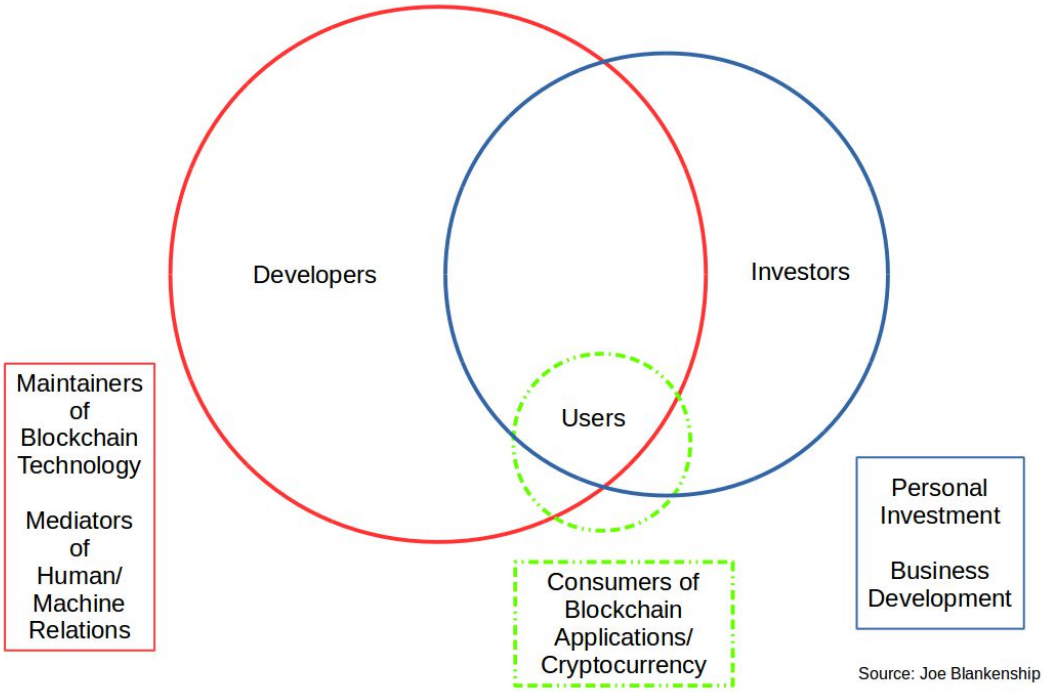

Figure 21: Social Spheres of Blockchain Spaces

capitalize on these technologies need people to innovate and produce prototypes which are then promoted as revolutionary and evolutionary to many consumers today. Developers in many early blockchain projects, such as Bitcoin, were the initial users and providers of use cases for these projects. It also appears to be difficult to bring developers into these spaces and to maintain their involvement in these

11 The size of the circles are indicative of the relative balance between developers, investors, and users involved in the blockchain spaces of the interview, open conversation, and Reddit data sets (keeping in mind there is significant overlap between each category from and to one another).

projects without funding. In some cases, developers will accept digital assets produced within the blockchain ecosystem. Others will accept a mix of digital currencies and/or equity in these projects as they still need to interact with external economic systems (e.g., pay rent or mortgage, buy food, etc.). Many projects have moved to the model of initial coin offerings (ICO) to keep investors, developers, and potential users involved within the critical period of development required to get a project out to market. However, there is no guarantee that these people will sustain involvement beyond that initial investment.

Developers are the key maintainers of the blockchain frameworks (many of the key frameworks are open-source), users/investors of internal cryptocurrencies, and the core of these larger social spaces (often developers will move between multiple projects in a relatively short period of time). This can be seen to some extent through examination of the exchanges between Reddit communities and was also mentioned in various forms through the interviews and open conversations. More abstractly, they also act as the mediators in the human/machine code/spaces of the decentralized networks as a result of the aforementioned developer positions as maintainer, user, investor, and community leader. In many cases, they assign agency to the systemic actants (e.g., miners) through the designed functionality of the frameworks, protocols, languages, and contracts that are the core of blockchain ecosystems. As elaborated in the code and gray literature review, they are the gatekeepers of knowledge for these systems and, therefore, are key agents in the production of these spaces through that knowledge/power dynamic.

Investors primarily see these systems as a way to personally invest their existing assets in order to then extract some form of value that is ultimately economically beneficial. Investors and users may have social or political motivations to initiate and sustain involvement that are largely ideological in nature (e.g., libertarian appeals to adopt these systems in opposition to governmental regulation of an economy; criminal elements use of Bitcoin for black market activity on the Silk Road), but the end result is the holding of a value token that is exchangeable, fungible, and potentially profitable for said investor and/or user within any number of extended and connected economic markets. This is often accomplished in terms of cryptocurrency/digital currency exchanges and blockchain companies/projects. The processes of

crowd funding as was witnessed in the rise of the Ethereum project is one example of investment in these systems. Exchanges (such as the previously mentioned Poloniex, ShapeShift, and Coinbase) are used to transfer between digital currencies to any number of cryptocurrencies that are then used in an ICO or in more traditional venture capital/angel investments for a new blockchain system. This gives the participants in the ICO an often large amount of the new token value for funding this blockchain system and, depending on the consensus mechanism built into this new system, a potentially sizable amount of power in terms of how the blockchain may execute consensus-based decisions and how the system may evolve based on this pool of token value holders' use cases as presented to the developers of the blockchain framework. For investors who develop businesses around blockchain projects deemed as promising (this is determined in any number of ways by the investor(s) and/or developer(s) assisting the investor in shaping the form, function, and structure of the blockchain-focused business), the most common method is to establish a legal business within the nation-state they feel provides the best regulatory environment for their form of blockchain project and globally distribute the project development. This means the workers (e.g., developers, marketing, miners, etc.) are as decentralized internationally as the network of mining nodes (specific to a proof-of-work system, but also extends to other governance protocols). More recently, there has been a push to create more DAO-based companies on the blockchain which in turn hire developers, obtain resources via the smart contract frameworks, and manage the scope of operations for that blockchain-based business. However, this has ran into several problems and is still developing into a more dependable framework of business development as seen with the events surrounding Ethereum and *theDAO*. However, with the advent of permissioned blockchain frameworks such as Hyperledger, investors are working to acquire developer power in order to implement more controllable versions of DAOs for narrow, but much more lucrative, finance and business applications (as seen with IBM and DTCC) (Nicholas, 2017; Aitken, 2017).

It is difficult to determine the extent of absolute space for blockchain systems as their spatial production is persistently in the processes of abstraction. Though these systems are suppose to operate

autonomously from humans, they depend almost exclusively on human interactions from the outside via transaction mechanisms to perpetuate the production of intra- and inter-network space (Figure 22). As smart contract frameworks and DAO technologies progress, this may shift the current paradigms of agency, but currently these functionalities are being developed into a more stable standard that is acceptable to the larger developer/investor communities. Looking at the blockchain, it must exist on the decentralized network of mining nodes to meet the criteria of proof-of-work which acts as a mechanism

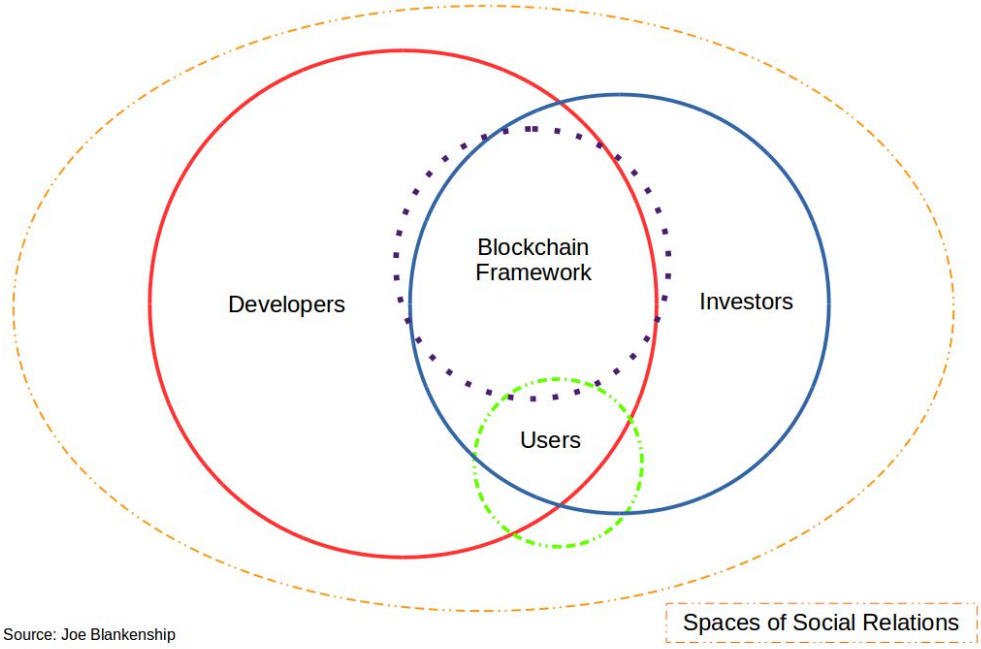

Figure 22: Spatial Dynamics – Blockchain Frameworks

of consensus and trust. This is contingent on the cryptographic key structure to not only provide the wallet function for miners and users, but to inextricably link the blockchain to the miners. Therefore, the production of space hinges around the human/machine nexus of mining. Humans must facilitate the hardware, energy, and ICT connectivity for the miners, but would have no way of doing so without the social, economic, and political conditions/functionalities the miner hardware/software provides. Humans as developers, users and/or investors cannot proceed beyond the mentioned provisions if the

aforementioned consensus and trust are to be maintained via the miner network and their specified actions as outlined by the framework and protocol. Therefore, humans have to interact with miners within the specific protocol mechanisms as outline by the blockchain framework in question. However, the autonomous, weak AI miners as actants given agency by the human agents to pursue this trusted, immutable, consensus-driven decentralized network geared to produce a blockchain through competition on block publication can still be directly affected by humans who control the blockchain framework of these miners.

In order to validate the above assessment, we have to examine the perceived, conceived, and lived conditions for developers, investors, and users as each attempts to define form, function, and structure as defined by Lefebvre within their respective relations to the blockchain framework and the other human agents in the processes of spatial production. Developers produce the framework as part of their material spatial practices, they only partially produce the representation of that blockchain space as the social practices that provide the use cases are in part developer, but they are also guided by investors via their use cases. This leads to any number of representational spaces as the process between spatial practice of the developer and the imposed regimes upon the conceived spaces via the investor use case are encapsulated in the token value or cryptocurrency. This is further complicated in blockchain 2.0 through the acceleration of these processes as smart contract and DAO functionality, though nascent as it may be, still assists the perception and conception of the blockchain space regardless of the decentralized mining network which is allegedly autonomous from human influence, but has to operate within the intent of the spatial regimes humans place upon that system and its spatial production. This is because absolute space is representational in which the body, whether biological or digital, must assume meaning via the perpetual testing of their embodied conditions (within varying forms of artificial relations within their code/spaces) which affect the production of social spaces and these larger political economies of blockchain systems.

Investors' material spatial practices center on the potential exchange value of these systems within larger circuits of the political economy common to neoliberal modes of capitalist production. They then enter into any number of social relations with developers and the blockchain framework in producing numerous representations of blockchain spaces which they bolstered through a set of politics formed of these social and economic ties. In this case, the resultant representational spaces are prototypical of capitalist circuits via the token value extracted from the social relations between investors, developers, and users and the means of production facilitated by the developers. Users of these systems in everyday life are extremely rare in comparison with traditional forms of currency (and their digital equivalents) as of this writing. The current form of user is split between the providers of use cases and users of cryptocurrencies. As discussed above, developers and investors, in their various aforementioned forms and functions, are the agents of use case and token value use with a small remainder being those who use it for expenses in everyday life. Participants in the semi-structured interviews and open conversation as well as authors in the Bitcoin subreddit often expressed frustration about their inability to use cryptocurrencies (specifically Bitcoin) outside of the social spaces of developers and initial investors. However, as reflected in the subreddit data, there is an increasing push by businesses traditionally outside of these social spaces to incorporate use of these currencies in the everyday lives of their customers. This expands the investor dynamic as described above and increases the pressure on developers within absolute space to increasingly acknowledge the use cases presented through these new social spaces and to incorporate investor utility through their material spatial practices, accommodating the shared representations of space which will both directly and indirectly affect any users' representational spaces. Developer resistance to these power dynamics can result in a departure from the social space, but often they participate in contextualizing the space with investors, accommodating their political, economic, and/or social sentiment; making them investors as well as developers. This may mean as individuals within their representational spaces are increasingly exposed to the regimes and opportunities utilization of cryptocurrencies and other token values afford them (via their exchange value), there may be a

potential shift in the developer/investor relations to incorporate these considerations into their respective material spatial practices. This is by no means a sign of an alternative or revolutionary economy as the means, as currently implemented, do not obtain a true condition of autonomy within the modes of spatial production that are required to liberate the means of production from the spatial structures of centralized developer and investor social relations and to obtain a true state of egalitarian participation within these cryptocurrency-economies. These spaces of social relations provide for and dominate the transformational

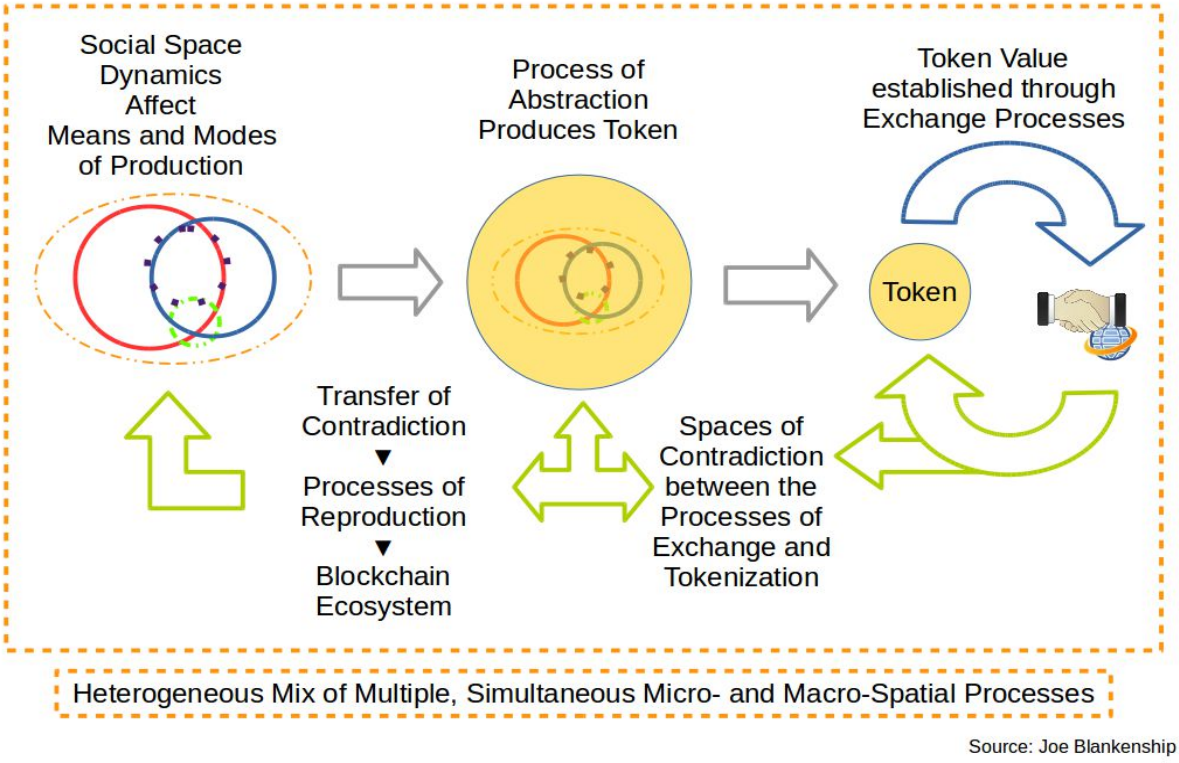

Figure 23: Tokenization to Exchanges

processes that initiate and perpetuate reproduction of blockchain frameworks within unique economic and political spaces, ultimately affecting how these human/machine spaces evolve.

The abstract spaces that emerge are contingent on the facilitation of persistent value transformation via the cryptocurrencies or tokens these systems produce (Figure 23). This process strips

away the nature of the above developer/investor/user social relations leaving the abstracted, enframed signifier of the underlying human/machine social relation. Digital currency exchanges and P2P evaluations of value exchange utilize the token while the various politics that drive framework development allow for diversification of these abstractions, applying technological fixes to obscure the relations found within the initial social space. These processes of tokenization allow people to obfuscate the process of value transformation from one transaction to another in the form of Bitcoin or another cryptocurrency denomination. However, the token cannot truly obfuscate the material spatial practice despite being projected as the dominant form within the processes born of the forms, functions, and structures of the developers, investors, and users that conceived them.

The move from Bitcoin to alt-coin functionality and the introduction of the Ethereum smart contact languages to DAO functionality demonstrate that due to the dominance of an abstract space via its token value, some humans agents within those dynamics that produced that token value condition have at some point found issues with those means and modes of spatial production. In the case of the Bitcoin protocol, Bitcoin was widely accepted as a cryptocurrency in which state-of-value could be efficiently stored and proven. However, other social circles with the technical ability to manipulate the Bitcoin software frameworks solidified around a politics such as open DNS and data storage to produce Namecoin. This new protocol still functions like Bitcoin in terms of decentralization, cryptographic key structure, and mining, but the value is connected to another politics in the form of governance as produced in the spaces of the blockchain framework protocol. The economic incentive is there in terms of mining Namecoin (just like mining Bitcoin), but due to the similar costs in terms of hardware, energy, and ICT infrastructure, the social space will dictate how the human/machine interactions will ultimately evolve with one cryptocurrency versus another. This is due to how the process of encapsulating Namecoin (i.e., tokenization) varies from that of Bitcoin. Since the Bitcoin token is focused on producing a cryptocurrency, that abstraction (the Bitcoin cryptocurrency) appeals to numerous economic and politically-driven social spaces via its pragmatic application, but creates conflict and various restrictions

in other social spaces which may not have use for or may not accept the pragmatic application of the cryptocurrency token. The Namecoin token produces a decentralized domain names blockchain which appeals to other economically and politically-driven social spaces (e.g., people who do not want to use a DNS that is controlled by a centralized regulatory body such as ICANN) which then accommodate those new modes of production. Once these two enter the larger social spheres of blockchain technologies, people only deal with the token commodity and eschew the larger dialogue on the underlying mechanisms, politics, and economics of the respective protocols. Once these tokens enter a digital currency exchange, the process of parity evaluation to the US dollar and other currencies takes hold as new cycles of token abstraction begin.

It is this contention between these aforementioned processes of abstraction and contradiction that ultimately led to the many differential spaces within the blockchain 1.0 and 2.0 communities. Matters of privacy are promoted as essential within some systems (e.g., the obfuscation algorithms used in Dash and ZCash) while matters of immutability are promoted as essential in others (e.g., the public, open ledger of Bitcoin). However, the Bitcoin protocol, as well as many newer blockchain systems, was originally conceived with the ideas of transparency and freedom at its core values despite the pseudo-obfuscation of the cryptographic identity via the public/private key structure. This led to the development of projects such as Dash and Zcash in order to provide truly anonymous and obfuscated transactions within a blockchain-based system. So there is the simultaneous demand for privacy and obfuscation, but to still maintain an immutable, censorship-proof record of transactions so the system can perpetuate itself via mining. They also demand security from these systems in terms of reliable access and persistence of their recorded token holdings on the network, but the systems often require transparency of the transactions in order to do this. These systems can and do find a differential space in the form of soft or hard forks in an attempt to resolve systemic contradictions and crises (e.g., a hack, change in consensus protocol, block size, updates to framework), but these rarely resolve the issues connected to the deeper, underlying

functionalities, forms, and structures of blockchain technologies and their connected human spaces in everyday life.

The above modes of spatial production and the associated means via blockchain frameworks and protocols are also consistent with Massey's concepts on spatial production. The developer/investor/user social space dynamics are supported by the underlying blockchain framework (i.e., the blockchain, cryptography, decentralized network of nodes, programming language (for 2.0)) (Figure 24) in which

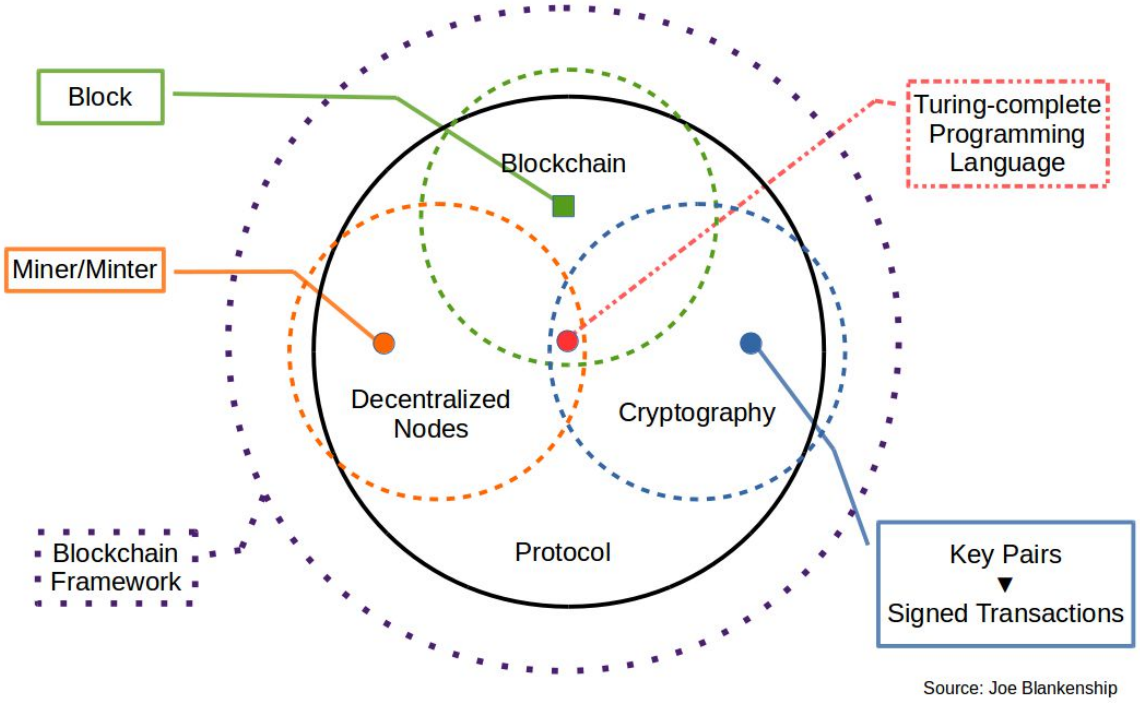

Figure 24: Blockchain Framework – Core Concepts

consensus mechanisms play a large part in those micro-spatial practices. As mentioned previously, these system social spaces are largely digital and transduced through social media and other ICT infrastructure. However, the concept of governance implies and requires that the consensus mechanism maintain a mode of production that is internal to the decentralized network away from the potential interference of human agents. Mining nodes, via the protocol, express block creation as a micro-spatial practice that is regulated

by its relations to the other mining nodes. The resultant representation of space is a record of token value transactions performed within the higher social space conceived of developers/investors/users in their modes of production which produce the token value as well as the mining network's absolute space.

If the miners were mere actants in this system, the network would act as an inert database of transactions and would not be able to manifest a condition of immutability or trust as humans would be direct mediator in its creation. However, if the mining nodes are given agency via the human agents' protocol within the decentralized network as is proposed by the maintainers of the blockchain frameworks, then the representational nature of the miners within their representations of micro-spatial production is that of compulsory labor by the digital mining node as this space of consensus is fed energy and infrastructure with the expected output of their labor being token value accompanied by a record of that product of labor (i.e., the blockchain). This would be a space constantly produced of interrelations between the coexisting heterogeneities found between the mining network and the maintainers of the frameworks and infrastructures used within a living process of value transformation by the larger social space. The maintainers of these systems, in cognizance of the micro-spatial practices, have to simultaneously observe said practices in meeting the multiplicity of use case expectations from investors and users. If a contradiction between the social space and the micro-spatial emerge, a technological fix must be instituted within the existing system or a differential space must be created via a new system (dissolving the previous modes of production to make way for the new).

This still leaves many questions regarding "sense of place" within the above spatial processes as it relates to miners dual nature as actant and agent within the modes of spatial production for these blockchain code/spaces. These modes of spatial production also call for further investigation as to why there was an aversion to or lack of ethical consideration by participants of this study whose language suggested some awareness as to the above spatial relations within these blockchain ecosystems and the potential cyborg intentionalities that would need to be addressed in the human/machine processes of space/place construction. As I will discuss in the next section, the transition of agency to the mining nodes

of the decentralized network creates a unique and new paradigm between humans and machines experienced within the political economy of these cryptocurrency economic systems and the digital blockchain frameworks within which they function.

Political Economy

In further examination of the results from our data sets, we now focus on how these blockchain systems, since their respective conceptions, are situated in relation to political economy, neoliberal capitalism, and globalization. The production of these spaces demonstrates the deeply interwoven relations to existing economic systems and the mindsets that are prevalent in today's globalized world. In much the same way Lefebvre drew from Marx in his examination of urban spatial production, we can examine the means, modes, and mindsets surrounding and influencing these spatial processes today.

The dominant and arguably most critical facets of these systems are the frameworks and their protocols. These frameworks encapsulate the protocols and their mechanisms while also acting as barriers for environmental factors that influence the internal components and simultaneously reflect the very forces that influence and form those barriers. The framework, as a key mean of production, is initially the realm of the developers who are involved in their conceptions, maintenance, and evolution. As previously discussed, frameworks using proof-of-work are means to produce a cryptocurrency as well as means of perpetually reproducing blockchains' requisite conditions. In this manner, these intangible software systems meet the criteria of Lefebvre's matériel in that it acts as the tooling, language, and instructions, via an agenda, to enable the modes of production in these spaces. Open-source software, licensed in any number of ways (e.g., MIT, Apache, GNU, Creative Common), is used in the creation of these systems which in turn assists developers in conception of their tooling needed to create both a common language (for both the social spaces of developers/investors/users and technical spaces of decentralized mining labor networks and distributed technological human labor networks) and a usable protocol (instructions) through which systemic actants and agents function intra- and inter-blockchain system. As a means of

production, open-source software, which began as community-led, “freedom as in free to use” tool sets within technologist social spaces, has rapidly become a means through which companies like Google and Facebook become economic Leviathans. The issue with this as it relates to this study is how labor is compensated for its labor time within open-source projects and the larger open-source social spaces. As proposed before, if the mining nodes are considered proxies of human agency in the decentralized mining network, then we can also make a parallel case for developers in the open-source community in that given the appropriate license on an open-source project, a multi-billion dollar company can take and use the open-source software, earning millions from exploitation of the software and its developers’ labor time, without the need to appropriately compensate developers for their efforts. The same can be said of an autonomous network of digital labor within the human/machine spaces of blockchain systems.

This draws out the question as to the current condition of proof-of-work and the claims made regarding proof-of-stake. Proof-of-work, within the blockchain systems that use this mechanism in mining, is critical in the measure and persistent maintenance of consensus (every mining node has to agree on which blocks are the true blocks in the canonical blockchain) while providing incentives to humans who run the mining nodes through a token value reward system upon successful validation and publication of a block. In proof-of-stake, the blocks are created at random by an account and an account’s chances of doing this increase with the more wealth is accumulates (i.e., more wealth equals more stake and a higher chance of publishing a block). As of the time of this study, proof-of-stake has yet to establish itself as a better protocol to proof-or-work in that equating influence over the blockchain to one’s wealth in a system is no better than the proof-of-work’s equating compute power and energy expenditure in the production of the blockchain space.[12] Both distributed consensus models, and all others, must answer the inherent contradictions (e.g., token as a process, technology and human/machine labor) related to these blockchain ecosystem power dynamics and the effects it has on global adoption as a legitimate financial and social mean of production.

12 Ethereum is working on a promising proof-of-stake protocol (Casper) and there are systems like Steem that use both proof-of-work and proof-of-stake in their frameworks.

In terms of the framework as a mean of production, developers were the original owners (Figure 25). They were the first to mine and gather large amounts of cryptocurrency. This meant that the direction and intent of the software, the decentralized network, and the relations between that machine environment and the humans using it were ultimately due to the internal ethics of the developers responsible for maintaining the open-source project. However, as time progressed and the cryptocurrency Bitcoin began

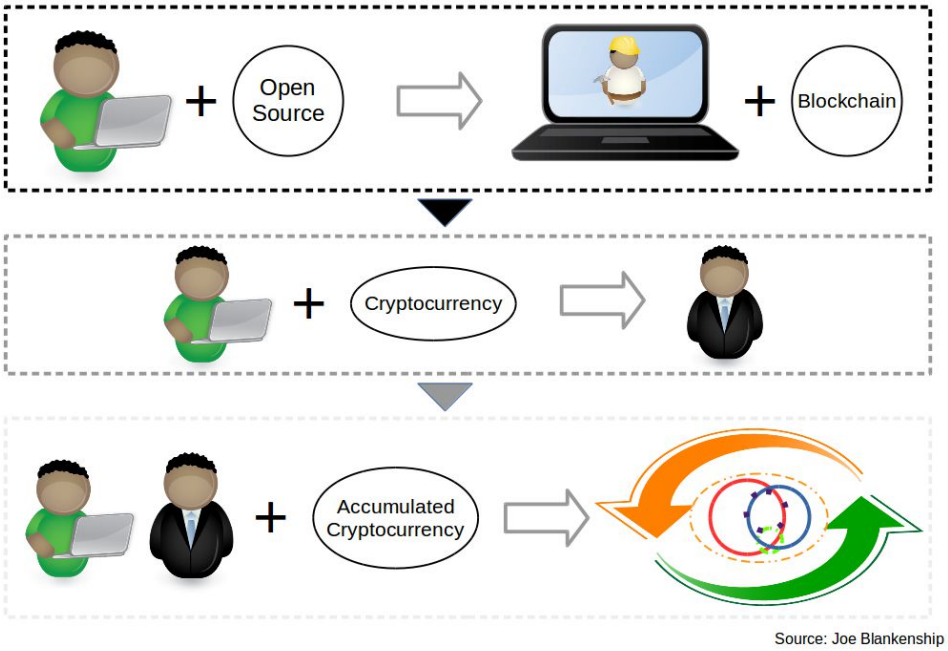

Figure 25: Blockchain Ecosystem Relations and Transitions

to achieve and exceed parity with the US dollar, the developers who were once accumulating these relatively worthless tokens then became the primary shareholders and investors in this blockchain system and its means of production. Other cryptocurrencies could then find a relation (and relational value) to Bitcoin. This quickly led to digital currency exchanges where those wishing to invest sans development experience or access could now purchase a stake (sometimes a very large stake) in a cryptocurrency while those who had stake (in terms of infrastructure, holdings, access, or all of the above) now have a means by which to accumulate both traditional digital currencies and the new cryptocurrencies.

When developers and investors began blockchain 2.0-based systems, they accelerated the modes of cryptocurrency accumulation via the ICO, which immediately put a controlling share of the token value in the hands of a relatively small group of people with previous access to Bitcoin and its exchange mechanisms. For systems wanting to move to a proof-of-stake, this means that an economic dynamic of control is placed, by default, around the initial maintainers and investors of governance and consensus mechanisms within the blockchain system. Whether by proof-of-stake or proof-of-work, movement towards blockchain 3.0 applications, which are allegedly non-monetary applications, still have to worry about how these shifts in mechanisms within the means of production affects immutability, censorship, and trust within the modes of production. There are currently many proposed and implemented measures to ensure those with a controlling stake in these systems (both in hardware and holdings) cannot override the alleged democratic features that many state are at the core of their governance frameworks, though there are example of these counter-measures being persistently challenged (e.g., increased hash difficulty for PoW vs. 51% hash power achieved by Ghash.io in 2014). However, the *theDAO* hack and the following hard fork prove that this is a difficult premise/promise to maintain when leaders in both their development and investment cannot agree on the ethics which are supposed to be the defining features of a blockchain systems and social spaces (e.g., immutability, trust, transparency, consensus, decentralization, security, censorship-proof, etc.), especially in moments of systemic crisis.

To these points, there is a connection between the productions of space as discussed above and the mindsets of the agents within the means of production. Throughout the data sets collected for this study, it became clear that the developers and investors within the production of the blockchain space often adhered to mindsets that were libertarian in nature. They wanted to be compensated for their labors and make a profit under the hospices of a new form of economic regulation that is not directly administered by a government (this is not true of all people participating in these spaces; this is simply what the data I collected shows). However, this does explain the tendencies within these systems such as accumulation and systemic crises endemic to capitalist modes of production via hard forks, soft forks, and

creation of new blockchain systems. This also relates to how value via tokenization is produced in the processes unique to each blockchain system. Even the idea of purchase power is prevalent in the use of venture capital, angel investment, and ICOs. As the absolute spaces of these blockchain systems are produced and abstracted through the social dynamics of developers, investors, and users, largely within places that have been the originators of the neoliberal capitalist mode of production via globalization (namely, Western nations), it should be no surprise that the mindsets found within these modes of production are reflected in the conception and utilization of the means (i.e., the mechanisms within the blockchain framework). This presents a challenge to the claims that these systems are revolutionary in any sense as they do not produce a new type of economic system. Rather, we see a reformulation and digitization of economic processes typical of our current modes of electronic capitalism. This was noticed through not only the interview and open conversation content, but through the differences seen in the dialogue between and within Reddit communities. Bitcoin has transformed (from 2009 to the time of these writings) from a token value that presented conjecture and challenge to existing forms of money to a condition of integration with existing economic systems. Blockchain 2.0 and now 3.0 applications have also, in a much more accelerated fashion, done the same, finding use cases in the augmenting and shifting of relations and functionalities within finance and businesses across numerous industries. These new applications often target contradictions such as labor, technological fixes, and uneven geographic development persistent in existing neoliberal modes of production.

Through examination of relationships between the production of blockchain spaces and the modes of production within the dominant form of political economy (i.e., neoliberal globalization), we begin to develop a sense of the blockchains' overarching political economy. As discussed above, the sentiment found in the data set indicating libertarian and neoliberal mindsets suggests that these technologies as fixes within traditional capitalist crises is far more counter-revolutionary than is currently acknowledged. The manner in which blockchain technologies manifest and reproduce as technological fixes depends on the dynamics between perspective of these relations, positions to and within these

relations, and sentiment within the abstractions of the spaces via the means of production. Much like D.W. Meinig's reading of landscapes, one can explore and expand on the condition of agents and actants within the means and modes of production through perspective and position, but we must also expand this to account for the transformative processes that generate not only the abstract spaces of blockchain systems within which this dialectic is examined, but the sentiment of the abstraction itself as a mechanism of persistent re-situating of the absolute space and its social dynamics.

Positions Perspectives	Developer	Investor	User
Development	Investment of Time Innovation Use-case	Manifest the Pragmatic Application per Use-case	Bolster/Contest the Pragmatic Application per Use-case
Investment	Manifest the Pragmatic Application per Use-case	Economic ecosystems Political Investment Social Dynamics	Invest Money Token Value Use
Utility	Bolster/Contest the Pragmatic Application per Use-case	Invest Money Token Value Use	Social Dynamics within Sentiment per Use-case

Source: Joe Blankenship

Figure 26: Perspectives and Positions

The perspectives of developers and investors towards the blockchain frameworks are that of innovation and investment (Figure 26). Developers invest their labor time in the hopes of producing an innovative solution to a unique use case via the investor and/or user. Investors see these spaces as largely ecosystems of economics and political investment which is fostered by the social dynamics. This indicates that investors and users via an initial investment of their time via money (in some form) into the

spaces of developers and blockchain frameworks is expected to yield some form of token or money value from this transaction. These perspectives on innovation and investment often find different manifestations within the positions of developers and investors dependent on the sentiment permeating the abstract spaces of the blockchain ecosystem. As previously discussed, the politics that drive projects like Bitcoin are different from those that drive Namecoin within the same generation of blockchain technology and both are far different than the politics and ideologies driving projects like Ethereum and Ethereum Classic. This in many ways is due to how the means of production manifest themselves in their pragmatic applications to the investor and users of these systems via their associated modes of production. A distributed DNS can be extremely useful, if not more so, in liberating control of international domain name control from the centralized power of ICANN than Bitcoin is useful as a cryptocurrency via its initial pragmatic application. However, when a transformational sentiment is adopted within a dominant politic and exerted through the dynamics of social spaces of these blockchain systems, the abstractions are imbued with a sentiment which then has to engage and merge with societies, economies, and political structures that are dominated by the situated processes of neoliberal capitalism (Figure 27). For Bitcoin, the initial pragmatic application found in exchangeable and fungible cryptocurrency was adopted by libertarian social spaces and was then given a sentiment of freedom from regulations, increased individual security and privacy, and increased individual and collective control over how governance in this system is determined. For Ethereum, the pragmatic application of smart contracts was seized upon by industries in which labor concerns and government regulation are key factors in increasing profitability and then injected the social and political abstraction surrounding the blockchain ecosystem with sentiment of *revolutionary innovation* in the means of production to these ends.

However, the examination of perspective, position, and sentiment of agents and actants to and within the means and modes of production for blockchain ecosystems make apparent that the current counter-revolutionary conditions, within which these system are utilized, largely serve as technological fixes within the larger neoliberal modes of production (Figure 28). This, as we will discuss shortly, are

meant to answer capitalist contradictions while accelerating the processes within the neoliberal mode of capitalist production, but is done so with unseen and unknown effects. There is a third possible way to harness the means and modes of production for blockchain ecosystems in the realm of localized, grassroots-based activism and economy, but this would require smaller scales of political economy to deal

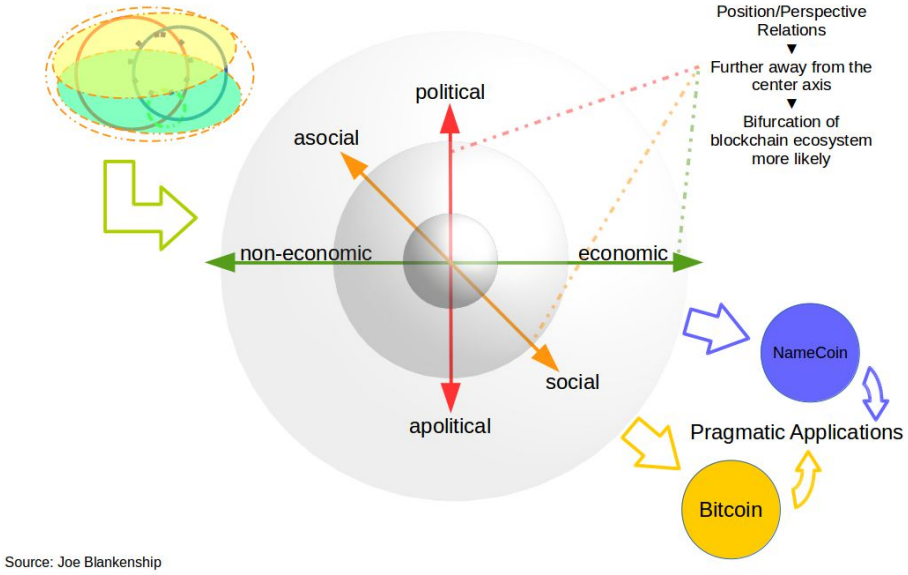

Figure 27: Heterogeneity via Sentiment

with the above productions of blockchain space and the implication for those smaller scales based on the form of pragmatic application and the resultant political economy that emerges via the sentiment through any number of abstract spaces via token values.

This leads me to my previous assertion that the space/time of blockchain systems, as fused within their coeval micro- and macro-spatial processes of renewal, produce emergent social, political, and economic sentiment (the abstract condition) through one's position (as developer, investor, user) to any number of subjective perceptions which in turn forces the means of production (the human/machine blockchain framework) into its processes of evolution to adapt to the modes of production being shifted through the abstract condition. The miner within the decentralized network via the framework and

consensus protocol is now given agency for more than the purpose of consensus and governance; its agency is infused with the politics of the abstract condition for the purpose of social and economic reproductions of space. For the purpose of examining the above analysis, I turn to Harvey's theory of space/time compression and his analysis of capitalist functionalities and contradictions.

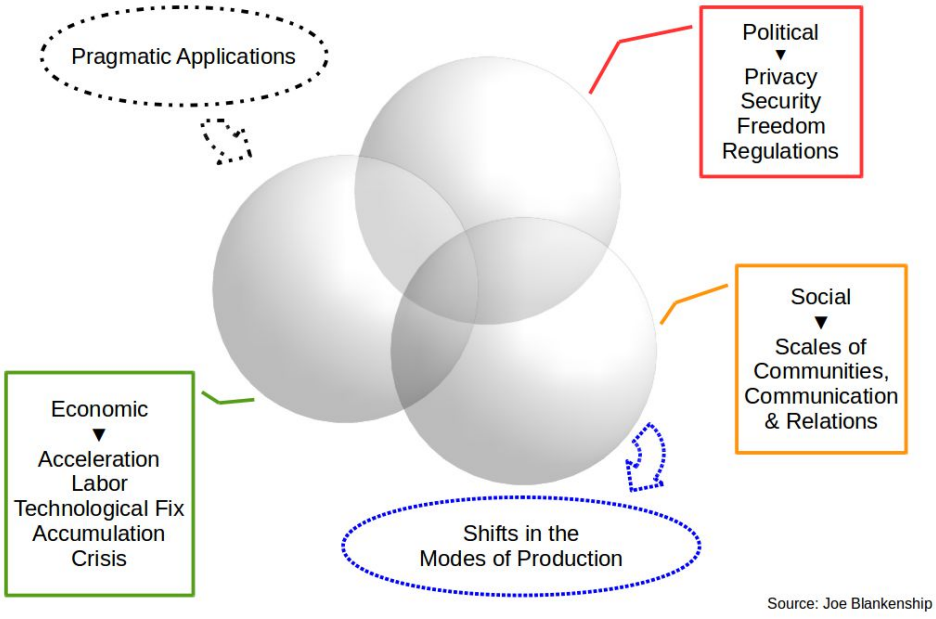

Figure 28: Modes of Pragmatic Application Production

Harvey initially has an issue with how space is conditioned and subdued relative to time which we can see when the blockchain core processes within the means of production (Figure 29). As the means are increasingly obfuscated, the abstract condition opts to increasingly promote the temporal efficiency of its pragmatic application and obscure their true spatial natures as manifested through the production of their token values. However, when we look back to the material spatial practices of developers, investors, and users in their processes of producing token values within blockchain systems, we also observe the reproduction of a social space in which conflicts between the material practices of the three groups, in their respective temporal constructions, results in lumping together their temporal perceptions, their

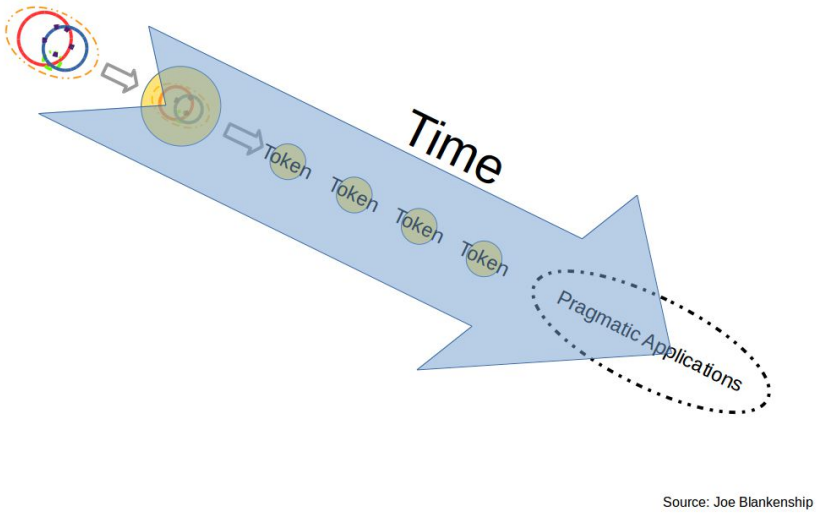

Figure 29: Blockchain Space subdued by Time

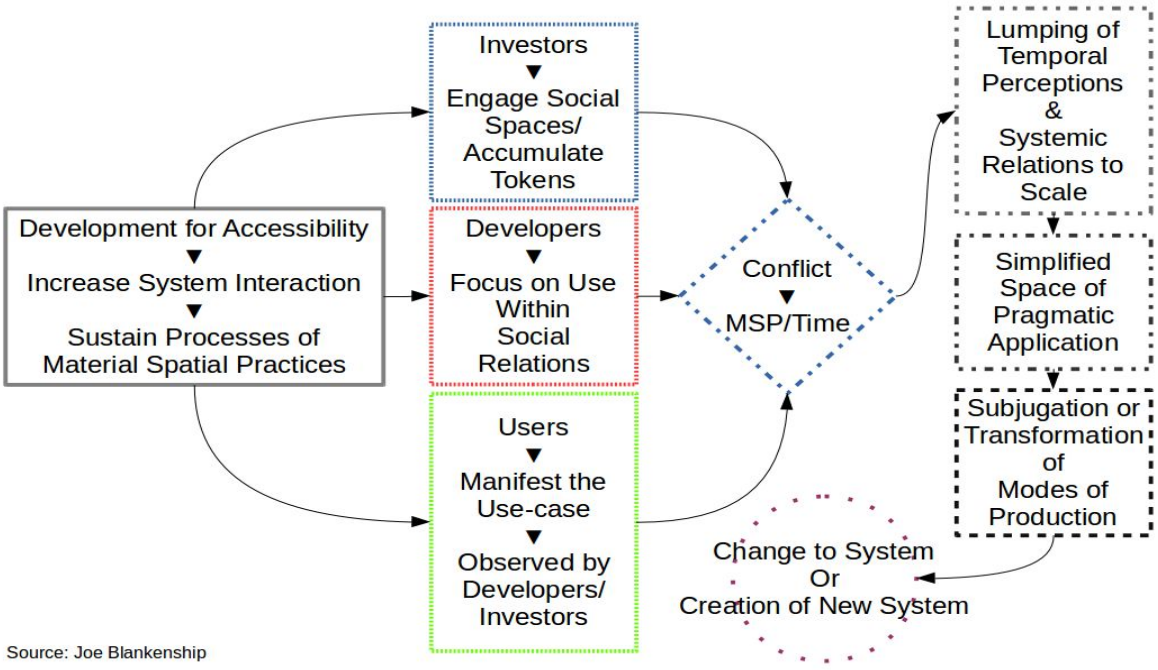

Figure 30: Resolution of Space/Time Conflicts

systemic relations to varying scales per the blockchain system, and ultimately simplify the spaces of their pragmatic application (Figure 30). When there is a shift in the abstract condition, it comes into direct conflict with material spatial practices for one or more groups and their individual spatial practices resulting in their simplification to the point of erasing the traces of social practice in both time and space. As was seen in the course of the interviews, open conversations, and in the dialogues of the Reddit forums, discussions on accessibility centered around getting more users and more use cases introduced into the systems for investors for purposes of overall growth of a blockchain systems. Developers also saw a need to get more accessibility which was tied to a number of concerns related to specific social, economic, and/or political rationales, but centered on increasing the amount of human interaction within the blockchain system to spur developer, investor, and user spatial practices. However, both groups had a difficult time explaining how issues of distanciation for many people with accessibility issues would be resolved. The investors specifically promoted persistent engagement with blockchain social spaces and appropriation of their token values given their personal heuristics on the blockchain systems' past and current abstract condition; developer engagement was centered on appropriate use and use cases within the social spheres surrounding the blockchain framework. The material spatial practices and their processes of abstraction placed in relation to the abstract condition and the token value generation now put developer, investor, and user positions in direct conflict with the varying perspectives (both internal and external to those positions) in a struggle for control of the abstract space of the token value. These social power dynamics now force subjugation or transformation in the modes of production for and by the blockchain system, resulting in a change to the old or creation of the new. This process is exemplified in the hard fork of Ethereum as seen in the dialogues of the Ethereum and Ethereum Classic subreddits.

These power dynamics now bring into this analysis the form, function, and structure of the token value in relationship to the abstract condition of the blockchain ecosystem's space/time. With a focus on ultimately producing a profitable, exchangeable, fungible, and legitimate token (i.e., cryptocurrency), the token value as commodity must negotiate the exchange/use value dialectic within a power dynamic which

forces a resolution through impacting socially necessary labor time (Figure 31). Unlike traditional economic systems, the most important part of labor, the governance and consensus on the blockchain, is performed by machines. Therefore, the resultant conflict between the abstract condition and the pragmatic application mirror Harvey's suggestion that this being/becoming relationship exposes the true nature of these human/machine spaces through the symbolic ordering via token values (Figure 32).

This leads us to how the above processes are related to the creative destruction of labor and the acceleration of economic processes (Figure 33). The use of cryptography and decentralized networks of nodes are essential in maintaining blockchains; these core mechanisms within the blockchain system require transactions via human or human automation to engage mining network protocol which, via its agency, internally regulate the blockchain within the larger social dynamics of the abstract blockchain

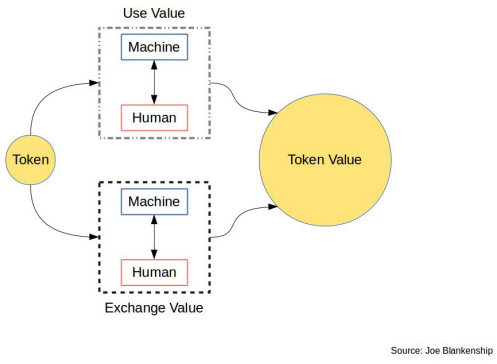

Figure 31: Token Value Formation

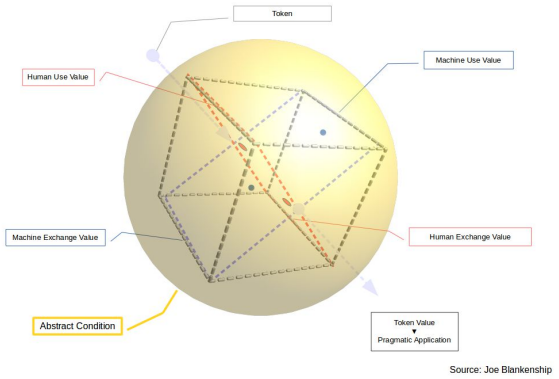

Figure 32: Token Value Dialectic Structure

condition for a given system. This means that given the form, function, and structure of the developer's, investor's, and/or user's material spatial practices, the social dynamics, in the processes of their abstraction, also manifest a power dynamic through the position/perspective/sentiment triad of the human agents which then becomes an imposed regime upon the blockchain framework and the underlying decentralized network of miners. In this way, competition and crisis, for both human and machine, is an integrated part of the core blockchain ecosystem as machine labor via the mining network is infused with

the aforementioned politics stemming from those social dynamics. However, instead of erasing borders, these systems keep a record of how borders evolve and shift while accelerating via the systemic crises such as hard/soft fork, changes to the protocol and framework, and the social dialogues found within the written and recorded history of the developers, investors, and users of these systems. Therefore, issues such as friction of distance are made visible via their spatial manifestations as seen in the varying dialogues of the human agents (e.g., developers, investors, users) involved with and guiding these

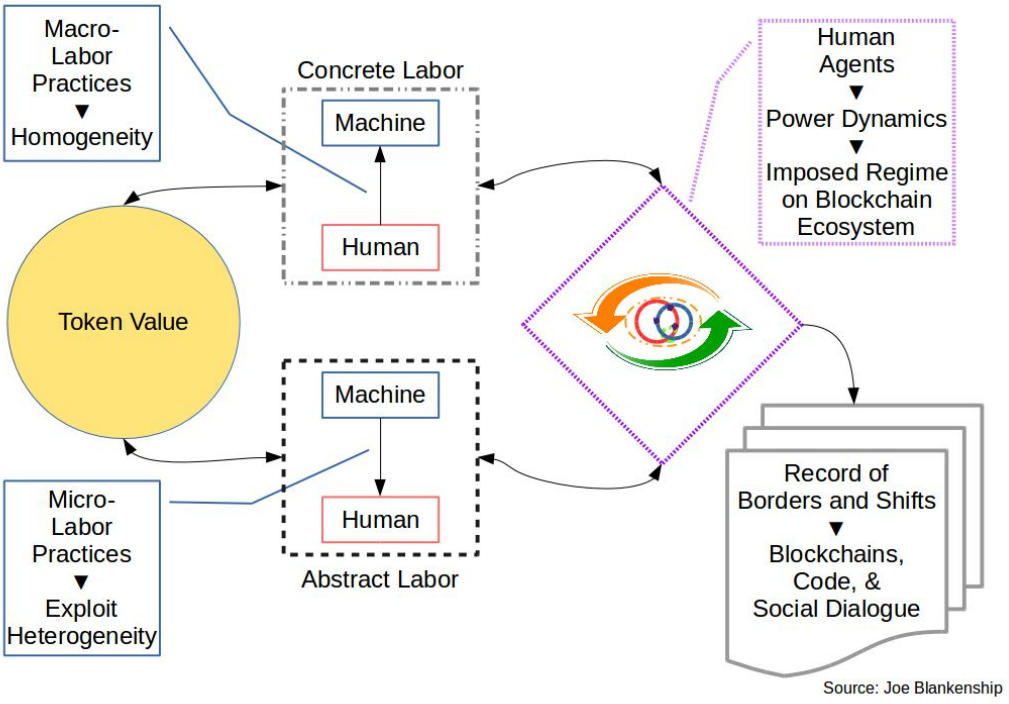

Figure 33: Effects on Labor

systems' usages and evolutions in relation to subjective ethics, issues of ICT accessibility, and regulation within the social, political, and economic dynamics of these larger global spaces. As was seen with Ethereum and Bitcoin, hard forks have been initiated by social dialogues within political and economic ethics related to the material spatial practices of the token value (i.e., cryptocurrency). As the crisis accelerates, the competition to provide a solution within the contradictions of the space (shifts between

the abstract condition and pragmatic applications) and the result is devaluation of the token value. If the resolution to this process is a change in the existing system, the token value will recover if the abstract condition via the social power dynamics can maintain the material spatial practices of developers, investors, and users in the reproduction of pragmatic applications. If resolution to this process is a new blockchain system (as seen in Bitcoin and Ethereum forks) or maintaining of a variant of the old blockchain system (such as Ethereum Classic), further crisis and competition will emerge effecting both the old and new systems alike until the abstract conditions and pragmatic applications of both systems resolve their conditions of being as distinct from the their historical legacies of becoming (in terms of stabilization of material spatial practices following the creative destruction of labor within both the old and new systems at their respective accelerations). In terms of the micro- and macro-scalar dynamics of these systems, the ultimate goal of the abstract condition of the blockchain systems is to maintain an appearance of homogeneity at the macro scalar as to not draw attention to the internal natures of these systems as related to their means and modes of spatial production via the blockchain systems spatial, human/machine organization.

This nexus of human/machine labor also exposes points made by Harvey on technological fixes related to class dynamics (Figure 34). Within these systems, we are not seeing an egalitarian system of exchange as promoted in many mainstream applications of this technology. We are in fact seeing a reinvention of the mobilities of capital and labor as these systems have great potential in hyper-accelerating expansion via micro- to macro-competition within global economic systems. However, the conflict between the vectoralist bourgeois and the hacker working class takes three distinct forms: the machine-to-machine competition as found within the DAO construction of the blockchain system; the machine-to-human relation to transactions; and the abstract condition's effects on human agents vis-a-vis one another and how it affects the human-to-machine relation. As discussed above, the machines are designed and then given an infused autonomous-agency to engage in competition which then affects a human agent via the balance between token value to infrastructural investment. This then entails a

dynamic in which the form, function, and structure of transaction is negotiated between the human and machine with the machine as the exploited working class within this lower layer of technological fix for the higher layer of neoliberal capitalist practices as negotiated between the developers, investors, and users of these blockchain systems. Though it appears that the human/machine relations control a sense of place in terms of abiding by the framework and protocol of a blockchain system for an allegedly 'revolutionary' application, it is still at the mercy and control of the dominant capitalist spaces and logics

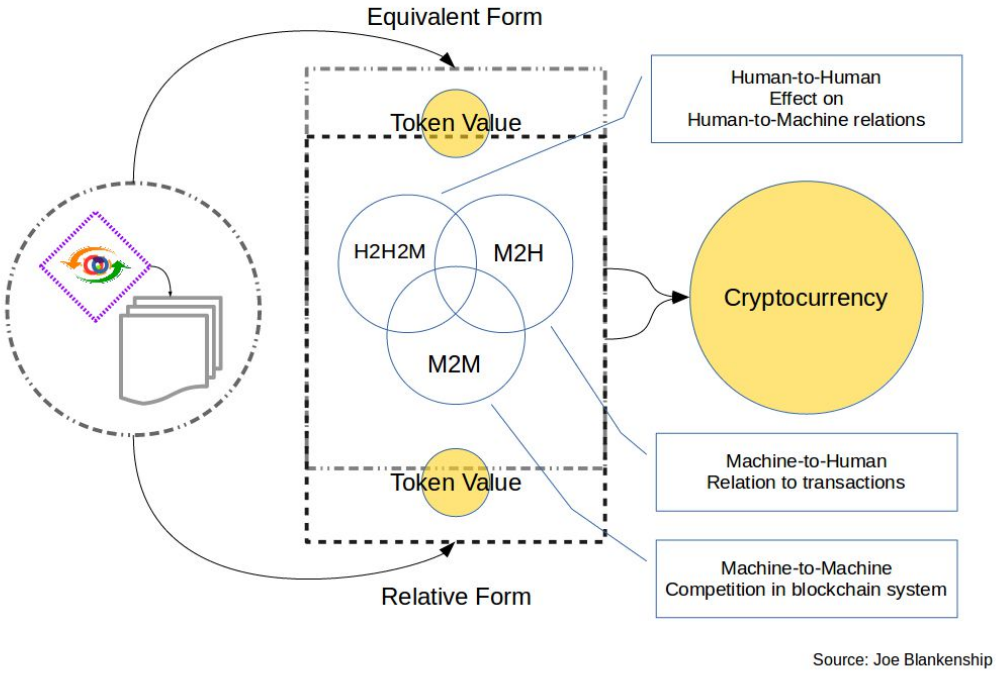

Figure 34: Technological Fixes and Class Dynamics

which ultimately guide its abstract conditions, space, and time.

In observation of the above dynamics relationship to decentralized autonomous organizations (DAOs), and corporations (DACs), time/space compression uses the perspectives of the human agents (in their material spatial practices) as the mediator of human/machine relations within the blockchain system (as representations of space) which then codes the reproductions of these spaces (through the processes of abstract condition reproduction), in an attempt to resolve contradictions that arise for spatial

fragmentation of capitalism through the homogenization of these spaces in their conceptions of human/machine place. As we explored above, the conflicts between the micro- and macro-scalar, moving from machine space dynamics to human social space, exemplify these processes as described by Harvey as these demonstrate a persistent need to intensify labor and apply new technological fixes within new organizational forms through automation in areas such as blockchain framework, machine learning, and "Internet of Things" (IoT) devices. We sees these when examining the blockchain social space's effect of the conception and reproduction of the abstract condition for that very system. These systems also make transparent how the attempts to diminish spatial barriers through the DAO concept via the blockchain systems expose the increased sensitivity of capital shifts through these blockchain places within the larger capitalist spaces: fragmented, unstable, uneven.

Code/Space

I have made many references in my analysis to blockchain systems as code/spaces due to the meeting of several criteria as presented by Rob Kitchin and Martin Dodge. Through an examination of the core components of these systems (e.g., blockchain, cryptography, decentralized network), we can see the overarching software framework, via a chosen protocol, is necessary in terms of how human agents engage in processes of reproduction of these spaces. In order for the blockchain to grow, it must be mined by the mining nodes and supplied transactions from humans and/or other machines. The blockchain is not an inert record as through the cryptographic requirements of the system; it becomes the place through which humans interact with the machine spaces and from there begin negotiating the social dynamics that then manifest themselves, via the abstract condition and pragmatic application, as conceived through the human agents' material spatial practices. As seen within the Bitcoin and Ethereum blockchain systems and between many other forms of blockchain system, these processes are neither deterministic nor universal in how form, function, structures, and purposes within these systems contingently evolve within and between each other.

In terms of the levels of code/space activity, we start with the mining node as coded object (Figure 35). Of all the actants in these blockchain systems, it requires the framework software to function as a node and to maintain its form as a miner within the structures and purposes of the decentralized mining network. The mining network, defined and governed by the framework as used by the mining nodes and through which they are situated, constitutes the coded infrastructure through which the human

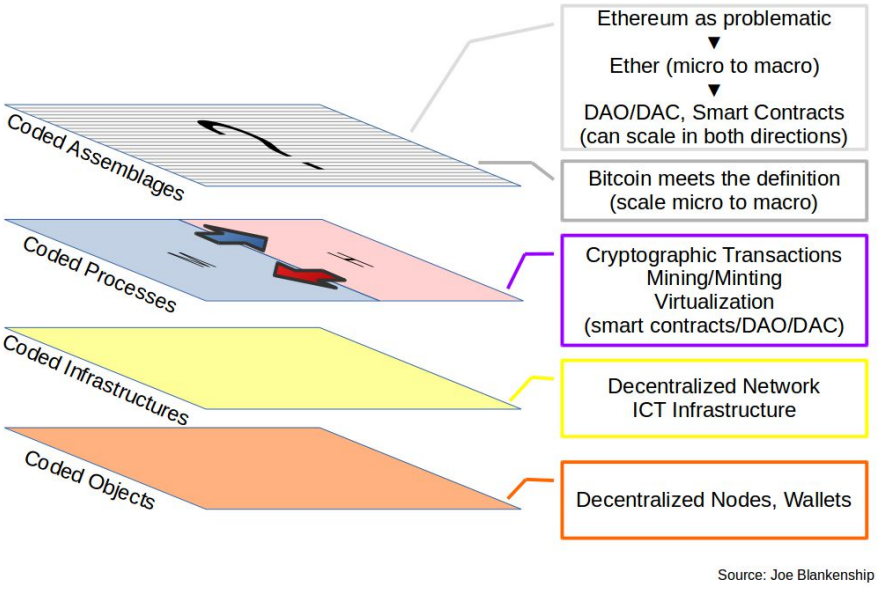

Figure 35: Blockchain Code/Space – Levels of Activity

agents form their social relations and spatial material practices. The human agents then used cryptographically-signed transactions that the coded objects and infrastructures use to establish their conditions within the blockchain systems' coded processes. These processes vary depending on the generation of blockchain technology and the form of DAO a particular blockchain system takes its intended function and surrounding structures. Within the Bitcoin blockchain system, transaction within the process are focused on the relatively simple state-of-value function for the Bitcoin cryptocurrency. However, within the Ethereum blockchain system, the transactions that are processed by the coded infrastructure are smart contracts, which are data objects that are also coded objects within the virtual

machines of the Ethereum state machine. Not only that, but these virtually held coded objects can also produce other functional coded objects within that same virtual machine anywhere in the decentralized infrastructure.

When we come to the level of coded assemblages[13] as proposed by Kitchin and Dodge, a dilemma arises. Bitcoin and its exchange relations to other cryptocurrencies fits the description of an assemblage: its infrastructure and any number of other infrastructures can interact to exchange one cryptocurrency for another. This is in terms of alt-coins of the Bitcoin framework and protocol as well as its mechanisms to interface with newer generations of blockchain technologies such as Ethereum. However, how do we classify an infrastructure like Ethereum when at the infrastructure level, smart contracts and the more complex DAOs (as transactions) can conceive and perpetuate their own cryptocurrencies, crowd sales, and liquid democracies virtually within that infrastructure's coded objects (i.e., Ethereum's decentralized nodes), but then have the ability to act autonomously as coded objects themselves (post-validation to the blockchain) in creation of their own coded objects and coded processes within Ethereum's virtual infrastructure (i.e., Ethereum's virtual machine). Instead of creating coded assemblages from connected coded infrastructures moving from micro- to macro-scale in the case of system scaling (such as automated warehouses and other examples), we are creating two different forms of code/space via these transactions moving from micro- to nano-scale. First, coded assemblages are created that sit in parallel with the decentralized network in the case of smart contracts, but have autonomy in how they form as coded objects post transaction and have the ability to establish their own processes given the limitations of the programming language built for the blockchain framework and the human or machine actants' ability to manipulate it. The second potential code/space created is decentralized, autonomous infrastructure (within any scale not exceeding the extent of the Ethereum decentralized network of mining nodes, but not nested within it) within which it defines any number of coded infrastructures based on its own framework, even

13 A coded assemblage is "several different coded infrastructures converge, working together—either in nested systems or in parallel, some using coded processes, others not—and, over time, become integral to one another in producing particular environments." (Kitchin & Dodge, 2014)

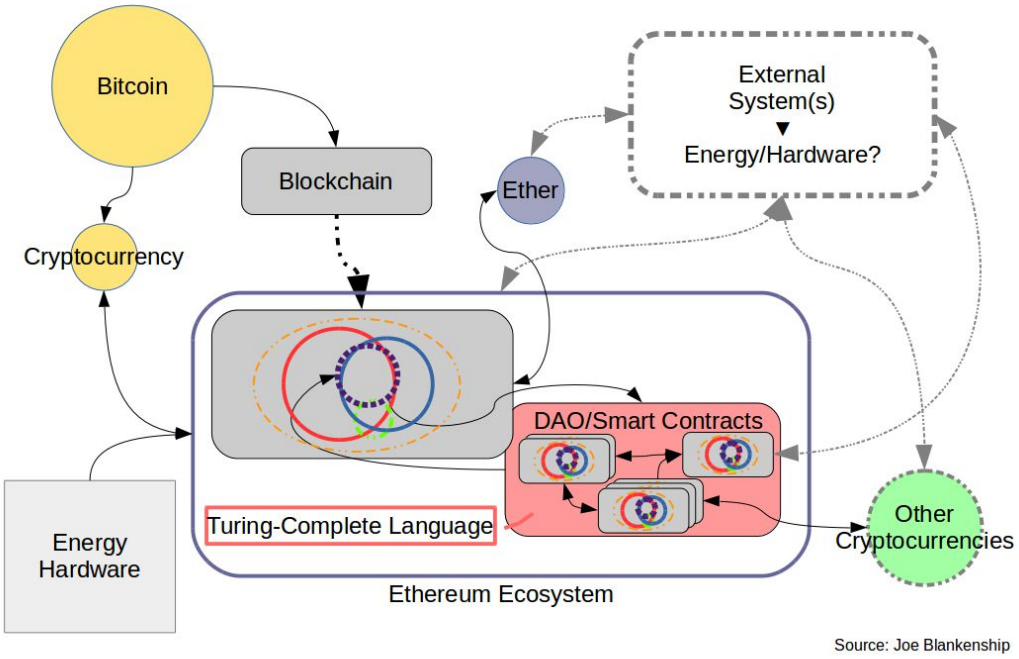

Figure 36: Potential Processes of Collective Autonomous Life (Ethereum)

to the point where those infrastructures can create smart contracts and DAOs (e.g., a DAO that interacts with IoT devices and manipulates the data to provide a desired output as established via the DAO). Given this ability to hyper-compress the space/time of these coded infrastructures within a very different form of code/space, this has direct implications on both the production of space and its effects on humans involved with and affected by these technologies within varying scales of political economy.

Though stated that these coded parts have the potential to produce a kind of collective, autonomous life, Ethereum's form of blockchain code/space gives us the opportunity to explore the processes by which this may occur (Figure 36). Through the code walk-through and the analysis connecting it to the conditions within the Ethereum social spaces of Reddit and specific cases of individuals guiding these spaces, we can in many ways see how the developers and their numerous intents formed the Ethereum blockchain in such a way that considered the code/space of the Bitcoin blockchain, built coded objects and processes to interface with this legacy system, and then built a framework and

protocol for a new infrastructure using these considerations, but with a focus on the desired form, function, and structure of developers for their material spatial practices (for Ethereum, a blockchain framework with a Turing-complete language for the creation of smart contracts and DAO transactions). This allowed people with Bitcoin to purchase Ether through the ICO crowdsale (later through digital currency exchanges) which funded the development of the larger functionalities of the blockchain framework (e.g., key functions for the core framework, tools for developers, tools for investors and users). Now looking to the code walk-through, any individual with Ether can learn the smart contract/DAO language as not just a tool (or medium) to produce a transaction, but to take form itself as a coded object (a token value via smart contract functionality; one of the initial claims of Ethereum is that you could replicate Bitcoin within their blockchain framework). A new form, function, and structure is encapsulated in its smart contract and/or DAO framework, given a purpose through its conception, but also subject to the dynamics of the social spaces of the larger blockchain community as the processes of spatial production begin to emerge from the abstract condition/pragmatic application dialectic.

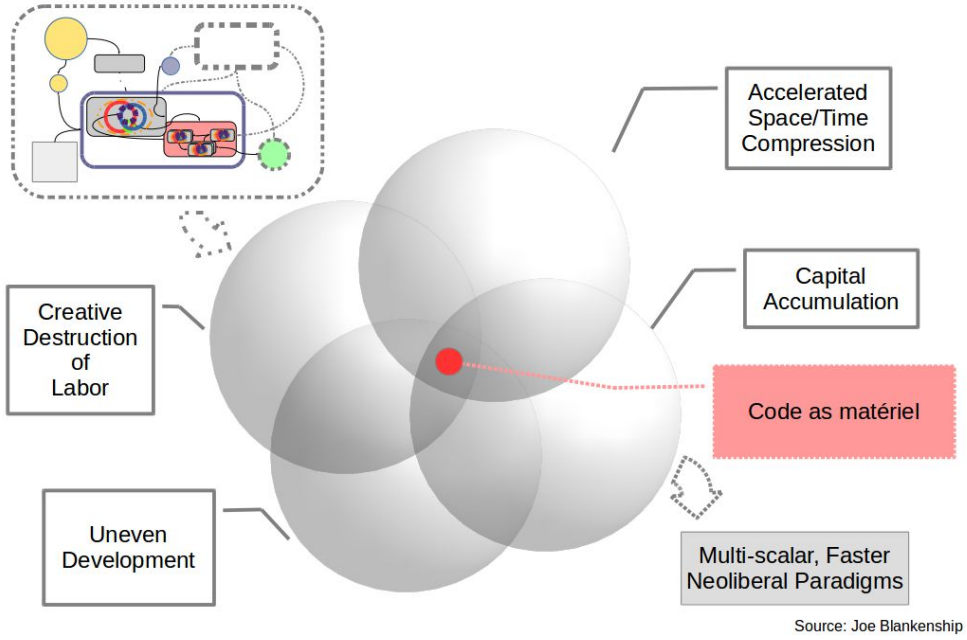

Figure 37: Potential Effects of Blockchain Technicity

This is a form of technicity much more evolved than that of Bitcoin; moving from cryptocurrency to smart contracts and DAOs while advancing the capabilities of the infrastructures (hyper-accelerating and compressing the space/time under which larger assemblages are conceived (Peck & Theodore, 2015)) (Figure 37). These productions of space also have the potential to then drastically affect the creative destruction of labor and accumulation typical of neoliberal capitalism. If one can create a smart contract within or in combination with a DAO/DAC that replicates the function of a human laborer, that jobs become obsolete within the circuits of political economy seen today. The proposal of a company called Chronobank (2017) stands to eliminate thousands of jobs in the recruitment industry by connecting skilled labor directly to employers if they are to launch and be adopted successfully. Sberbank in Russia is eliminating 3000 jobs by installing a robot lawyer (a weak AI program) which will process letters of complaint (Naumoff, 2017). As these technologies advance in their ability to completely fulfill employee's job requirements, numerous crises will increasingly emerge in these human/machine code/spaces. In these cases, code once again must be used as more than a tool; it is the language within which developers, investors, and users are placing their politics, ethics, and codes which can then be read and deconstructed like any other text. This was demonstrated in the connecting of documentation from the code to the topical discussions found on Reddit and in the rhetoric of my study participants. This is where we also have to ask whether code/spaces are defined through their co-production or if this should be expanded to a condition of co-evolution within the cyborg spaces of the ever accelerating spatial productions of the Anthropocene (affecting the physical, human, and cyberspaces in a simultaneous multiplicity of inter- and intra-relations).

Code as a product as presented in the text does agree with the above analysis in terms of the process of conception, manifestation, abstraction, and discursive relations. This extends to the assertion that these blockchain spaces affect both the human spaces of everyday life while simultaneously being effected by those spatial dynamics and relations. Within the context of nonrepresentational theory, we can see aspects of the material spatial practices of developers and investors as instinctive and/or subconscious

as these are guided by the blockchain framework once established as a space which is controlled by an abstract condition and any number of pragmatic applications. However, there is also an answer to why these spatial practices are partially or completely automated in the course of resolving persistent relational problems in that, as we have discussed with Ethereum's smart contract and DAO transaction process, these micro spaces become the most efficient way to resolve the internal conflicts of abstract spatial production within the modes of neoliberal capitalism. As with the above examples, when crises emerge from value extraction via the abstract spaces of the token value (i.e., a blockchain space related to pragmatic application fails to yield a "promising" investment of token value and/or time), the abstract condition begins its processes of reproduction through the social, economic, and political aspects of the social space (often guided by developers who are also key investors or have tied their interests to key investors via a provided use case) to then guide the developers, investors, and users in shifting the forms, functions, and structures of these systems (both human and machine). In the case of the Ethereum hard fork, a crisis emerged surrounding a hack of a DAO that was unintended by both the creators of that DAO and the core developers of the Ethereum framework they were using. However, the token value of both Ethereum and that DAO still yielded a "promising" investment to the holders of that token value which forced the maintainers of the software framework to propose a shift in that space's abstract condition (i.e., the political idea that transactions are immutable on the blockchain) that would undo the hack. Due to the mechanism of consensus within the means of production for that blockchain space, a vote could be taken by the human maintainers of the mining nodes as to whether a hard fork should occur to resolve this dilemma. In this case, the shift in form, function, and structure guided by the abstract condition resulted in a bifurcation of the Ethereum community; resulting in the creation of Ethereum Classic which then began its processes of reproduction via its abstract condition.

A final point to address is the concept of transduction (Figure 38). As elaborated above, these blockchain frameworks not only have the ability to transfer labor and functionality into coded spaces and code/spaces, it is the imperative at the core of their conception. I previously mentioned the persistent

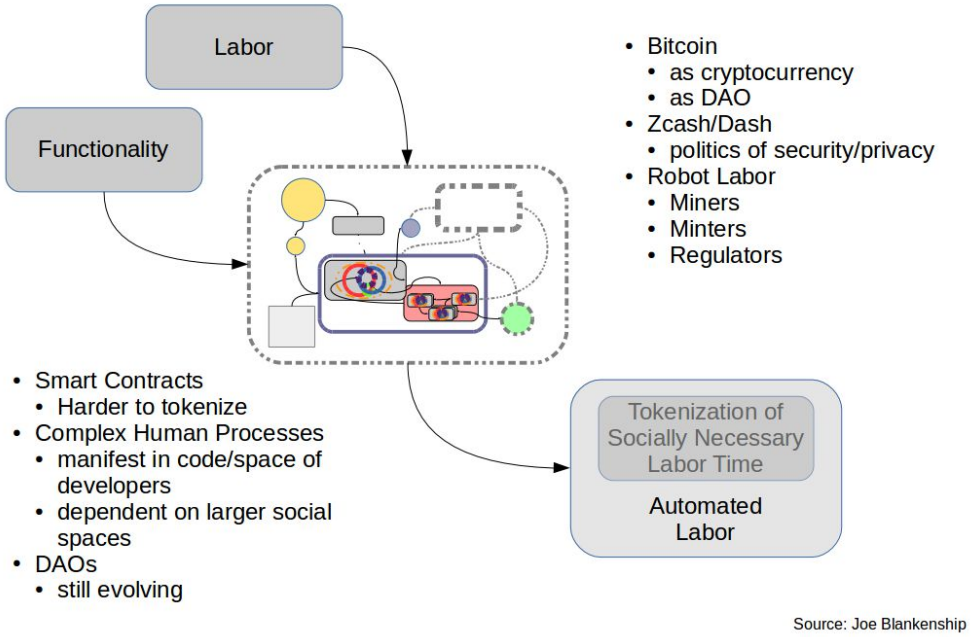

Figure 38: Blockchain Code/Space Transduction

occurrence of “idea” as mentioned frequently in the course of interviews and open conversations related to “concepts”. This coincided with the explanation of how certain blockchain-based projects would be carried out in order to fulfill a pragmatic application within a larger blockchain ecosystem directly related to human labor tasks. These tasks ranged from data storage and notary services via smart contracts and hashing structures to banks and insurance companies via complex DAO assemblages. These human tasks range from moderate to high skilled, single employee jobs to hundreds of thousands of jobs within global finance industries. There was persistent mention within all three study areas regarding elimination of third-parties. In terms of the interviews and Reddit content, this was in the context of reducing unnecessary human labor. For the code walk-through, this was in the context of the internal governance mechanism built into the core blockchain framework and its means of production.

The conversation on transduction then pertains to matters of tokenization. The transduction of labor into these spaces in not just about the elimination of redundant human jobs that can be automated, it

is about the socially necessary labor time the jobs represents. If a business can maintain the same function with a reproduction of the form and structure which yields equal or more profit, that profit comes in the form of labor time, 100 percent extracted from collective, autonomous robot labor. Bitcoin has survived, functions, and will continue to function because it is simple in respects to this form of transduction. The protocol may be used for a great many things such as side-chain applications, metacoins, and colored coins, but the primary purpose (and the purpose for which any change is made) is to produce and sustain use of the Bitcoin cryptocurrency. This is something that many people as developers, investors, and users can perceive as reliable and legitimate because it is something they can understand in very simple terms. Even if they do not understand the complexities of how monies or currencies are generated and what that represents, they now (following the white paper by Satoshi Nakamoto in 2009) have little trouble transducing such functionality and structures into underlying blockchain code/space forms that sustain the Bitcoin blockchain system. Despite the frequent mention of the complexity of the Bitcoin core framework (which is open source and available for anyone to access), the simplicity is due to the condition of Bitcoin as a DAO that provides a general use commodity via a tightly controlled set of robot laborers that mine the blocks using proof-of-work in order to create consensus and trust in the blockchain and the resultant token value: the Bitcoin money commodity in the form of the Bitcoin token. Blockchain frameworks such as Dash and Zcash have take these concepts and applied them within the politics of security and privacy as they provide a protocol that ensures transactions are recorded but remain obfuscated to all except the sender and receiver of the transaction. This means that robot labor which regulates and mints blocks and associated tokens for Dash or Zcash are now being controlled by an additional layer of robot labor which regulates security and privacy.

As the complexity of a blockchain system and its resultant DAOs increase, so does the complexity and difficulty of their abstraction processes into the token form; general understanding of a smart contract is far more involved than that of a generalized currency and therefore becomes difficult to find a general acceptance and use of the token form (representative of its underlying systems and its

cryptocurrency). This also means that the politics surrounding and permeating a more complex blockchain system becomes more apparent as do the resulting contradictions in their purposes and ethics. The implications for transduction are now tied to much more complex human processes in which developers and their material spatial practices are responsible for the resultant representations of space and these now automated processes within newer, more complex code/spaces. However, this is all contingent upon the social spaces of the key human agents producing the blockchain spaces and their ability to negotiate the abstract conditions by which the process of transduction occurs. Developers would have to transform a job or set of jobs into a labor function with a form and structure that would meet the requirements the robot labor would then need to fulfill within the contract language. The related DAO would accept and then institute this robot laborer via a blockchain transaction. This may be another point at which a crisis emerges in these systems as the use cases presented by developers, investors, and users become more complex, requiring a much more involved process of spatial production of the surrounding scales of code/space and their intricate micro-spatial relations.

Network Society

Examination of the data sets collected for this thesis exposes another dimension of these human/machine code/space. As the processes surrounding transactions and block generation reproduce themselves and one another, often encapsulated and abstracted via a symbol token, they provide another direct challenge to the distance-lacking network society. This challenge comes in the dialogues emerging from the critical discourse on scaling these code/space architectures (Figure 39). In the now present proof-of-work-enabled systems, these decentralized systems that span the globe experience both technical and social barriers to entry which manifests themselves in the mining of the blockchain. Each side (technical and social) necessitates the other's condition of existence in their respective spatial productions: the social harnesses a geopolitic, within and surrounding a blockchain ecosystem, relating any number of economic systems to this, and then perpetuates the standards of both within the

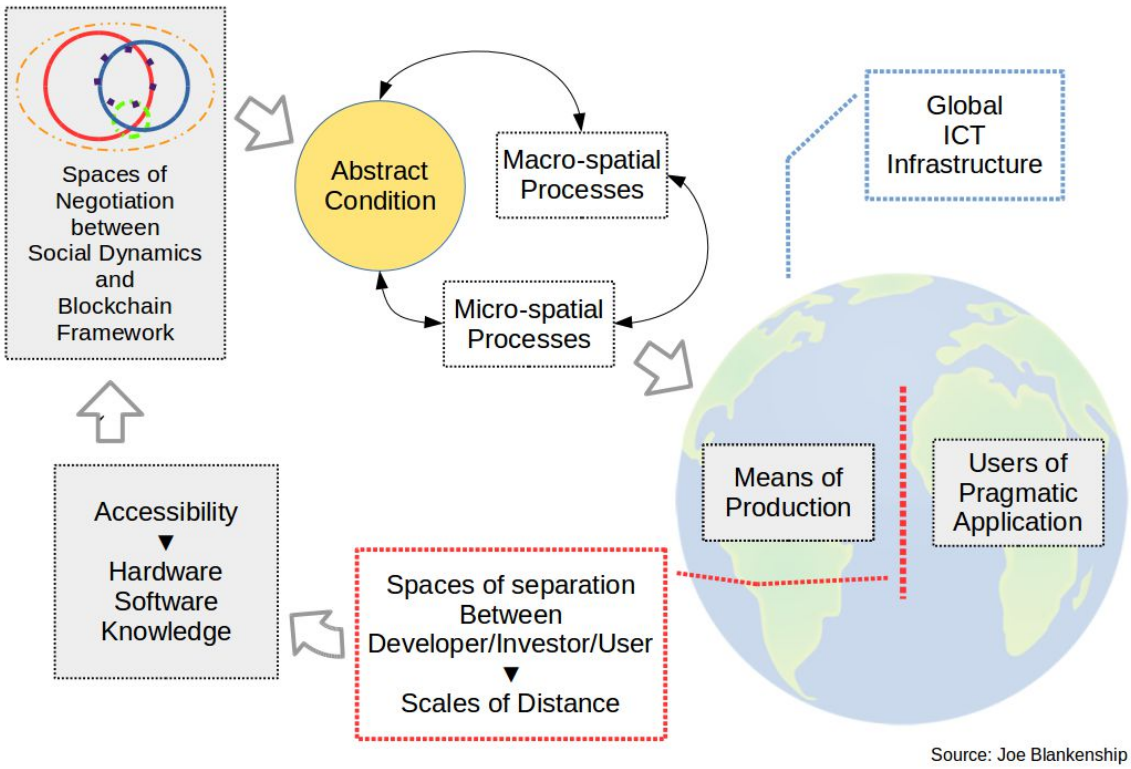

Figure 39: Blockchain Scaling and Network Society – Borders

development of a compatible software framework. However, the blockchain ecosystem and its core components (e.g., blockchain, cryptographic security, distributed mining) have now had three generations of evolution in which not only have the applications of the blockchain technologies expanded beyond a state-of-value as seen in Bitcoin, they now enter the realm of 'non-economic' applications which are ironically still commodified within neoliberal capitalist dynamics. These are 'code/spaces' as not only defined in the sense that Dodge and Kitchin presented through their work, but also through the measure of the social and economic distances (i.e., flows and puddles) that indicate shifts in politics (which manifests in the abstract condition) since the conception of the blockchain as promoted by Satoshi Nakamoto.

These shifts and their resultant distances can be seen in all data sets. The first and most dominant border creating shifts are found in the social space dynamics of developers to investors and users (via the use-case). In many ways, the newer generations of blockchain framework are blank slates: they can be

used in any number of ways to create a pragmatic application for a use case. As discussed above, this happens within three interrelated spaces: the abstract condition; the micro-spatial processes; and the macro-spatial processes. The social space affects the form, function, and structures within which the material spatial practices occur for and with the developers and the blockchain framework. The micro-spatial processes of the miners must operate within the protocol assigned to their labor tasks. The macro-spatial, which dominates the use-case as provided by the investor (by or as the user which may be a developer, fellow investor, or user in everyday life), acts through the abstract condition of this burgeoning blockchain code/space to then negotiate distance between the users of the potential pragmatic applications and the mean of production through which the scale of pragmatic application is bound (i.e., the distributed network of nodes and the related algorithmic protocols). This process of negotiation takes form in the physical aspects of accessibility to and within ICT infrastructure around the world (via the required hardware, software, and knowledge to leverage these means of production (i.e., the mechanisms of the blockchain framework)). The result is a limitation of the extent and penetration of this form of code/space infrastructure to form the limitless coded assemblage status as promoted through many blockchain-based companies and service providers. We can see this in the discussion surrounding distribution of and access to mining resources in the process of establishing Ethereum Classic as a legitimate blockchain system. In the process of bifurcation from Ethereum, during and post hard fork, the concerns immediately turned to how a secure consensus through a critical mass of mining nodes could be achieved. Without this critical mass, crises of over-accumulation would plague this framework via a concentration of mining power through the proof-of-work-enabled decentralized network. In the physical sense of decentralization to and within ICT/Internet systems, Ethereum Classic had to establish the extent of their network (i.e., its borders of functionality via its form and structure) in order to be seen as a legitimate entity within the cyberspaces of blockchain systems.

However, there is another border forming set of processes happening across and guiding from within the three interrelated spaces mentioned above: the developer/investor social space dynamics and

their relation to any number of ephemeral ethics (Figure 40). The physical aspects of these blockchain ecosystems, via the human/machine code/spaces co-evolution, requires a persistent engagement with the hardware, software, and the coded matériel (via the programming languages and their documentation) from and dominated by the processes of the abstract condition for a given blockchain framework. The dialogue within and between developers must as some point engage with the dialogue within and between investors; these dialogues involve one another in defining use-cases through which the pragmatic application will be conceived. These set the terms of the material spatial practices of both, resulting in the abstraction of the processes leading to the creation of the pragmatic application through the established modes of spatial production. In the case of public blockchain projects, much of this is transparent in terms of the open-source software that anyone with access to it can obtain and examine. Many projects with resources to do so ensure that at a minimum there is a website, social media, and multi-media resources available to inform the voyeurs of these spaces of the blockchain systems intent. Bitcoin and Ethereum both have the resources and reach to ensure their use-case providers have ample information to engage with and use the means of production of these systems, extending this to the social spaces of blockchain-related conferences and the more focused developer conferences (or smaller hackathons). However, the voyeurs of these spaces rarely see the processes within the social spaces of the developer/investors dynamics that ultimately determine the material spatial practices (even through videos, podcasts, and other conversations made open to the public). This is because it is often hiding in plain sight. There is a literacy needed on both the part of the developer and investor in their material spatial practices. For developers, there is a barrier in the ability to produce understanding of how the use-case take form through coded matériel resulting in the pragmatic application as negotiated via the developer/investor social dynamics. For investors, there is a barrier in the ability to understand developer processes for both their internal utilization and external proselytization. Though both appear to be transparent, these barriers establish a knowledge/power dynamic over the physical and ephemeral aspects of these systems, creating real borders to true entry with these system. One can see this in Ethereum code documentation and how it

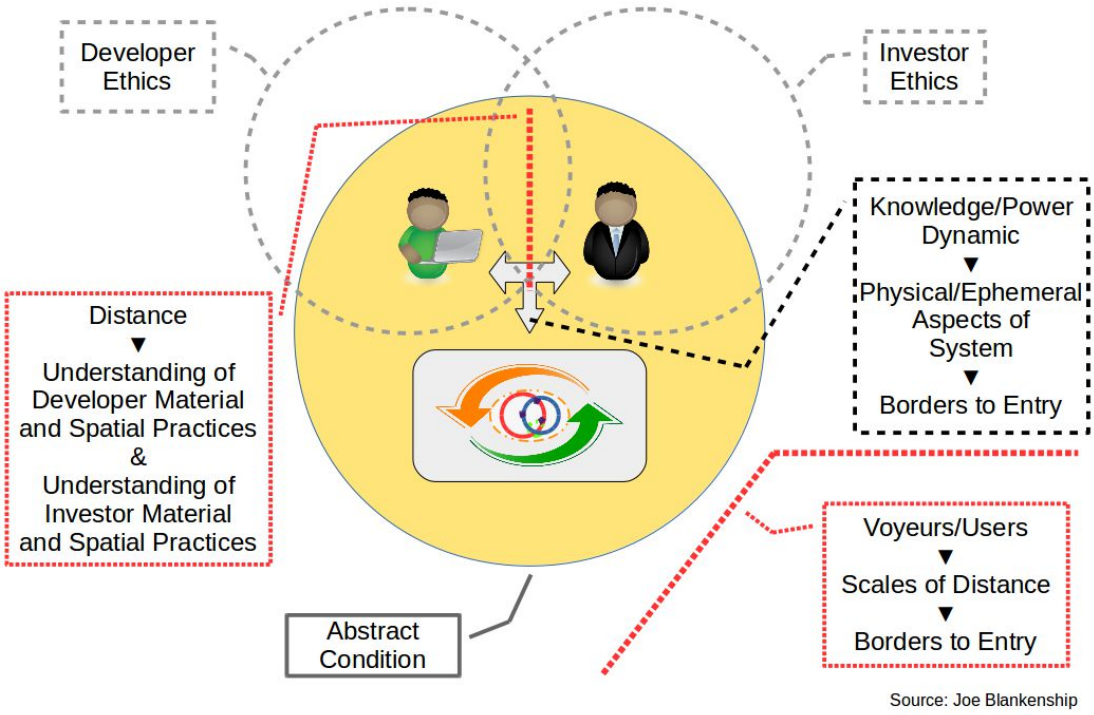

Figure 40: Blockchain Scaling and Network Society – Ethics

manifests through the blockchain system documentation, and the dialogues of Reddit and other blockchain communities. Developers, as key contributors to these dialogues, affect and are affected by the other members of the communities who desire or need to leverage these systems in any number of pragmatic applications. But the processes that reproduce the abstract condition via the social space through the abstraction process into the token value is mired with the tropes of coded language of both the developer and the investors, within and between these blockchain systems.

The relation of the developers and investors to each other in their material spatial practices not only produces the representations of space at the micro-spatial and macro-spatial scales, but also produces an ethics through their negotiations with the physical and ephemeral aspects of these systems' borders. Bitcoin and Ethereum both work diligently to ensure their language is internationally understandable and accessible. However, the borders of the physical systems are still dominated by the people and nations

that can afford investment in these blockchain ecosystems (both in human and machine labor resources) and interpret their numerous coded languages. A developer, investor, and/or user wanting to enter a blockchain space or a number of blockchain spaces must then negotiate how understanding of these systems and their abstract conditions (still partly unknown due to the coded language obscuring the internal spatial relations of developers and investors) must then accommodate their own social spaces and processes of spatial production within a burgeoning abstract condition in which they begin another layer of abstraction via the relations between their use-case and the unknown manifestations of their pragmatic applications. They must then utilize their forms of robot labor in a way that ultimately accommodates the production of spaces within and surrounding their pragmatic applications. The developer/investor dynamic over the blockchain framework, whether inadvertently or intentionally, creates a set of borders (though informal as they maybe) in terms of the ethics tied to the sense of accessibility via the coded language regimes of systemic agents and actants. This is ultimately what produces the multi-scalar senses of place for agents and actants in these blockchain systems and larger network societies.

Conclusion

> At the time of drafting this for review, I contemplated attending the 2017 North American Bitcoin Conference in Miami (one of the largest blockchain technology conferences in the world). Despite the raise in Bitcoin and Ether value in January of that year, the primary payment option for the conference was still US dollars. To pay with cryptocurrency, one had to email the organizers directly to arrange for payment in Bitcoin and Ether; no other cryptocurrencies were accepted. They responded to me stating they would accept any of the top ten cryptocurrencies on an exchange which also happened to be the cryptocurrencies that had the highest levels of exchange to US dollars at that time. Cash was still the preferred method of payment.

"What is the purpose of human life… what is value?"[14]

In the course of exploring the research question for this thesis, we have addressed numerous aspects and relations of the production of blockchain spaces to the realms of political economy, code/space, and network society. This was accomplished through a case study of two blockchain systems, Bitcoin and Ethereum, within three data set: semi-structured interviews and open conversations; content analysis of Reddit communities associated with these two systems; and a walk-through of the processes and code related to the Ethereum Project use-cases as experienced from a user and developer perspective. These data sets were then examined individually and collectively through the three distinct approaches: a phenomenology of these systems' developer, investor, and user material spatial practices; a content and discourse analysis of their larger communities dialogues on the forms, functions, and structures of these systems based on the individual and collective perspectives, positions, and sentiments; and a systemic analysis of the software framework of Ethereum as a text to determine the connections to the larger phenomenology and discourses of developers, investors, and users.

In examining how spatial production of blockchain ecosystems occurs by and with the blockchain software/hardware frameworks as DAOs from the situated contexts of the human/machine dialectic, we were able to explore the manner in which the means of production for each of these systems are distinguished from each other. We examined how developers currently dominate these spaces via their control over the means of production and how they play a major role in the process of reproduction of the social, political, and economic dynamics contextualizing both the systems and the systems' byproducts. The counter to this influence is found in the investor position, its associated logics, and the simultaneous conception of the sentiment (the abstract condition) of the modes of spatial production for a given blockchain ecosystem (the human/machine code/space). These relate to any number of use-cases intra- or inter-blockchain system, the pragmatic applications, which then integrate into the means and modes of

14 Chris Williams (blockchain developer) on the ethical dilemmas facing blockchain systems [personal exchange] 2016

production within the political economy of neoliberal capitalism. Much of this is facilitated through a transference of agency with the human/machine dialectic of collective, automated labor via the distributed network of nodes required for the blockchain framework and gives form, function, and structure to that network as well as the overarching framework via the abstract condition, all of which is ultimately abstracted into the token form of value.

I came to this conclusion based on the developer participant personal accounts of their material spatial practices which were then placed in the larger context of the Reddit posts. The subreddits also served as the communication mechanism by which developers would translate their coded language to the large community of investors and users in terms of the systems' functionality, any issues related to the system or functionality, and how these related to any number of external concerns for projects requiring knowledge of the token value, the blockchain framework, and/or the potential exchange value. These areas also show how crises in the conception and abstraction processes related to token values are symptomatic of the internal contradictions and the processes of their resolution as described in the event leading up to and following the Ethereum hard fork. This thread of analysis concluded with an examination of the effects of scale, simultaneity, and multiplicity as manifested in the heterogeneous action taken within the human/machine dynamics of the blockchain framework. This is typified in the manner by which a contradiction calls for a technological fix to either reform the blockchain ecosystem or create a new variant as seen in the creation of Ethereum Classic.

The examination of the modes of spatial production reveal the distinct relations to current modes of neoliberal capitalist production studied extensively in human geography and how these blockchain systems both manifest these modes of production in their political economies and their crises. This entailed examination of these spaces' means, modes, and mindsets dominating their unique spatial productions which began with the blockchain framework. The framework encapsulate the protocol and mechanisms required by the system to situate itself as a blockchain system. The framework is also the space in which the material spatial practices of the developers, investors, and users are manifest through

its means, giving it form, function, and structure within its specific modes of production. Bitcoin and Ethereum as open-source projects, within which unique human politics are leveraged in a social space with numerous economics considerations, exemplify how the resultant token value carries with it the abstract condition of those relations in both the framework and the processes by which these systems reproduce those conditions via the exploitation of automated robot labor and shifts in the human/machine dialectic based on the pragmatic application. This involved an examination of how these differed through their similar consensus mechanisms and protocols which produced very different effects based on their frameworks reflecting of the intent imposed by the human agents upon the human/machine dialectic. This related to the legacy of these systems' evolution from the initial Bitcoin blockchain to that of Ethereum in how developers as the dominant class within the social and technical spaces of the blockchain technology have ultimately leveraged their knowledge/power dynamics to accumulate wealth via the token value, and shifted them into the role of investor. This now directly affects the processes of spatial production for the framework as a developer-driven condition is now conflicting with the investor driven one. This not only affects the form, function, and structure of the framework, it means that there is also an imbalance within the power dynamics tied to the token value system as situated within and between wider systems of token value exchange and their respective knowledge structures, placing users at an extreme disadvantage. As reflected in the collective examination of the data sets, this could and has resulted in the abstract condition's dominance over the pragmatic application as conceived via the framework. For example, there is no generally accepted ethic for how these systems are used as they are viewed as inert and only given an ethic when actualized within a specific use-case (ultimately denying any form of politics being attached to the framework). Another example is in the opinions of accessibility improvement in such a way that users entering the system can utilize the system, but at the upper level of a layered obfuscation of the underlying framework via a simple user interface (once again eschewing the politics of the framework via its abstract condition). Even when used as a technological fix within the means and modes of capitalist production, it is presented as a means through which efficiency and reliability of an existing

system is achievable, but only as a tool within the existing politics of that space and not as a means of creative destruction of labor, means of accelerated accumulation, and catalyst of crisis that the implementation of the framework could potentially manifest. Through obscuring of the politics as applied within the abstract condition and then reformed through the token value, the practical application is produced via these means as inert and can then take on the politics of the use-case.

Finally, these systems were analyzed in terms of their conditions as code/spaces and networks within the context of network society. A comparison between the two theories (i.e., code/space and network society) suggests many symmetries between the two schools of thought. However, using blockchain systems as a case study to both expose the bifurcations and juxtapositions in those symmetries, we expanded both the theoretical possibilities for code/spaces and network society while simultaneously expanding the exposition on how blockchain systems connect to and manifest the conditions of DAOs to the human/machine dynamic. The data supports the assertions that blockchain ecosystems meet the criteria of coded objects and processes. However, their forms, functions, and structure make defining them as infrastructures and/or assemblages in their own rights difficult. This is due to the introduction of Turing-complete language used for smart contract and DAO creation which in turn reproduces a micro-scalar space of blockchain form, function, and structure based on, but not determined by that initial blockchain space. These new micro-scalar spaces can then, if so conceived as part of a new abstract condition, build yet another micro-scalar space ad infinitum. As shown in the data, hash tree structures using various forms of induction and recursion have the potential to store massive amounts of data on these blockchains. This also means that these code/spaces can not only scale in either the micro or macro directions, but they can create their own interstitial spaces that do the same and in turn produce borders in the code and infrastructures of these distributed networks and any networks that connect to or contain them. However, these spatial productions are still conceived through human domination of the abstract conditions that interacts to create these code/spaces, then reproduce within the human/machine code/spaces of the originating blockchain frameworks. The ability of these code/spaces

to compress or unfold space/time within their spatial productions becomes the place of displacement and deferral for crises within the modes of capitalist production. This displacement depends upon the concept of transduction, where the processes connected to tokenization (via the token value of cryptocurrency) then become the vehicle of encapsulation for crises through automation and obfuscation of the mechanisms within the means that are creating the crises in the modes of neoliberal capitalist production. This extends from social conflicts over security and privacy to the labor and logistics issues of corporations. We then use all of the above points to debunk the idea that network societies, such as those in the blockchain space, are borderless and distanceless intra-system. When examining the human/machine dialectic of these spaces and how conflict, as part of their nature, creates shifts in old spaces or creates new spaces, the result are spatial productions that have to account for the scale of the physical and coded spaces, producing geographic borders via the conflicting abstract conditions (social, political, and economic) within the varying aspects of the evolving code/spaces.

The assessment for these courses of study and thesis is that these specific technologies and their various manifestations are not the revolutionary technologies promoted to many consumer bases, but are a technological fix with immense potential to both answer and complicate issues related to neoliberal capitalism and its related political economies. The space of the blockchain and its processes are grounded in the qualitative context of the social dynamics by which that are both produced, given form, function, and structure to not only overt byproducts of their use (pragmatic applications), but the underlying politics embedded in both the byproducts and the systems that produce them both (abstract conditions). This produces contradiction such as the legitimacy that is wanted for cryptocurrencies with an absolute lack of regulatory purview, but legitimacy from people would need regulation of some sort to ensure recourse for violations within the system. However, such legitimacy would be in direct economic contention with political and economic entities which currently hold those powers dominantly around the world today. It is therefore critical that we take what is presented in the literature and expand it

towards our present and possible future; this is what these studies, this thesis, and my continued research attempt to accomplish.

Limitations

New cyber geographies present challenges not previously engaged geographically, but stand to gain the most from that engagement which only the interdisciplinary field of geography can provide. As the literature pertaining to these newer forms of spatial production and political economy grow, so will the ability of researcher to engage the more complex and technical aspects of these spaces. If interviews and open conversations are to be used, there will be a need for a larger sample of participants as the number obtained for this thesis were far less than desired. This includes far more ethnographic involvement with key developers of these technologies which for the purpose of this study were developers of the Pyethereum software. Also, to perform a far more complex, textual, and symbolic analysis of the texts collected for this thesis, more time and resources will be needed to develop the custom and open-source software used which would make the analysis and interpretation much easier to perform and reproduce for validation. There are lingering questions surrounding delineation of simple robot labor (miners) from more complex robot labor (smart contracts and DAOs) within the heterogeneous dimensionalities of automated and AI labor that require additional research focused, in part, on blockchain technologies as a new manner by which labor power is organized. Those answers would improve and expand on the distinction of cyber geographies via code/spaces and their robot/cyborg relations from human geographies of human/machine spaces of social relations that are still a determinant factor in the productions of code/spaces.

Significance

At the time of writing this thesis, Coinbase (one of the largest digital currency exchanges) was sent a subpoena by the IRS for records of all US customers (Armstrong, 2017). These technologies are

expected to reach market caps in the billions in 2017 which is less than a decade from the creation and initial implementation of Bitcoin. It is assumed by many speculators in these spaces that 14% of governments will be using blockchains by the end of 2017 and 90% of all governments globally will be using some form of this technology by 2020 (Zaharchuk, 2017). The UAE has begun integrating these systems into their central banking system (Central Bank of The United Arab Emirates, 2017) and the US is quickly examining the ways in which these systems can be used for payments, clearing, and settlement (Federal Reserve Board, 2016). Despite the work on blockchains' effects on banking, governance, and how humans affect these evolving systems, there has been little critical work done on their geographic effects within political economy; a gap that private, multi-national companies are rapidly filling with ample rhetoric (MacDonald, Allen, Potts, 2016; Reijers, O'Brolcháin, Haynes, 2016; De Filippi & Loveluck, 2016; BBVA, 2016). Almost a decade after Bitcoin's genesis, this rhetoric is still being negotiated from blockchain code/spaces to the broad dialogues between developers, investors, and the world which are quickly being dominated through the funding and direction of large blockchain consortiums who are keen on garnering adoption of their respective frameworks (Figure 41) (Marr, 2017; Buntinx, 2017; Braunstein, Volintiru, Laboure, 2017). Usage of these technologies for global, distributed citizenship movements and basic income cannot escape the increasing focus on these technologies for the acceleration of neoliberal capitalist processes and the commodification of new forms of poverty (d'Anconia, 2017; Kastelein, 2017; Iyer, 2017; Thomason, 2017). In many ways, the rhetoric promoting these technologies and their applications as revolutionary obscure the fact that industries are simply retrofitting existing systems, ideas, and people to make them fit a new paradigm for political economy and the spaces of everyday life.

Studies such as this thesis position geography as a key discipline through which studies, methodologies, methods, and validation can be developed. This is due to the sheer complexity of the functional mechanisms and processes involved at the micro- and macro-scales of these human/machine code/spaces. For research related to the production of space, there is great potential in how we approach

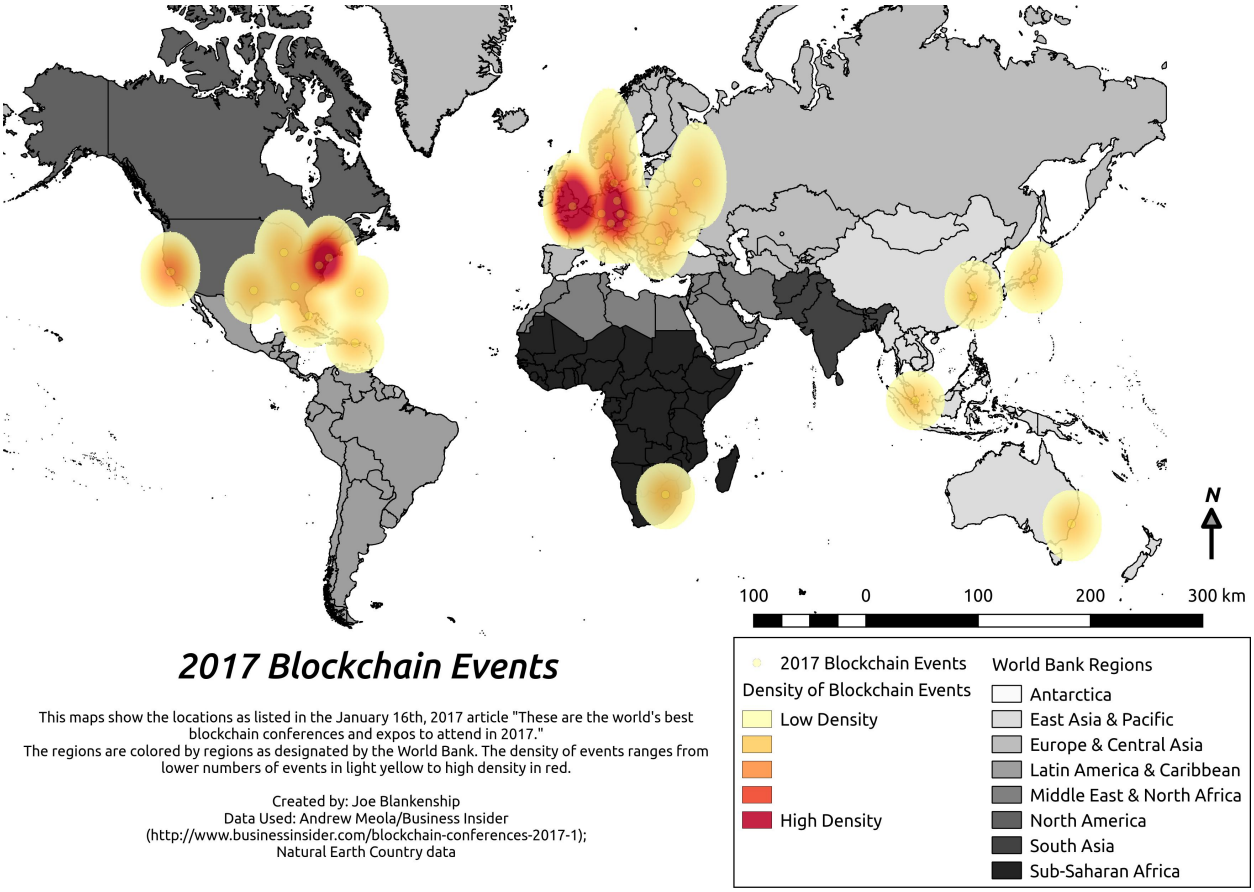

Figure 41: 2017 Blockchain Events

these evolving and accelerating spaces in terms of cyborg natures in the 21st century. For political economy, we stand to better appreciate how something as innovative and useful as the blockchain is not getting any closer to a revolutionary condition within the existing spheres of geopolitics or geo-economics despite what is being promoted and sold to customers around the world. However, the work started by this thesis could greatly benefit from expanded research on code/space and how it might re-conceptualize actor network theory and information society for the 21st century. This will require a massive effort from a broad array of interdisciplinary researchers, but hopefully this thesis has a few thoughts and concepts that could yield novel theories and techniques in a relatively new field of geographic software studies.

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APPENDICES

Appendix A: Interview Questions

History with Bitcoin/Ethereum

- What do you do for a living?
  - Other employment history?
  - What is their educational background?
  - Demographic information (Gender, Age group)
- Did this lead you to Bitcoin/Ethereum?
  - If not, what led you to these technologies?
- What were your goals when getting involved with these technologies?
  - Did these change over time?
- How did you get started with these technologies?
  - When did you get started?
  - Where were you when you first got started? (actual location)
  - What did you use to get started?
  - Did you have a community of people to help you?
    - Who?
    - In what way did they help?
    - Was this a factor in your sustained involvement?

Current involvement with Bitcoin/Ethereum

- What are you currently doing with these technologies?
- Do you see yourself as more of a user, investor, developer or any combination thereof?
  - User
    - Why use Bitcoin/Ethereum?
    - How do you use these systems?
      - What about these systems makes them useful to you?
    - Has their use become easier over time?
      - How?
    - Where do you use them?
      - Online and Offline Communities?
      - Has accessibility become easier over time?
      - How?
    - How do you see others using Bitcoin/Ethereum?
    - Are there any restrictions you place on your usage of Bitcoin/Ethereum?
      - Ethical considerations
  - Investor
    - Why invest in Bitcoin/Ethereum?
    - How do you invest in these systems?
      - What about these systems makes them useful to you?
    - Has investing in Bitcoin/Ethereum become easier over time?
      - How?
    - In what areas do you invest?
      - Online and Offline Communities?
      - Has accessibility for investors become easier over time?
      - How?
    - How do you see others investing in Bitcoin/Ethereum?
    - Are there any restrictions you place on your investment in Bitcoin/Ethereum?
      - Ethical considerations

    - Developer
        - Why develop Bitcoin/Ethereum?
        - How do you develop these systems?
            - What about these systems make them useful to you?
        - Has their development become easier over time?
            - How?
        - Where do you develop them?
            - Online and Offline Communities?
            - Has accessibility become easier over time?
            - How?
        - How do you see others developing Bitcoin/Ethereum?
        - Are there any restrictions you place on your development of Bitcoin/Ethereum?
            - Ethical considerations
- What do you think of the current state of affairs surrounding Bitcoin/Ethereum?
    - In terms of the software/hardware?
    - In terms of community?
    - In terms of market spin and investment?
- What is your exposure to the concepts and applications of DAOs/DACs?
    - Where do you see them being used/developed/invested in?
    - Who is most involved in their conceptions and implementations?
        - Users/Developers/Investors?
        - In what ways?
    - What do you think their current utility is?
    - Have DAOs/DACs changed the way in which you approach blockchain technologies?
        - How?

Future plans/predictions for Bitcoin/Ethereum

- What is the future of Bitcoin/Ethereum?
    - In what areas do you see Bitcoin/Ethereum making impact in the future?
        - Near term impact in what way?
        - Long term impact in what way?
    - What do you think are the major forces guiding its direction?
        - Uses
        - Investments
        - Developments
    - Is accessibility to these technologies increasing?
        - If so, how?
        - If not, what could increase accessibility?
    - What ethical considerations should be addressed in the course of their futures?

Appendix B: Qualitative Codes

History: an indicator of events, both personal and community related, that led up to or affected the participant.

Present: an indicator of current activity or events that affected or are being affected by the participant.

Future: perception and notions of where these technologies may be in the future from the position and perspectives of the participant.

Ethics: any number of factors that guided how the participant interacted with or utilized blockchain technologies.

Accessibility: the perceptions of participants toward the ease or difficulty one has and can have in using these systems as users, investors, or developers.

Political: an indicator of a politics held by the participant that affects their actions related to blockchain systems and social spaces.

Economic: an indicator of an economic rationale in the participant's interaction with blockchain technologies..

Education: an indicator regarding some form of schooling, training, or knowledge production by the participant.

DAO: an indicator of a comment pertaining specifically to a participant's exposure or involvement with a decentralized autonomous organization (DAO).

Social space: indications that a comment was contextualized via some form of internal or external social relation critical in understanding how the participant is involved in a particular form of spatial production.

Employment: an indicator regarding the form of past and current employment of a participant (which may or may not be related to blockchain technology).

Code/space: indications that a comment was contextualized via some form of internal or external human/machine relation critical in understanding how the participant is involved in a particular form of code/space production.

Technical divide: an indicator of a technical difficulties a participant may have experienced related to blockchain systems.

Regulatory/legal concerns: an indicator of a participant's involvement with blockchain technologies due to a regulatory, governance, and/or legal rationale.

Developer: an indicator that the participant self-identifies as a blockchain systems developer.

User: an indicator that the participant self-identifies as a blockchain systems user.

Investor: an indicator that the participant self-identifies as a blockchain systems investor.

Male: an indicator that the participant self-identifies as male.

Female: an indicator that the participant self-identifies as female.

Identity issues: an indicator of a participant's involvement with blockchain technologies due to a concern over identity protection, anonymity, obfuscation, and/or other identity related matters.

Smart contract: an indicator of a comment pertaining specifically to a participant's exposure or involvement with smart contract use, development, or funding.

Security: an indicator of a participant's involvement with blockchain technologies due to privacy, information protection, identity protection, software, hardware, personal protection, and/or other security related matters.

Freedom issues: an indicator of a participant's involvement with blockchain technologies due to civil, political, economic, ideological, and/or other liberty related issues.

Scale of system: an indicator of a participants concern or awareness related to the issues of scaling related to blockchain systems.

Activism: an indicator related to freedom issues, but specific participants intend to use blockchain technologies for activism.

Productivity: an indicator that a participant saw blockchain technologies specifically as a means by which processes of varying forms could be augmented and/or improved.

Interview: an indicator that a participant took part in a semi-structured interview.

Conversation: an indicator that a participant took part in an open conversation.

Appendix C: Glossary

Abstract condition: The positions, perceptions, and sentiments surrounding and guiding the production of abstract spaces.

Block: A block is a package of data that contains zero or more transactions, the hash of the previous block ("parent"), and optionally other data. (Ethereum Glossary, 2014)

Blockchain: The total set of blocks, with every block except for the initial "genesis block," containing the hash of its parent and the entire transaction history of a network. (Ethereum Glossary, 2014)

Code/space: A space that is dependent on software for it to be transduced as intended. The relationship between software and space is dyadic; they are mutually constituted (produced through one another). (Kitchin & Dodge, 2014)

Coded assemblage: A confluence of several different coded infrastructures and their coded objects and processes wherein they become integral to each other in the production of particular environments. (Kitchin & Dodge, 2014)

Coded infrastructure: Networks that link coded objects together and infrastructures that are monitored and regulated, either fully or in part, by software. (Kitchin & Dodge, 2014)

Coded object: A material object in which code has been embedded, but where this software is incidental to the primary functioning of the object. (Kitchin & Dodge, 2014)

Coded processes: The transactions and flows of digital capta across coded infrastructures. (Kitchin & Dodge, 2014)

Decentralized autonomous organization: An organization that has no centralized leadership, instead using a combination of formal democratic voting processes and stigmergic self-organization as their primary operating principles wherein the method of governance is in some fashion "autonomous" or is not controlled by some form of discussion process or committee. (Ethereum Glossary, 2014)

Hash: A hash algorithm is a process by which a document or piece of data is processed into a small piece of data which looks completely random, and from which no meaningful data can be recovered about the document or data, but which has the important property that the result of hashing one particular document is always the same. (Ethereum Glossary, 2014)

Mining: Mining is the process of repeatedly aggregating transactions, constructing a block, and trying difference nonces until a nonce is found that satisfies the proof of work condition by each mining node. If a mining node produces a valid block, they are granted a certain number of coins as a reward as well as all of the transaction fees in the block. All miners start trying to create a new block containing the hash of the newly generated block as their parent. (Ethereum Glossary, 2014)

Pragmatic application: The manifestation of a use-case given the means and modes of production for a given system. As the means and modes of production shift due to the abstract condition, so will the form, function, and/or structure of the pragmatic application.

Proof of work: This is a computationally intensive process through which a hash of the block must be smaller than some target value to be published by the decentralized system of mining nodes. This provides a way of measuring how much consensus there is behind a particular version of the blockchain. (Ethereum Glossary, 2014)

Sousveillance: The self-monitoring of one's personal life through surveillance technologies. (Kitchin & Dodge, 2014)

Technicity: The extent to which technologies mediate, supplement, and augment collective life; the unfolding or evolutive power of technologies to make things happen; to perform meaningful work in the world. (Kitchin & Dodge, 2014)

Token: In blockchain systems, a token is an abstraction of the blockchain framework, the social dynamics, and transformational processes which produce a fungible virtual good that can be traded.

Transduction: The constant making anew of a domain in reiterative and transformative practices. (Kitchin & Dodge, 2014)

Use-case: In the context of code/space, use-case is the intended utility of a code/space defined through the means and modes of production for that code/space.

Appendix D: IRB Approval Letter

USF
UNIVERSITY OF
SOUTH FLORIDA

RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4799
(813) 974-5638 • FAX (813) 974-7091

May 13, 2016

Joe Blankenship
School of Geosciences
Tampa, FL 33612

RE: **Expedited Approval for Initial Review**
IRB#: Pro00026327
Title: Understanding Cyberspace and Spatial Production: Case Studies of Bitcoin and Ethereum

Study Approval Period: 5/13/2016 to 5/13/2017

Dear Mr. Blankenship:

On 5/13/2016, the Institutional Review Board (IRB) reviewed and **APPROVED** the above application and all documents contained within, including those outlined below.

Approved Item(s):
Protocol Document(s):
ThesisProtocol_Version1_20April2016

Consent/Assent Document(s)*:
Pro00026327 Verbal Informed Consent Form

*Please use only the official IRB stamped informed consent/assent document(s) found under the "Attachments" tab. Please note, these consent/assent document(s) are only valid during the approval period indicated at the top of the form(s). Verbal consents are not stamped.

It was the determination of the IRB that your study qualified for expedited review which includes activities that (1) present no more than minimal risk to human subjects, and (2) involve only procedures listed in one or more of the categories outlined below. The IRB may review research through the expedited review procedure authorized by 45CFR46.110. The research proposed in this study is categorized under the following expedited review category:

(6) Collection of data from voice, video, digital, or image recordings made for research purposes.

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Your study qualifies for a waiver of the requirements for the documentation of informed consent as outlined in the federal regulations at 45CFR46.117(c) which states that an IRB may waive the requirement for the investigator to obtain a signed consent form for some or all subjects if it finds either: (1) That the only record linking the subject and the research would be the consent document and the principal risk would be potential harm resulting from a breach of confidentiality. Each subject will be asked whether the subject wants documentation linking the subject with the research, and the subject's wishes will govern; or (2) That the research presents no more than minimal risk of harm to subjects and involves no procedures for which written consent is normally required outside of the research context. (Verbal Consent)

As the principal investigator of this study, it is your responsibility to conduct this study in accordance with IRB policies and procedures and as approved by the IRB. Any changes to the approved research must be submitted to the IRB for review and approval via an amendment. Additionally, all unanticipated problems must be reported to the USF IRB within five (5) calendar days.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

Kristen Salomon, Ph.D., Vice Chairperson
USF Institutional Review Board