Multidisciplinary Blockchain Research and Design: A Case Study in Moving from Theory to Pedagogy to Practice

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Abstract. The application of multidisciplinary theoretical models in an emerging field of study like blockchain can improve both collaborative learning and solution design, especially by creating a valuable shared language for colleagues from different disciplinary areas. This tripartite paper traces a journey from theory to practice by outlining the origin and development of the theoretical ‘three layer trust model’ for blockchain technologies, discussing the pedagogical utility of this model within a virtual education setting, and describing a student’s application of the learned model in a technical blockchain product design setting. By providing a thorough grounding in the complex multidisciplinary balance involved in designing blockchain systems (and adding the autoethnographic reflections of participants in this multi-setting focal design application) the following paper supports the potential value of such theoretical models to establish shared language for complex concepts across disciplinary divides. Future research directions are suggested to establish greater validity for the concepts presented within this paper and dive deeper into the foundations of its many referenced disciplines.

Keywords: Multidisciplinary Design · Blockchain · Pedagogy

1 Introduction

The application of multidisciplinary theoretical models in an emerging field of study like blockchain can improve both collaborative learning and solution design, especially by creating a valuable shared language for colleagues from different disciplinary areas of expertise. While intentionally collaborative methods may not strictly be required in traditional pedagogy and design, they can be greatly beneficial for research, learning, and application in nascent technological domains, as we discuss in this paper. The context of this participatory research, focused on climate change solutions, demanded innovative ideation from all its collaborators. This tripartite paper first covers the origin and development of the theoretical three layer trust model for blockchain technologies, then discusses the pedagogical utility of this model within a virtual education setting, before...

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describing the application of that learned model by one of the students in a technical blockchain product design setting.

The following paper begins with a literature review of terminology from the blockchain and distributed ledger field, and the concepts of social trust modeled therein. It will then shift to coverage of the established literature on multidisciplinary collaboration and tools to support it, as well as the broad range of design methodologies which lay the groundwork for our proposed approach. This will be followed by an overview of the background and context of the research described, as well as the specific methods used, and finally “Reflections on the Student Experience and Findings,” which will switch briefly to a more personal narrative and reflection. Since this research was preliminary, its most significant contribution is as a qualitative account of the impact on teaching and design of collaboratively defined multidisciplinary tools like the three layer model we discuss. Overall, this contribution aims to highlight both strengths and areas of suggested improvement for the multidisciplinary model which we will describe in more depth below.

2 Background

Tricky problems and ethical conundrums in design are not a new topic in the realm of arts and material manufacture [1]. Similarly, multidisciplinarity - which we define for purposes of this paper as a process wherein people from different disciplines work together on a problem solution, each drawing on their disciplinary knowledge - has been well attended to in the networked learning space, as have critical design thinking and practice-focused design methodologies [2]. Additionally, critical perspectives on ethics and design are well established in the field of communications [3]. There is even an increasing adoption of ethics-centered approaches in science and technology design [4, 5]. Across all these approaches, a “design methodology” is any research approach which employs design frameworks or principles as one of its central elements.

In general, multidisciplinary frameworks and analyses prove useful in the study and design of complex computing systems in knowledge societies [6–8]. Additionally, multidisciplinarity is a recurring concern in novel technological education and networked learning [9–11]. Finally, multidisciplinarity arises as a core concern for iSchools in general, due to the tradition of the library and information sciences indexing all other disciplines at a meta-level [12]. Derry et al. establishes an early understanding that collaboration across disciplines involves unique elements of human cognition and communication [13]. Monk builds a parallel argument for the importance of developing shared language, and thus “common ground,” in multidisciplinary undertakings [14]. Paletz presents a similar finding from multidisciplinary teams working with big data: effective communication starts with building shared mental models for the complex intersecting topics at hand [8]. Taken as a whole, this research drives home the potential value of explicitly collaborative methods for learning and design when focused on intrinsically multidisciplinary topics.

The following paper will present a design methodology which extends the Multidisciplinary Design Optimization [MDO] model [15]. Whereas MDO is often multidisciplinary across technical disciplines (e.g. building spacecraft, airplanes, self-driving
vehicles), Lemieux and Feng’s three layer model recognizes blockchains as fundamentally socio-information-technical systems revolving around social trust goals [16]. This distinction suggests that existing MDO frameworks are not fully suitable to blockchain design, thus Lemieux and Feng have further iterated on the specific requirements of blockchains and other distributed ledger technologies in this context [16]. The closest parallel research is Carroll and Bellotti’s exploration of “the emerging design space of peer-to-peer currency,” but even this work produced more broadly descriptive themes rather than a rigorous and potentially replicable, systems model [17].

3 Theory

3.1 Blockchain as a Multidisciplinary Design Space

While it is beyond the scope of the present paper to cover all facets of blockchain’s multidisciplinarity, we will briefly establish preferred definitions for the terminology used herein. These preferred definitions are drawn from those established by International Organization for Standardization’s [ISO] Standard 22739, which was formed with the input of over three hundred global experts collaborating across three years. Most crucially, ISO Standard 22739 establishes that Distributed Ledger Technology [DLT] utilizes shared ledgers which are coordinated and synchronized across a network via consensus mechanism, and that a blockchain is a specific type of distributed ledger data structure that appends data blocks which are confirmed as valid by the network consensus mechanism to a continuous, immutable chain [18]. These network effects are enabled by distributed computing systems, and often include an element of decentralization in control of the system. Both DLTs and their structural subset of blockchains rely on rigid standards of confirmation and validation to establish an on-chain norm for trust (which can be reliably verified by network participants) [19]. Despite the part-and-whole relationship established by the ISO standard, for simplicity in this paper we will simply refer to all types of distributed ledgers, including blockchains, by the term blockchains.

Multiple open access resources exist as foundational introductions to blockchain, distributed ledgers, and cryptoeconomics.¹ There are many volumes on the multidisciplinary concerns introduced by nascent blockchain technology. Some of these focus on the changes in law and regulations that may arise from decentralized protocols [23–25]. Other essays and texts cover the broader social, political, and economic implications of these tools and platforms [26–29]. Numerous papers cover technical aspects of DLT and blockchain design, including the common information architectures and consensus mechanisms utilized in these systems [19, 30–32].

Given the multidisciplinary focus of blockchain design efforts, one might expect that trade-offs among different design dimensions would be well-studied in the blockchain design field. So far, however, this is not the case. The most often cited design trade-off is “Buterin’s Scalability Trilemma,” which invokes the necessary compromises involved in balancing scalability, decentralization, and security in a “best of two” circumstance [30]. Additionally, these systems are further complicated by their reliance upon, and interoperation with, communities that are often contentious and non-homogeneous, in

¹ For further introductory reading on this topic see [20–22].
which unpredictable agents can disrupt the planned flow of ecosystem participation and governance [26].

Social trust can be taken as the idea that “one party to the relation believes the other party has incentive to act in his or her interest or to take his or her interest to heart” [33]. Numerous writers have associated blockchain technology with increased social trust of this kind [25, 33, 34]. At the technological level, one of the core driving factors behind this social trust association is these systems’ incorporation of key-based cryptography and digital signatures from the cybersecurity field [35]. As the ISO standard vocabulary highlights, the critical quality of immutability in blockchain systems provides another foundation for a very specific sort of trust: network participants know that ledger records cannot be altered after they have been added to the chain of confirmed blocks [18].

In the ISO standard vocabulary, trust is itself defined as “the degree to which a user or other stakeholder has confidence that a product or system will behave as expected by that user or other stakeholder” [18]. ISO’s more technical-focused definition of trust fits well with a focus on multidisciplinary systems. Taken together, these varied and granular definitions of trust within the blockchain context help illuminate its distinction from traditional notions of reputation-based interpersonal trust. Despite this attempted transition away from the importance of reputation, some research with cryptocurrency users suggests that elements of human and institutional trust are still widespread within these communities [36]. Beyond that, some authors seek to highlight that in a blockchain’s technical information architecture is itself based upon trust between nodes [37].

### 3.2 Blockchain: The Three Layer Model as a Multidisciplinary Pedagogical and Design Framework

In this paper, our goal is to focus on how the three layer model provides a framework for generative conversations across and among epistemic communities for pedagogy and design. Lemieux and Feng’s three layer trust model, which goes beyond fixed declarative definitions, was motivated by a desire to both broaden and deepen consideration of the necessary tradeoffs in blockchain solution design, which they argue will lead to better solutions with fewer unintended negative consequences [16]. By architecting space for generative discussions to arise around the complexity of multidisciplinary problems, the three layer trust model moves beyond the projection of rigid categorical definitions for specific material forms of “trust” seen in earlier research in the blockchain and cryptocurrency space [36, 38].

In 2018, the three layer trust model was born of the need to develop an appropriate framework for the problem-centered design of blockchains, in which the problems are themselves “wicked,” multidimensional, and multidisciplinary [39]. Systems designed from a single point of view have often proved to have “blind” spots which render them ineffective, or even dangerous [40]. With this in mind, we aimed to design a framework which encouraged holistic problem analysis and afforded a common language, underpinned by a reasonably shared ontology and epistemic worldview [16]. The framework this produced was intended to enable meaningful engagement in the design process from graduate students in disciplines as diverse as engineering, business, and the arts. This three layer trust model establishes blockchain as an inherently multidisciplinary field
of study, much in the same way that scholars are establishing artificial intelligence as multidisciplinary [41].

In 2019, a diverse group of blockchain scholars came together at the University of British Columbia to discuss Lemieux’s original three layer model, especially the interactions among its three layers. This led to further theoretical refinements of the model. The primary change introduced at this stage arose from collaborators recognizing it more as a complex, dynamic systems model with four complex, interrelated sub-systems. In addition to refining the previous model, these ideas generated novel reflections on the capabilities and properties typically associated with blockchains (such as decentralization, security, governance, provenance and incentives) that were captured in an updated theoretical model disseminated to students in the Blockchain@UBC Summer Institute course. This new model conceived of the original three layers (the social, the informational and the technical) as sub-systems of blockchains as large complex, dynamic systems, and added a governance sub-system. The model also incorporated temporal and environmental interactions (see Appendix A).

4 Pedagogy

Over the past few years, there has been an increasingly visible output of research on blockchain in relationship to education and pedagogy. While many of these publications focus primarily on the use of blockchain technology as a supporting infrastructure to disrupt the creation, storage, and access of academic records and certifications, augment admissions processes, and enable new pedagogical approaches (e.g. [42–45]), a handful of papers provide valuable insights to the specific challenges of effectively weaving together the multidisciplinary threads of blockchain in teaching.

Blockchain’s inherent conceptual novelty, stemming from its foundational and transformative nature [46], means that a fundamental shift in student mindset may be necessary to grasp its core tenets [47]. To address this, scholars have found active learning and gamification to be effective approaches for helping students explore and comprehend basic principles of blockchain, such as how data is structured and secured via cryptographic methods [47], and how the network can reach consensus on the state of the ledger [48]. Beyond basic principles, other scholars have argued that blockchain education should be applied to real-world business cases [49], emphasizing the entrepreneurial process and the co-creation of knowledge [50]. Together, prior research concludes that pedagogical approaches to blockchain education should be experiential, collaborative, and focused on real-world processes and outcomes which empower students’ agentic behavior.

Our setting for multidisciplinary blockchain education was the 2020 Blockchain@UBC Summer Institute. This was the Institute’s fourth overall iteration and the first time this was offered as a for-credit graduate-level course. In response to the COVID-19 pandemic, it was also the first delivery of this summer program in a fully virtual setting. The course was delivered over two full weeks of morning and afternoon sessions via online lectures facilitated by a primary instructor with guest speakers from industry and academia. Each session involved immersive case-based discussions and engagement in small virtual breakout groups.
The graduate students participating in this course came to the first session with various degrees of exposure to blockchain concepts, from absolute newcomers to relatively well-established industry participants, and from diverse disciplinary backgrounds (including Library and Archival Science, Electrical Engineering, Computer Science, Public Policy and Global Affairs, Psychology, Public Health, Occupational Therapy, and Business Administration). The course aimed to help this diverse cohort gain a holistic understanding of blockchain as a foundational technology and an appreciation of the different perspectives that contribute to blockchain use case design, analysis, and critique. A diversity of perspectives was emphasized as important for spurring innovation and creativity, and for helping to ensure that blockchain-based solutions not only create value, but also minimize social harm. In line with our inherently multidisciplinary goals, teaching combined systems-thinking and design-centric approaches anchored by the three layer trust model.

The course began by presenting the foundations of blockchain and distributed ledger technologies, including key definitions and core capabilities. Students were then introduced to the notion of blockchain use cases as complex systems, and to the three layer model of blockchain system design. During the first week of the Institute, students gained exposure to a range of use case applications across multiple industries, public sector domains, and social issues (including social media, finance, climate change, public procurement, healthcare, Indigenous data governance, and sports management). In the second week, the focus turned to more hands-on sessions that walked through how the three layer trust model is applied in existing blockchain systems to enable profoundly new capabilities (such as a self-sovereign digital identity for individuals).

At this point, students were also tasked with finding an academic article from their own discipline and communicating its core contribution(s) in a discussion post for a general audience by relating it to the three layer model and its practical implications. Students then reviewed and commented on one another’s posts. The objective here was to sharpen students’ ability to communicate the value of their own discipline in a multidisciplinary setting, deepen their appreciation for different perspectives, and facilitate a dialogue between these. The course concluded with a miniature virtual blockchain hackathon, where students worked in groups to design and present blockchain systems of their own that addressed issues related to the global pandemic. Groups were formed by the instructor to optimize their diversity with respect to academic discipline, gender identity, and cultural background.

Throughout the two weeks, the three layer model provided a common frame for examining blockchain use cases and designing new ones, which helped to ensure that multiple perspectives were effectively communicated and integrated in student collaboration and analysis. This grounding allowed students to gain an appreciation of the various disciplines involved in blockchain system design and governance, ensuring that multiple voices were heard in group collaborations.

5 Practice

Upon completion of the Summer Institute, one of the graduate students that attended the course proceeded to utilize the three layer trust model as a core project planning document
in the discovery of scope and technical specifications for a blockchain solution prototype. In this section, we focus on an exemplar solution design (the focal solution design), which is explored in the format of an autoethnographic reflection from a graduate student who was first introduced to the three layer trust model within the pedagogical setting described above. This focal solution design setting aimed to deliver a Proof of Concept for the nonprofit Blockchain for Climate Foundation’s mission to put the UNFCCC’s Paris Agreement for carbon credit trading on a public blockchain ledger platform. Building upon Blockchain for Climate Foundation’s long-standing warm relationships within the public Ethereum blockchain ecosystem, the graduate student employed a toolkit which combined the three layer trust model’s framework with a “user stories”-driven Agile project management methodology, borrowed from the design practices of a local web development team [51]. This helped set the stage for a practical system prototype (which is presently being built by a blockchain developer), to model potential behavior for a fully featured platform fulfilling the United Nations’ Paris Agreement carbon credit trading requirements.

On weekly check-in calls, and with asynchronous document collaboration in between, the small team brought together domain expertise from the carbon reduction industry, blockchain ethics, and user-centric design thinking to fully define and scope a prototype for implementation on an Ethereum blockchain test-net in Fall 2020. Along the way, the illuminating Question-Led Systems Three Layer Model Design Framework (Appendix A) consistently anchored the team’s conversations around long-term social trust implications of many seemingly minute design choices for the prototype. At times, the team was thoroughly stumped by how to answer some of the higher-level questions from this framework. Inevitably, those questions that the team found hardest to answer served the most illuminating role in defining what still needed to be explored in the context of the proposed carbon credit trading use case.

6 Reflections on the Student Experience and Findings

My first exposure to the three layer model was through the Question-Led DLT Systems Design Framework in the context of an implementation of the first fully virtual Blockchain@UBC Summer Institute. This accelerated-pace course, which was offered through UBC’s iSchool, took place just a few months after the COVID-19 lockdown. Many plans were in transition at that point, and many courses were understandably cancelled. I remember being quite happy to hear the Summer Institute was moving forward as planned for its fourth year. I had the pleasure of being present for the first two instances of this Summer Institute, and its corresponding Blockathon, as a community organizer in the blockchain space, and looked forward to experiencing it as a student for the first time.

The Question-Led DLT Systems Design Framework was presented to us early on to contextualize the projects and use cases we explored. Rather than being left to come up with discussion prompts on our own or sticking to the broader questions that might be provided by an instructor on the spot, we had a consistent anchoring document to refer to throughout all our group discussion sessions. It also proved to draw us together across disciplines, providing broader and deeper discussion points than we could have
generated on our own. As the peers in my group came from outside my own graduate department in the iSchool, the shared language this model and its anchoring documents provided was supportive of much more productive collaboration than we might have achieved if we each tried to use mental models from our own preferred fields.

The one struggle we found with the model, and Question-Led Framework, was its sheer complexity and the many possible avenues available to converse upon. Especially in instances where we had a briefer period available to apply the framework to a given use case, the necessity to determine that pathway from first principles took up some time. Still, this was mostly a challenge of familiarity, because as our team became more accustomed to the full range of framing questions, we were better skilled at jumping directly into the relevant categories in analysis of any given blockchain system example. Any early stumbling blocks in our comprehension of the three layer model proved well worth the challenge, considering how useful this framework proved in the final deliverable for the course: our virtual implementation of a “Blockathon for Social Good” use case.

In this final group project, we worked with our established team to design a blockchain-based solution to any number of problems resulting from the actively unfolding COVID-19 pandemic. Our team chose to focus on supply chain coordination of vital consumer goods, which at that time were being stocked unreliably online and on grocery store shelves. Seeking to utilize already-existing government support for local-grown produce, we proposed the introduction of a verifiable and subsidized online platform for accessing food, toilet paper, and hand sanitizer at a time when these were difficult items for many to obtain. Our familiarity with the three layer trust model and its related concepts gave us excellent grounding to clearly define the system’s goals, constraints, and capabilities in a tangible fashion. Perhaps the greatest value of our past use of the three layer model became clear as we constructed our final presentation on the project. At this point, our team realized we had started to unconsciously lean in the direction of automatically discussing the model’s multiple complex axes from the outset of any conversation about the system we were proposing.

Additionally, the paid summer collaboration I undertook with Blockchain for Climate Foundation, bolstered by an Innovator Skills Initiative Grant from New Ventures BC, was directly anchored in the Summer Institute course and its use of the three layer model. Although I had been operating as a de facto “blockchain professional” for a handful of years, primarily as a community educator on Bitcoin, I had not previously felt confident in my capacity to legitimately architect the technical requirements for a blockchain-based system. The hands-on curriculum design, driving us to collaboratively apply the three layer model's concepts to analyze multiple consecutive projects lent me greater confidence in the recurrent elements and building blocks of these systems. Most crucially, I was able to utilize the thorough Question-Led Framework to frame useful planning discussions about what might go wrong in engineering such a system. This meant these high-level concerns were discussed thoroughly in the technical specification discovery process, well before a single line of code was written.

\[\text{Representing social, informational, technical, and governance sub-systems, with the temporal and environmental axes in mind as well. See Appendix A for more details.}\]
The public and permissionless blockchain our team focused on, Ethereum, is currently in the process of altering its foundational consensus mechanism [52]. This transition (from Proof-of-Work to Proof-of-Stake consensus) is intended to mitigate deleterious environmental effects of blockchain technology and support more effective scaling for widespread global use. The still-shifting timeline for this transition presented one of the significant challenges in the Blockchain for Climate Foundation’s initial design decisions: should we build a full implementation based on the current Ethereum Proof-of-Work norms, or wait until the transition to ETH 2.0 became clearer? By utilizing the Question-led Framework to anchor our scope discussions, we could more clearly delineate necessary requirements for an immediate prototype in contrast to long-term design goals for the full system (these latter aspirations were recorded for later reference).

Finally, the more subtle gains from utilizing the three layer model and its foundational documents when planning an Ethereum system prototype were related to its efficacy as a lens on the previously “unknown unknowns.” While some of the sections and topics validated system elements and choices that were already well-established,3 others helped us understand the true breadth of possible ethical concerns in a multidisciplinary design setting. One powerful example related to framing questions on the temporal aspects of our blockchain system, leading us on long conversations about possible futures decades down the road. As so much of the climate change conversation is necessarily focused on immediate amelioration, it was refreshing to spend some time imagining post-crisis needs for a sustainable carbon credits trading system.

Additionally, the technical sub-system framing questions led us to explore ideas around interoperable trustless layers in the context of Internet of Things (IoT), which could be built in conjunction with this system for just such a long-term future. There is existing contemporary research on the concerns with interoperating blockchains with smart cyber-physical systems, especially those serving “safety-critical” purposes [37]. However, we are at such an early stage that implications for deeply layered interoperable systems between blockchains and IoT devices have not yet been fully explored, leaving rich possibilities for both liberation and exploitation of these powerful domains. These are just two examples of perhaps a dozen threads of dialogue shared by our small team of four collaborators during Summer 2020: the Question-Led Framework proved to be generative, associative, and intellectually expansive in the product design setting.

7 Conclusion

A unifying thread runs through the original genesis of the three layer model, its corresponding generative documents, and the research implementations described above: when dealing with complex systems, it is difficult to predict the crossover “knock on” effects of any given design decision. With the advent of multidisciplinary topics in advanced computing systems, the potential ripple effects begin to transcend even the complexity of yesteryear’s most advanced chess games. As the systems we design together grow more complicated, elaborate, and interdependent, they are increasingly

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3 For example, our conscious decision to follow Privacy-by-Design principles whenever possible, a choice that was bolstered by informational sub-system questions from Appendix A.
embedded with power relations, social norms and social praxis woven together with specific materialized forms of human communication and novel technical configurations. This means it is crucial to engage in thorough dialogue on common ground before putting anything into action, which rings doubly true in systems employing immutable ledgers and programmatic (even self-executing and self-perpetuating) processes [35, 53].

This paper presents the three layer model as a useful tool for grounding blockchain research, education, and innovation. The three layer model was used to mobilize systems-thinking and design-centric pedagogical methods in a multidisciplinary graduate-level course to help students more deeply appreciate the importance of different perspectives, and practice communicating and integrating these in practical application. Case-based exercises, written assignments and discussions, and a virtual hackathon provided students opportunities to practice collaborating in multidisciplinary design, and the business benefits of this were realized in a student’s practical application of the model in a real-world setting. Together, we illuminate how holistic, multidisciplinary frameworks can facilitate the conceptualization, communication, and application of nascent technologies by providing a common foundation for interpreting and integrating diverse perspectives. In this manner, we begin to establish collaborative pedagogical practices in which students from seemingly disparate disciplines and specializations come to understand the perspectives, theories, and methods which drive each other’s fields.

The primary area for improvement in pedagogical application of the three layer model is in grounding its useful complexity with more approachable inroads for newcomers to this multidisciplinary field. While the Question-Led Framework provides a concrete and comprehensible one-pager, its content addresses high-level technical ideas across a broad set of disciplines. Even for this brief framing document, content accessibility might be improved by architecting a few suggested pathways to progress through the six major categories of questions. Another option would be providing some truncated versions of these documents for discussion prompt purposes, representing some of the primary questions in each of the major conceptual domains. This increased efficacy would be further bolstered by directly linking the ISO standard’s blockchain terminology in support of the three layer model as early as possible in supporting documentation, to help anchor these concepts to concrete technical terms.

At their best, complex theoretical lenses like the three layer model and resulting Question-Led Framework (Appendix A) can serve to invite us to consider the potential “butterfly effect” of choices that seem innocuous to the designers and engineers who may be preoccupied inside their own filter-bubbles of enthusiasm. In the solution design setting, even when the small team reviewed evaluative questions which ultimately did not apply to the platform being built, the topics brought to the forefront proved valuable each time. Every iterative return to the deep concepts of the design decisions’ long-term implications more fully rounded out the vision of the complex socio-informational-technical systems that this platform would inevitably interoperate with. In a nod to the classic concerns of Engineering, design teams invariably had a much stronger sense of what could potentially go wrong within the system.

We will conclude this paper by providing a few recommendations for future research directions, as well as parallel research that could more reproducibly establish the efficacy of multidisciplinary design frameworks in hands-on application by universities and
startups alike. We envision a more controlled empirical experiment wherein groups are
given the three layer model and others are given a less multidisciplinary design frame-
work (essentially, A/B testing). It would be crucial to ensure diversity within the groups’
population, to control for gender, disciplinary affiliation, economic status, and other such
categories. Another research direction we envision to establish generalizability of the
design framework’s effectiveness involves testing it out for use in other multidisciplinary
fields (such as AI).

Finally, we must highlight the inherent limitations of the research presented in this
paper. As the research design was participatory, organic, and highly individualized, it
cannot be validated or reproduced in the traditional sense. It primarily represents a reflec-
tion on the initial value observed in applying this multidisciplinary framework for both
learning and professional practice. While we cannot declare the efficacy of applying
this theoretical framework over any other pedagogical or design process approach, we
hope to provide rich grounding for further reflective prototyping of thoughtful multidis-
ciplinary lenses for reflection, discussion, and analysis. Ultimately, as existing design
approaches in many cases appear to have yielded unintended consequences and poor
societal outcomes, it is perhaps not a stretch to think an intentionally collaborative mul-
tidisciplinary approach would be embraced as a welcome alternative in the design of
decentralized technology protocols and other emerging technologies.

Appendix A: Question-Led DLT System Design Framework

System Goal

- What is the stated purpose of the DLT system?
- How does the stated purpose support social trust?
- What problem(s) should this system solve?
- What use cases is the system designed to support?

System Constraints

- What behaviors must the system be designed not to tolerate?
- What is the system’s space of permissible actions?

System Capabilities

- What capabilities must the system possess in order to achieve its goal within prescribed
  constraints?

Environment

- Is the environment in which the DLT system operates relatively homogeneous or is it
  more heterogenous?
- What assumptions about the environment does the DLT system make in its
design/operation?
What aspects of the environment does the system rely upon? At what points and for what purposes are these relied upon?

How aligned with all aspects of the environment is the DLT system?

What elements from the environment influence or constrain designers of the DLT system?

What elements from the environment influence or constrain system actors or actants?

**Social Sub-system**

- Who are the social actors in the DLT? How are they identified/represented? How are their identities regulated?
- How does the DLT system empower or constrain their agency? What types of actions of social actors are forbidden, encouraged, or tolerated?
- Where is power located among social actors?
- What values are important to the social actors in this system?
- What expectations do we have of the behavior of the social actors?
- What actions will or might they take? How are these actions expected to impact upon others?
- When is the consent, permission, and authority of social actors needed, granted, or assumed?
- Will some social actors act on behalf of others? On what (moral, legal?) ground do they implement the will of others? Which others?
- How do social actors need to exercise (or do they exercise) discretion when conflict arises?

**Informational Sub-system**

- How does the ledger serve to support social trust in the context of the DLT system?
- What data is captured/flows through the system to support the system goal? What records are generated to support the system goal, either on ledger or off ledger?
- How are the data/records actants in the system identified and how are their identities regulated?
- What data and/or records must the system store? (What are the legal or regulatory obligations?)
- What data and/or records must not be stored in the system? (For purposes of privacy, financial risk management, or corporate policy.)
- Are there data and/or records that require special consideration? For example, are there data and/or records containing personally identifiable information that requires special treatment under law?
- Are there data and/or records that must not be kept indefinitely?
- Where are records stored? How are they propagated across networks? How are the intellectual components of the record assembled?

**Technical Sub-system**

- What are physical actants in the DLT system (e.g., sensors, vehicles)?
How are the technical actants in the system identified and how are their identities regulated?
How do the physical actants serve to support social trust in the context of the DLT system? What capabilities and properties do they require to support the system goal?
What is the system architecture?
What is the network architecture/topography?
What social actors control the physical actants in the DLT system? How do these social actors empower or constrain the activity of physical actants?
What level of authority/authorization do the physical actants have?

Governance Sub-system

How much reliance will there be on internal or self-regulating governance versus external governance under normal operating conditions? Under abnormal operating conditions?
How will consensus decisions be made among technical, informational, and social actants/actors?
What incentives are or will need to be put in place so that the consensus mechanism operates in a manner that supports the goal of the system?
How should decision management rights and decision control rights be allocated among various interacting components (where social, informational, or technical)?
How will disagreement about those decisions be resolved?

Temporality

What known future changes will the system have to be able to respond to?
What mechanisms need to be put in place to assure the longevity of the system?
Could future events bring about consequences where the platform ought to be completely replace or cease operation?
How will the governance sub-system address actors/actants’ changing relationships to the system over time?
How will risk factors be addressed, including those that lie unknown in the future and that may present existential or systematic risk?
How has/does power shift among social actors over time?

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