Affordances of Decentralised Technologies for Commons-based Governance of Shared Technical Infrastructure

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In this article I will illustrate affordances of decentralised technologies in the context of commons governance. My aim is to summarise the conversation around the lecture "When Ostrom Meets Blockchain: Exploring the Potentials of Blockchain for Commons Governance" I gave in the Mereologies Open Seminar organised by The Bartlett School of Architecture at University College London on 25th April 2019. I will also extend the conversation by providing a concrete example of such affordances in the context of a community network.

What is Blockchain? Three key Concepts around Decentralised Technologies

In 2008, an anonymous paper presented Bitcoin: the first cryptocurrency based purely on a peer-to-peer system.[i] For the first time, no third parties were necessary to solve problems such as double-spending, thanks to cryptography. The solution was achieved through the introduction of a data structure known as a blockchain. In simple terms, a blockchain can be understood as a distributed ledger. Distributed refers to a technical property of a system in which certain components are located on different computers connected through a network. The blockchain, in this sense, can be thought of as a 'decentralised book' in which agreed transactions can be stored in a set of distributed computers. Data, such as the history of monetary exchanges generated by using cryptocurrencies, can be stored in a blockchain. The key aspect resides in the fact that there is no need to trust a third party, such as a bank server, to store that information.

Nakamoto's article opened what is considered to be the first generation of blockchain technologies.[ii] This generation, up to approximately 2013, includes Bitcoin and a number of crypto-currencies that appeared after it. The second generation, approximately from 2014 onwards, is the extension of these blockchains with capabilities beyond currencies in the form of automatic agreements or smart contracts.[iii] Smart contracts can be understood as distributed applications which encode clauses that are automatically enforced and executed without the need for a central authority. They can be employed, for example, to enable the execution of code to provide certifications, such as obtaining a diploma or a registry of lands, according to previously mutually agreed rules. Again, the novel aspect here is the fact that the execution of such rules, in the form of computer instructions, is distributed across a large number of computers without the need of a central point of control.

Complex sets of smart contracts can be developed to make it possible for multiple parties to interact with each other. This fostered the emergence of the last of the concepts I will introduce around decentralised technologies: Decentralised Autonomous Organisation (DAO). A DAO is a self-governed organisation in which interactions between the members of the organisation are mediated by the rules embedded in the DAO code. These rules are sets of smart contracts that encode such interactions. The rules embedded in the code are automatically enforced by the underlying technology, the blockchain, in a decentralised manner. DAOs could, for example, hire people to carry out certain tasks or compensate them for undertaking certain action. Overall, this can be understood as analogous to a legal organisation, with legal documents – bylaws – which define the rules of interaction among members. The development of DAOs has been, unsurprisingly, significantly popular around financial services.[iv] However, DAOs could be used to provide a wide variety of services or management of resources in a more diverse range of areas. A more artistic example of a DAO is the Plantoid project,[v] a sculpture of a plant, which can hire artists to physically modify the sculpture itself according to the rules collectively agreed in the smart contracts encoded in it.
All of these potentials of decentralised technologies represent an emerging research field. Together with other colleagues of the EU project P2PModels,[vi] we are exploring some of these potentials and limitations in the context of the collaborative economy and, more precisely, on some of the models emerging around Commons Based Peer Production.

Collaborative Economy and Commons-Based Peer Production

The collaborative economy is a growing socio-economic phenomenon in which individuals produce, exchange and consume services and goods, coordinating through online software platforms. It is an umbrella concept that encompasses different initiatives and significantly different forms are emerging; there are models where large corporations control the platform, thus ensuring its technologies and the knowledge held therein are proprietary and closed. Uber, a riding service, and AirBnB, a short-term lettings service, are perhaps the most well-known examples of such initiatives. They differ from models that revolve around Commons-Based Peer Production (CBPP), where individuals produce public goods by dispensing with hierarchical corporate structures and cooperating with their peers.[vii] In these models, participants of the community govern the assets, freely sharing and developing technologies.[viii] Some of the most well-known examples of the initiatives around such commons-based models are Wikipedia and GNU/Linux, a Free/Libre Open Source Software (FLOSS) operating system. Commons-based models of the collaborative economy are, however, extending to areas as broad as open science, urban commons, community networks, peer funding and open design.[ix]

Three main characteristics are salient in the literature on CBPP.[x] Firstly, CBPP is marked by decentralisation, since authority resides in individual agents rather than a central organiser. Secondly, it is commons-based since CBPP communities make frequent use of common resources. These resources can be material, such as in the case of 3D printers shared in small-scale workshops known as Fab Labs; or immaterial, such as the wiki pages of Wikipedia or the source code in a FLOSS project. Thirdly, non-monetary motivations are prevalent in the community. These motivations are, however, commonly intertwined with extrinsic motivations resulting in a wide spectrum of forms of value operating in CBPP communities,[xi] beyond monetary value.[xii]

Guifi.net: An Example of a CBPP Community in Action

In order to extend the discussion of the affordances of decentralised technologies in CBPP, I will employ Guifi.net as an illustrative example. Guifi.net[xiii] is a community network: a participatory project whose goal is to create a free, open and neutral telecommunications network to provide access to the Internet. If you are reading this article online, you might be accessing to it through a commercial Internet Service Provider. These are the companies which control the technical infrastructure you are using to connect to the Internet. They manage this infrastructure as a private good. The Guifi.net project, instead, manages this infrastructure as a commons. In other words, Guifi.net is organised around a CBPP model,[xiv] in which the network infrastructure is governed as a common good. Over the past 16 years, participants of Guifi.net have developed communitarian rules, legal licenses, technological tools and protocols which are constantly negotiated and implemented by the participants.

I have chosen to discuss the potentialities of blockchain drawing on Guifi.net, a community network, for two main reasons. Firstly, the most relevant type of commons governed in this case is shared infrastructure, such as fibre optic and routers. The governance of rival material goods, in contrast to the commons governance of non-rival goods such as source code or wiki pages, better matches the scope of the conversations which emerged during the symposium around architecture of the commons and the role played by participatory platforms.[xv] Secondly, Guifi.net provides a large and complex case of governance of shared infrastructure. The growth experienced by Guifi.net's infrastructure and community since the first pair of nodes were connected in a rural region of Catalonia in 2004 is significant. In their study of the evolution of governance in Guifi.net, Baig et al. reported a network infrastructure consisting of more than 28,500 operational nodes which cover a total length of around 50,000 km of links that are connected to the global Internet. This study refers to the period 2005-2015.[xvi] The latest statistics reported by Guifi.net state that there are more than 35,000 operational nodes and 63,000 km of links.[xvii] Beyond the infrastructure, the degree of partici-

pation in the community is also significant: more than 13,000 registered participants up to 2015, according to the aforementioned study, and more than 50,000 users of this community network connect on a day to day basis, as reported by the community at present .[xviii] Thus, Guifi.net provides a suitable scenario for the analysis of the affordances of decentralised technologies for commons governance.

Ostrom's Principles and Affordances of Decentralised Technologies for Commons Governance

How do communities of peers manage to successfully govern common resources? The study of the organisational aspects of how common goods might be governed was traditionally focussed on the study of natural resources. This commons-dilemma was explored by Hardin in his influential article "The Tragedy of the Commons", whose ideas became the dominant view. In this article, Hardin states how resources shared by individuals acting as homo-economicus (out of self-interest in order to maximise their own benefit) results in the depletion of the commons. The individuals' interests enter into conflict with the group's, and because they act independently according to their short-term interests, the result of the collective action depletes the commons.[xix] As a consequence, in order to avoid this logic – 'If I do not use it, someone else will', which is not sustainable – it was necessary to manage these commons through either private ownership or centralised public administration.

Later on, Nobel's laureate researcher Elinor Ostrom, questioned and revisited "The Tragedy of the Commons." In her work, she showed how under certain conditions commons can indeed be managed in a sustainable way by local communities of peers. Her approach took into account that individual agents do not operate in isolation, nor are they driven solely by self interest. Instead, she argued that communities communicate to build processes and rules, with different degrees of explicitation, that ensure their sustainability.[xx] This hypothesis was supported by a meta-analysis of a wide range of case studies,[xxi] and has been confirmed in subsequent research.[xxii] As part of this work, she identified a set of principles for the successful management of these commons,[xxiii] which has also been subsequently applied to the study of collaborative communities whose work is mediated by digital platforms, such as Wikipedia and FLOSS communities:[xxiv]

1. Clearly defined community boundaries: in order to define who has rights and privileges within the community.
2. Congruence between rules and local conditions: the rules that govern behaviour or commons use in a community should be flexible and based on local conditions that

may change over time. These rules should be intimately associated with the commons, rather than relying on a 'one-size-fits-all' regulation.

3. Collective choice arrangements: in order to best accomplish congruence (with principle number 2), people who are affected by these rules should be able to participate in their modification, and the costs of alteration should be kept low.
4. Monitoring: some individuals within the community act as monitors of behaviour in accordance with the rules derived from collective choice arrangements, and they should be accountable to the rest of the community.
5. Graduated sanctions: community members actively monitor and sanction one another when behaviour is found to conflict with community rules. Sanctions against members who violate the rules are aligned with the perceived severity of the infraction.
6. Conflict resolution mechanisms: members of the community should have access to low-cost spaces to resolve conflicts.
7. Local enforcement of local rules: local jurisdiction to create and enforce rules should be recognised by higher authorities.
8. Multiple layers of nested enterprises: by forming multiple nested layers of organisation, communities can address issues that affect resource management differently at both broader and local levels.

What kind of affordances do decentralised technologies offer in the context of commons governance and, more concretely, with regards to Ostrom's principles? Together with other colleagues,[xxv] we have identified six potential affordances to be further explored.
Firstly, tokenisation. This refers to the process of transforming the rights to perform an action on an asset into a transferable data element (named *token*) on the blockchain. For example, tokens can be employed to provide authorisation to access a certain shared resource. Tokens may also be used to represent equity, decision-making power, property ownership or labour certificates.[xxvi]

Secondly, self-enforcement and formalisation of rules. These affordances refer to the process of embedding organisational rules in the form of smart contracts. As a result, there is an affordance for the self-enforcement of communitarian rules, such as those which regulate monitoring and graduated sanctions, as reflected in Ostrom's principles 4 and 5. This encoding of rules also implies a formalisation, since blockchain technologies require these rules to be defined in ways that are unambiguously understood by machines. In other words, the inherent process of explicitation of rules related to the use of distributed technologies

also provides opportunities to make these rules more available and visible for discussion, as noted in Ostrom's principle 2.

Thirdly, autonomous automatisation: the process of defining complex sets of smart contracts which may be set up in such a way as to make it possible for multiple parties to interact with each other, without human interaction. This is analogous to software communicating with other software today, but in a decentralised manner. DAOs are an example of autonomous automatisation as they could be self-sufficient to a certain extent. For instance, they could charge users for their services.[xxvii]

Fourthly, decentralised technologies offer an affordance for the decentralisation of power over the infrastructure. In other words, they can facilitate processes of communalising the ownership and control of the technological artefacts employed by the community. They do this through the decentralisation of the infrastructure they rely on, such as collaboration platforms employed for coordination.

Fifthly, transparency: for the opening of organisational processes and the associated data, by relying on the persistency and immutability properties of blockchain technologies. Finally, decentralised technologies can facilitate processes of codification of a certain degree of trust into systems which facilitate agreements between agents without requiring a third party. Table 1 below provides a summary of the relationships between Elinor Ostrom's principles and the aforementioned affordances.[xxviii]

	(I) Tokenisation	(II) Self-enforcement and formalisation	(III) Autonomous automatisation	(IV) Decentralisation of power over infrastructure	(V) Transparentisation	(VI) Codification of trust
(1) Clearly defined community boundaries	✓					
(2) Congruence between rules and local conditions	✓	✓		✓		
(3) Collective choice arrangements	✓			✓		
(4) Monitoring		✓	✓	✓	✓	

(5) Graduated sanctions		✓	✓			
(6) Conflict resolution mechanisms			✓		✓	
(7) Local enforcement of local rules		✓		✓		✓
(8) Multiple layers of nested enterprises			✓			✓

Table 1: Summary of the relationships between the identified affordances of blockchain technologies for governance and Ostrom's principles (Ostrom 1990), identified by Rozas et al. (2018).

These congruences allow us to describe the impact that blockchain technologies could have on governance processes in these communities. These decentralised technologies could facilitate coordination, help to scale up commons governance or even be useful to share agreements and different forms of value amongst various communities in interoperable ways, as shown by Pazaitis et al..[xxix] An example of how such affordances might be explored in the context of CBPP can be found in community networks such as Guifi.net.

A DAO for Commons Governance of Shared Technical Infrastructure

Would it be possible to build a DAO that might help to coordinate collaboration and scale up cooperative practices, in line with Ostrom's principles, in a community network such as Guifi.net? First of all, we need to identify the relationship between Ostrom's principles and Guifi.net. We can find, indeed, a wide exploration of the relationship between Ostrom's principles and the evolution in the self-organisational processes of Guifi.net in the work of Baig et al.[xxx] They document in detail how Guifi.net governs the infrastructure as a commons drawing on these principles, and provide a detailed analysis of the different components of the commons governance of the shared infrastructure in Guifi.net. Secondly, we need to define an initial point of analysis, and tentative interventions, in the form of one of the components of this form of commons governance. From all of these components, I will place the focus of analysis on the economic compensation system. The reason for selecting this system is twofold. On the one hand, it reflects the complexity behind commons governance and, thus, allows us to illustrate the aforementioned principles in greater depth. Secondly, it is an illustrative example of the potential of blockchain, as we shall see, to automatise and scale up various cooperative processes.

The economic compensation system of Guifi.net was designed as a mechanism to compensate imbalances in the uses of the shared infrastructure. Professional operators, for example, are requested to declare the expenditures and investments in the network. In alignment with Ostrom's principle number 4, the use, expenditure and investments of operators are monitored, in this case by the most formal institution which has emerged in Guifi.net: the Guifi.net Foundation. The Foundation is a legal organisation with the goal to protect the shared infrastructure and monitor compliance with the rules agreed by the members of the community. The community boundaries, as in Ostrom's principle number 1, are clearly defined and include several stakeholders.[xxxi] Different degrees of commitment with the commons were defined as collective choice arrangements (principle number 3). These rules are, however, open to discussion through periodic meetings organised regionally, and adapted to the local conditions, in congruence with principle number 2. If any participant, such as an operator, misuses the resources or does not fulfill the principles, the individual is subject to graduated sanctions,[xxxii] in alignment with principle number 5. As part of the compensation system, compensation meetups are organised locally to cope with conflict resolution, in congruence with principle 6.[xxxiii]

The compensation DAO could be formed by a set of local DAOs, whose rules are defined and modifiable exclusively by participants holding a token which demonstrates they belong to this node. These local DAOs could be deployed from templates, and could be modified at any point as a result of a discussion at the aforementioned periodic meetings held by local nodes and in congruence with the local conditions. Among the rules of the smart contracts composing these DAOs, participants may decide to define the different factors that are considered when discussing the local compensation system arrangements, as well as graduated sanctions in case of misuse of the common goods. These rules might be copied and adapted by some of the nodes facilitating the extension of the collaborative practices.

Some of the settings of these local DAOs could be dependent on a federal compensation DAO, defining general aspects. A mapping of the current logic could consist of reaching a certain degree of consensus between the participants in all of the nodes, but having this process approved by the members of the Foundation, who would hold a specific token. Examples of general aspects regulated by the federal DAO are the levels of commitment towards the commons of each operator, which is currently evaluated and monitored manually by the Foundation. General aspects such as this could be automatised in several ways therefore moving from manual assignations by the Foundation, as is currently the case, to automatically assigned tokens depending on the communitarian activities tracked in the plat-

form. This is an example of a possible intervention to automatise certain collaborative practices assuming the current structure. Figure 1 below provides an overview of a preliminary design of a DAO for a compensation system mapping the current logics.

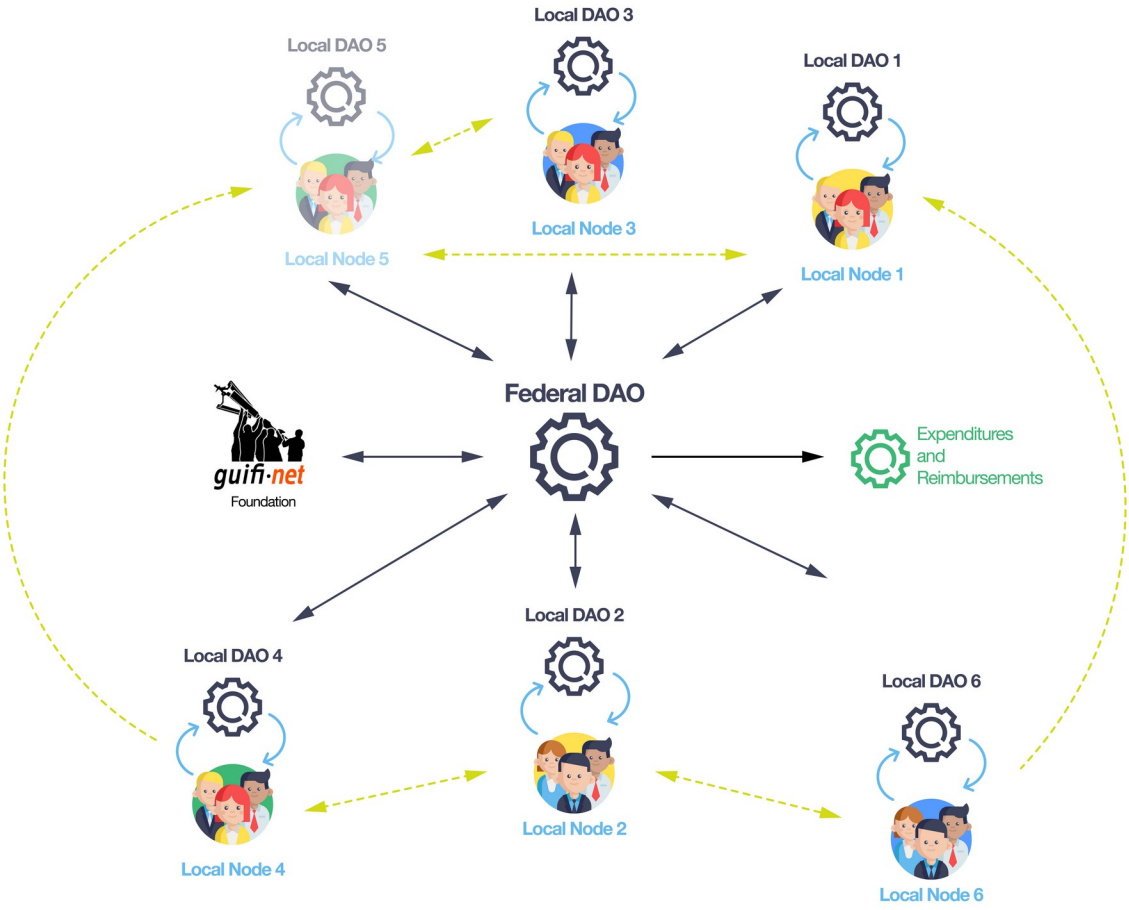

Figure 1: a proposal of a simple compensation DAO. The green arrows represent the extension of practices between local DAOs, including new nodes such as number 5. Black arrows represent the interactions between the local DAOs and the federal DAO, in congruence with Ostrom's principle 8.

More disruptive tentative interventions could consist of the implementation of more horizontal governance logics which allow modifications of the rules at a federal level or to transform the rules that regulate the monitoring. These interventions, however, should be carefully co-designed together with those who participate in the day-to-day of these collectives. Our approach states that the development of decentralised tools which support commons governance should be undertaken as a gradual process to construct situated technology, with an awareness of the cultural context and aiming to incorporate particular social practices into the design of these decentralised tools.

This basic example of a DAO illustrates, on the one hand, the relationship with Ostrom's principles: monitoring mechanisms, local collective choice arrangements, graduated sanctions and clear boundaries. These principles are sustained by the aforementioned affordances of blockchain for commons governance. For example, tokenisation with regards to providing permission as to who has the ability to participate in the choices locally and at a federal level and how, as well as the certification of the level of commitment to the commons; monitoring of the expenditures and reimbursements through the transparency provided by the blockchain; self-enforcement, formalisation and automatisation of the communitarian rules in the form of smart contracts. Another, more general example of this is the increment in the degree of decentralisation of power over the platform because of the inherent decentralised properties of the technology itself. In this way, this could result in a partial shift of power over the platform from the Foundation towards the different nodes formed by the participants. Furthermore, as discussed, the fact that such rules are encoded in the form of configurations of smart contracts could facilitate the extension of practices and the development of new nodes; or even the deployment of alternative networks capable of operating as the former network, and reusing and adapting the encoded rules of the community while still using the shared infrastructure. Overall, further research of the role of decentralised technologies in commons governance offers, in this respect, a promising field of experimentation and exploration of the potential scalability of cooperative dynamics.

Discussion and Concluding Remarks

In this article I provided an overview and discussed an example of the affordances of blockchain technologies for commons governance. Concretely, I described such potentialities drawing on the example of a DAO to automatise some of the collaborative processes surrounding the compensation system of a community network: Guifi.net. Throughout this example, I aimed to illustrate, in more detail, the affordances of blockchain for commons governance which I presented during the symposium. The aim of this example is to illustrate how blockchain may facilitate the extension and scaling up of the cooperation practices of commons governance. Further explorations, more closely related to the architecture field, could explore the presented affordances for commons governance with discrete design approaches that provide participatory frameworks for collective production.[xxxiv] In this respect, decentralised technologies offer opportunities of exploration to tackle challenges such as those identified by Sánchez[xxxv] to define ways to allocate ownership, authorship and distribution of value without falling into extractivist practices.

A better understanding of the capabilities of blockchain technologies for commons governance will require, however, further empirical research. Examples of research questions which need to be addressed are those with regards to the boundaries of the discussed affordances. For example, with regards to tokenisation and formalisation of rules: which aspects should remain in/off the blockchain, or furthermore completely in/out of code?

Overall, CBPP communities provide radically differing values and practices when compared with those in markets. In this respect, the study of the potentialities and limitations of blockchain technologies in the context of the governance of CBPP communities offers an inspiring opportunity to take further steps on a research journey that has only just begun.

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