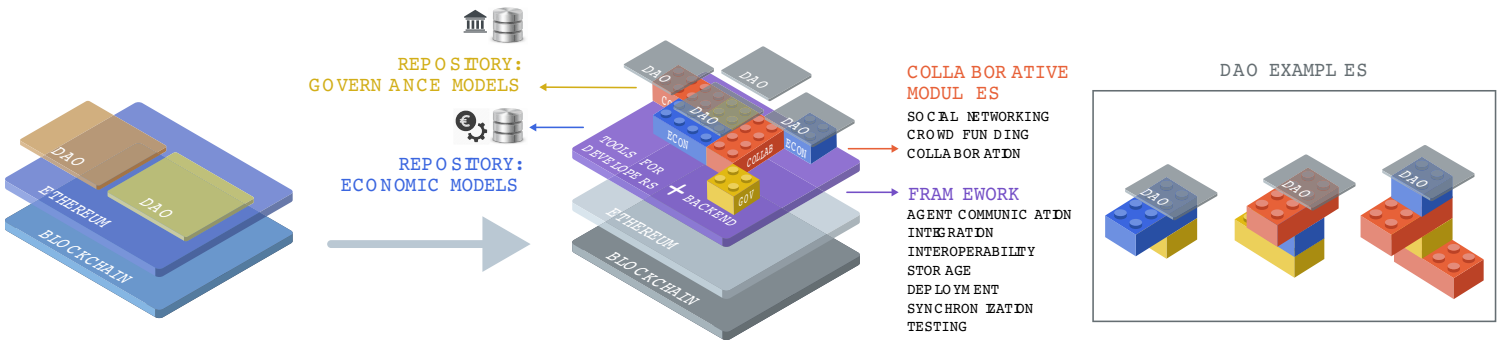
ERC Starting Grant 2017
Research proposal

P2P MODELS

Decentralized Blockchain-based Organizations for Bootstrapping the Collaborative Economy



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Name of the PI's host institution for the project: Universidad Complutense de Madrid
Proposal duration in months: 60 months

Proposal summary:

The Collaborative Economy (CE) is rapidly expanding through new forms of Internet labor and commerce, from Wikipedia to Kickstarter and Airbnb. However, it suffers from 3 main challenges: (1) Infrastructure: **centralized surveillance** that the central hubs of information exercise over their users, (2) Governance: **disempowered communities** which do not have any decision-making influence over the platform, and (3) Economy: **concentration of profits** in a few major players who do not proportionally redistribute them to the contributors.

How can CE software platforms be implemented for solving these challenges? P2PMODELS explores a new way of building CE software platforms harnessing the **blockchain,** an emerging technology that enables **autonomous agent-mediated organizations**, in order to (1) provide a **software framework** to build **decentralized infrastructure for Collaborative Economy organizations** that do not depend on central authorities, (2) enable **democratic-by-design models of governance** for communities, by encoding rules directly into the software platform, and (3) enable **fairer value distribution models**, thus improving the economic sustainability of both CE contributors and organizations.

Together, these 3 objectives will bootstrap the emergence of a **new generation** of self-governed and more economically sustainable peer-to-peer CE communities. The interdisciplinary nature of P2PMODELS will open a **new research field** around agent-mediated organizations for collaborative communities and their self-enforcing rules for automatic governance and economic rewarding. Bringing this proposal to life requires a funding scheme compatible with a **high-risk/high-gain** vision to finance a fully dedicated and highly motivated research team with multidisciplinary skills.

1. The Challenges

Collaborative Economy (CE) (or *Sharing Economy*) is an emergent socio-economic model where communities of individuals are coordinated through online software platforms for the creation, production, distribution, trade and consumption of goods and services, typically in a peer-to-peer manner. Its volume was estimated to be $15B USD in 2015 and projected to reach $335B USD by 2025 [1]. Well-known examples include free/open source software and Wikipedia, collaborative platforms (StackExchange Q&A, P2PUniversity courses, OpenStreetMap maps), resource sharing (Blablacar ride-sharing, FreeCycle gifting, Airbnb hosting), funding (Kickstarter crowdfunding, Zopa lending) and manufacturing (Fab Labs fabrication, Thingiverse 3D-designs). However, the Collaborative Economy ecosystem faces 3 key **structural challenges**:

A) Infrastructure Layer: Centralized Surveillance. The Web 2.0 model [2] has enabled participation and user-generated content, allowing the rise of the Collaborative Economy. However, the **high cost of maintenance of the server infrastructure**, especially when scaling to millions of users, forces the service owner to maximize its monetization. We have seen the emergence of **central hubs of information** which collect massive amounts of user data, and are mostly controlled by major industry players [3]. Too frequently, the users are not just the clients of the service, but also the product being sold [4]. **Surveillance** is frequently considered **the business model of the internet**, as most major websites run on advertising [3]. The problems of centralized platforms were highlighted by the Snowden revelations, showing the extent of governmental surveillance with industry collaboration [5]. Finally, as most services are **"walled gardens" with no interoperability**, network effects lock users into these platforms, making it prohibitively costly for them to leave, and thus reinforcing further centralization [6].

B) Governance Layer: Disempowered Communities. Early CE examples, mainly free/open source software and Wikipedia, were innovative and experimental in their governance structures, through community-led processes [7]. However, the CE economic success resulted in many initiatives being absorbed by industry monopolies (e.g. IMDb and Goodreads by Amazon, and Mendeley by Elsevier [8]). These multinational enterprises typically follow a hierarchical structure, **concentrating the decision-making power** at the top. This results in online communities of millions of users which have no say in the way they interact and relate to each other. Moreover, even with democratic and participatory governance models, **inequality issues arise** [9], [10].

C) Economic Layer: Concentration of Profits. Economic sustainability is hard for both emergent enterprises and CE contributors. The Internet creates winner-takes-all markets [11], in which a single enterprise captures the vast majority of a market share (e.g. Amazon, Facebook, Uber). This creates **high entry barriers** for new enterprises, and there is abundant evidence that **monopolies** create disadvantages for consumers [12]. In addition, CE enterprises concentrate the profits through the **appropriation of the value created** by their communities, as users are rarely rewarded for their work. Even in contexts where payment is expected, as in Uber-like ride-sharing, the driver's position is weakened, endangering labor rights and increasing the risk absorbed by precarious workers [13].

The P2PMODELS project aims to **leverage the potential of the new blockchain technology** to address CE's infrastructure challenge while laying the foundations to resolve the governance and economical challenges. The concrete **3 objectives** are:

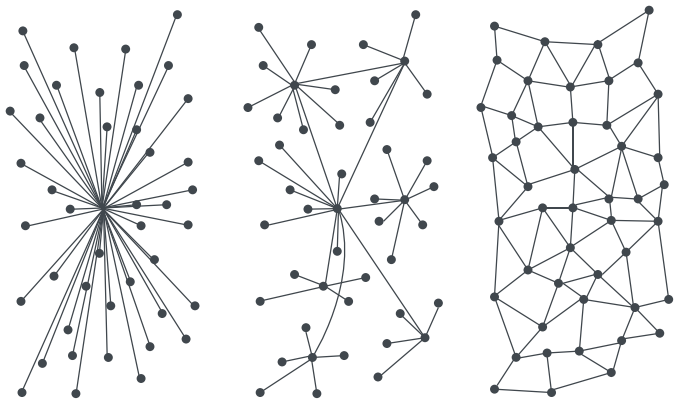
- To provide a **software framework** to build **decentralized infrastructure for Collaborative Economy organizations** which is interoperable, server-less, trust-less and subsequently minimizes dependencies with central authorities.
- To enable **democratic-by-design** and **models of governance** for communities, whose rules are encoded in the software to ensure higher levels of equality.
- To enable **value distribution models** which are interoperable across organizations, improving the economic sustainability of both contributors and organizations.

2. State of the Art

This section reviews the broad range of evolving decentralized infrastructure technologies, with a focus on the specific capabilities for which P2PMODELS chose the blockchain technology.

2.1 Decentralized Infrastructure

Federated Technology. The **first wave** of decentralized solutions has been through *federated* technology, i.e. multiple central nodes communicating with each other (center, in the figure), where users are free to choose the node to interact with. E-mail is a classic example of open protocol, together with more recent XMPP for chatting [14], OStatus for microblogging [15], OAuth for authentication [16], or SwellRT for real-time collaboration [17].



Distributed Technology. The **second wave** of decentralized solutions has been achieved through fully distributed technology, i.e. **P2P** networks without classical servers (right, in the figure) but instead ordinary computers (different from classical cluster/grid parallel computing). There have been multiple attempts to offer P2P web services, such as Freenet for censorship-resistant communication [18], but most of the work and success has been undertaken in the file-sharing, e.g. eDonkey, BitTorrent. The recent appearance of groundbreaking IPFS [19] to store and share files is already being explored as complement of the next wave.

The Blockchain. The **third wave** of decentralized solutions are a new approach towards the distributed/P2P technology explained above, which started with the advent of the first decentralized digital currency, **Bitcoin** [20]. Despite the wide spectrum of legitimate critics that Bitcoin has received [21], [22], its disruptive effect has been widely recognized [23]. Today, hundreds of new cryptocurrencies ("altcoins") are arising, each with their own distinctive features [24]. The underlying technology of Bitcoin is the ***blockchain***, the decentralized cryptographic ledger where transactions are recorded. The blockchain has meant a **paradigm shift for the implementation of decentralized systems** which are **trustless**, i.e. do not depend on the trust to a central authority [25]. It is a distributed database that maintains a growing list of tamper-proof records (called blocks"). This shared data structure, with its associated protocols, enables distributed identity management, record-keeping of transactions, and distributed computing. It maintains multiple advantages of the cloud (online web services, externalized computing, shared resources) without the drawbacks of central servers maintenance or trust on a provider. This has enabled blockchain-based decentralized solutions for other purposes, e.g. Dropbox-like cloud storage (Storj), domain name management (Namecoin), social networking (Synereo), and a music platform (Ujo). Over the past 3 years, $1.4 billion have been invested in blockchain technology [26] and players like IBM, Samsung, Microsoft, and Deloitte are entering the space [27].

2.2 Blockchain Capabilities

Distributed Applications. A groundbreaking project in the field is **Ethereum** [28], a blockchain-based distributed computing platform. Ethereum has its own programming language for developing applications whose execution is distributed across a large number of nodes. Ethereum's distributed applications (commonly referred to as *smart contracts*) can be regarded as **autonomous software agents** whose code is stored in the blockchain, i.e. in a ledger replicated in every node in the network. Their wide spectrum of applications and their particular environment provide an innovative combination of characteristics, allowing them to interact with both humans and other applications in the same blockchain ecosystem.

Blockchain Self-enforcing Rules. The blockchain allows the encoding of clauses in the distributed applications signed among different parties and, contrary to legal contracts, automatically enforce the rules embedded in their code [29]. This is agent-mediated human-to-human self-enforced interaction. The blockchain allows not only enforcing certain rules but defining them in the first place [30]. In fact, this is how Bitcoin is automatically governed by its algorithm [31].

Blockchain Value Distribution. So far most blockchain applications have focused on finance, i.e. "FinTech" [32]. This is directly related to blockchain ability to distribute value and incentives across a network. However, the transferred tokens may not only hold monetary value, as in the case of Bitcoin, but alternatively represent equity, decision-making power, or even property ownership digital certificates.

Decentralized Autonomous Organizations (DAOs). A distributed application can be implemented in such a way as to make it possible for multiple parties, humans or machines, to interact with each other. This is often referred to as a *decentralized autonomous organization* (DAO) *[28]*, an **organization** where the member interaction is mediated by a blockchain application, controlled exclusively by **set of immutable and incorruptible rules embedded in its source code**. A DAO can be regarded as a **digital organization mediated by a software agent**, whose code is in the blockchain. As a decentralized organization, *a DAO* can *provide services* (or resources) to third-parties, or even *hire* people to perform specific tasks. Hence, individuals can transact with a DAO in order to access its service, or get paid for their contributions. DAOs are fully autonomous, as they do not rely on any central server and thus cannot be arbitrarily shut down by any single party (unless specifically provided for in their code). A theoretical example is DAO-Couchsurfing (Couchsurfing is a hospitality network of members stay in each other's homes), which providing a public directory of places where users can interact and even reward the hosts with cryptocurrencies. Thus, **DAOs provide a new way of building online software platforms.**

DAO Development. No comprehensive effort has been undertaken to develop a toolkit for building DAOs, which could make research possible on complex issues including large-scale collaboration, community governance, and distributed economic models. Most of the work in the blockchain field is done by startups, which frequently fail and destabilize a new field with multiple challenges (e.g. constant evolution; different programming paradigm that cannot rely on established practices). Ethereum provides a programming language for distributed applications, but it is far from sufficient for complex DAOs [33]. **P2PMODELS will explore new approaches to building DAOs, focused on enabling a DAO ecosystem for non-financial purposes, and with appropriate standardization and interoperability.**

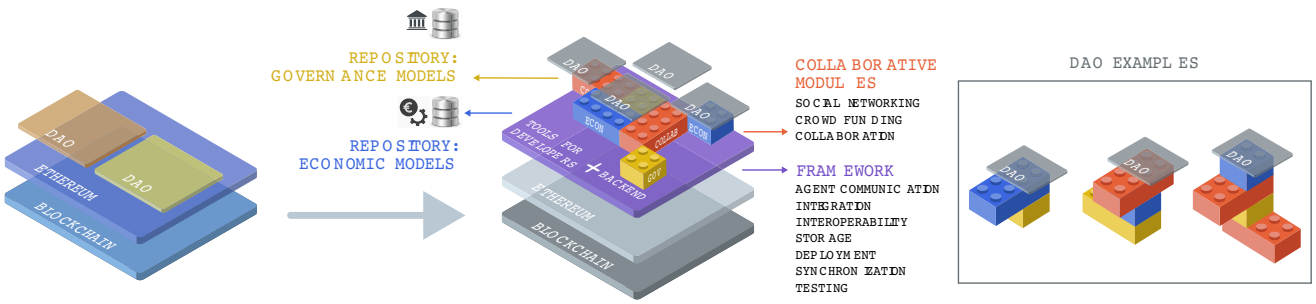
3. Goals

3.1 Challenge A) Infrastructure Layer: Centralized Surveillance

Goal A1: Bootstrapping the Development of DAOs. The **P2PMODELS** project **will build a software framework to develop DAOs to leverage all of their potential**. Such a framework will consist of a **middleware** with an extensive API together with several libraries and tools. As DAOs are agent-mediated organizations, it may be considered a **software framework for developing agent-mediated organizations as blockchain-enabled software platforms**. The aim is to facilitate DAO development through the generalization and encapsulation of common functionalities (e.g. DAO communication, collaboration, storage), while isolating developers from the complexities of blockchain-specific issues. This free/open source framework, built on top of Ethereum, will facilitate interoperability, modularity and reuse, increasing resilience and security of the DAOs developed, together with DAO-to-DAO interaction. It will provide open standards and best practices together with ready-to-use modules. Preliminary efforts by the PI have demonstrated the feasibility of this approach,

as he coordinated, under a EU-funded project, the development of a software framework to build decentralized collaborative apps (federated, not blockchain related) [17]. Its success was demonstrated when the project attracted the interest from the Apache Foundation and is currently being adopted within the Apache Wave project.

Goal A2: Bootstrapping the Development of Collaborative DAOs. P2PMODELS will enable the development of **Collaborative DAOs**, **i.e. DAOs for Collaborative Economy communities**. The software framework will cover their particular requirements, such as collaborative features, monetary and non-monetary exchange, social-networking, crowdsourcing, or crowdfunding. This will enable the emergence of a **new generation of CE**, enabled by decentralized infrastructure, and overcoming the main problems from Challenge A. Thus, the organization **operating costs** would not depend on expensive server maintenance, but instead may run indefinitely, as long as it is useful to its users. Communities **would not need to trust** a central authority, but instead delegate part of its rules to the code. And users would **not be locked in** a service, as DAOs interoperability may facilitate relocation. The PI has already performed advances in this context, building online tools for CE communities [35]–[37], and a blockchain-based crowdfunding prototype [38].



3.2 Challenge B) Governance Layer: Disempowered Communities

Goal B: Encoding Governance Models in DAOs. The self-enforcing rules that blockchain enables for the governance of Bitcoin apply also to DAOs. What are the limits of purely technical governance? How much of our social governance models can be embedded into code? How much trust can we place in the algorithms? **P2PMODELS will provide a testbed to explore the limits of this new space** of possibilities, providing ample support for the encoding of governance models into DAO code. The project will provide a set of **ready-to-use encoded governance models**, exploring existing models of governance in the Collaborative Economy, including: new forms coming from the Platform Cooperativism emerging trend [39]; prominent examples like Enspiral [40]; classical decision-making models such as majority-voting in e-democracy [41], or proxy voting [42]; reputation-based models already applied in online settings (e.g. eBay, StackOverflow). This will allow the emergence of **democratic-by-design models in which communities are governed, at least partially, by explicit rules embedded in the code** that aim to make CE communities more inclusive and equal (e.g. taking into account gender, minorities or low-income profiles). The PI has already started to explore the complex implications of embedding rules and regulation in blockchain code [30] and pioneered blockchain-based models to improve community governance [43].

3.3 Challenge C) Economic layer: Concentration of Profits

Goal C: Encoding Economic Models in DAOs. Similarly to governance models, economic models can also be embedded in a DAO's code. The blockchain facilitates monetary/non-monetary token exchange. P2PMODELS will provide a **testbed** for experimentation of **ready-to-use encoded economic models for CE communities to distribute the value generated by their users** and aid their **economic sustainability**. E.g. a model for distributing payments according to contribution value [45], or where uploaders are rewarded while downloaders pay a micro-fee to access resources [46], but also experimental models such as a community *basic income [47]*. Furthermore, the platform will allow communities to experiment with their own notions of value, as tokens may be also non-transferable reputation (e.g. Backfeed [48]), smart-property keys, or represent decision-making power. The PI has several works pioneering the implementation of blockchain-based economic models in CE communities [43], [49].

Impact. P2PMODELS presents multiple scientific and technological issues to solve, as it **opens a new field for research** around **agent-mediated organizations for human collaboration and their self-enforcing rules for automatic governance and economic rewarding**. This new field will attract **interest from a wide variety of scholars**, as it is in the crossroads of decentralized systems (blockchain), multi-agent systems (DAOs as agent-mediated organizations), software engineering (blockchain-based software platforms), the modelling of social systems (encoding them into DAO code), economics (value distribution models), political science (e-democracy), and law (regulation by code). P2PMODELS will provide a common space for the interaction of these disciplines, and by providing a **testbed** it opens door for the **scientific opportunities** of new kinds of software agents, online software platforms and socio-economic organizations.

The moment is now. Current experimental blockchain technology provides a window of opportunity for groundbreaking research exploring its potential. The deployment of agent-mediated organizations acting as CE platforms will imply a **significant socio-economic impact**. Current winner-takes-all markets with global leaders is leaving Europe behind the USA. P2PMODELS brings to life an interoperable landscape that **greatly benefits European innovation,** where barriers to competition are much lower, and users can easily move across interoperable DAO services. Moreover, the open doors for experimentation in community economic models allows the flourishing of **new forms of entrepreneurship and business** (e.g. enterprises delivering insurance or verification services to DAOs in exchange of cryptocurrencies). The highly innovative character of P2PMODELS is expected to open new horizons, by **expanding the limits of how software facilitates human collaboration**. In the short term, this project will allow us to understand the viability of DAOs as an alternative form of large-scale organization, and the extent to which technical governance is possible to promote human collaboration. In the long term, it enables a **new generation of communities** where users can collaborate without knowing or even trusting others, relying instead on decentralized infrastructures, with part of their decisions automatically executed by algorithms they define.

The PI is in an unique position to lead this effort. His interdisciplinary background has allowed him to explore and advance all these fields, receiving ample recognition in several of them, and international attention in his current position at Harvard University (see CV). He has extensive experience in knowledge transfer to collaborative communities, and is well-connected in the field. This ERC grant is instrumental for the future of the PI's career, since the high-risk nature of P2PMODELS limits access to conservative funding sources, despite its potential impact. This ERC grant allows the PI to materialize the groundbreaking ideas of the P2PMODELS proposal in full, building a worldwide team combining researchers in multiple disciplines around a common goal.

5. Work Plan

Work Package structure (see B2 for further details): P2PMODELS is structured in 6 work packages (WP) for a total duration of 60 months (M) using a **mixed-methods** and **multi-disciplinary** approach. The PI has prior experience with all methodologies used in the different WPs. The best way to validate a development framework is through building real applications facing real user feedback, not mere demonstrations for a lab environment. Then, new unexpected requirements (and challenges) will appear, empirically validating the framework features. More precisely, P2PMODELS follows a ***Lean Development*** [50] approach, in which all aspects of the production process are empirically validated using a scientific method with a focus on meeting the target needs (i.e. CE communities). *Lean* performs social research to better understand the target, followed by short cycles of ideation-prototyping-testing (to detect mistakes early). Moreover, the software development will follow the **agile methodology** Scrum [51], to perform the rapid prototyping cycles. Besides, the project will abide to a fully **Open approach**, with all software and documents released with an open license.

• **WP1: Development of Backend Framework (M1-M60)** will **develop a software framework for the development of DAOs** and collaborative DAOs. It will provide tools for the development of DAOs (deployment, testing) facilitating the integration and interaction between multiple connected smart contracts that pertain to the same DAO. Our approach will consider DAOs as **agent-mediated organizations**, drawing inspiration from other multi-agent frameworks developed by the PI's team [52], [53]. (2) It will provide an integrated API encapsulating functionalities such as DAO communication or storage, while enabling ready-to-use modules for CE collaboration, governance and economic models.

• **WP2: Modelling** (M7-M48) will review, model, simulate and encode **governance** and **economic systems** to be implemented in DAOs, and thus in WP1's framework. Those found in literature and WP1 social research will need to be adapted to a DAO and blockchain context. However, it would be problematic to apply DAO versions of governance or economic models in real settings without prior testing. Thus, this WP will implement these models as **agent-based models** for the **simulation** of their behaviour. The simulations will provide insights for the selection of the appropriate models to implement. This prior modelling will facilitate their encoding in actual DAO source code that can be integrated in the framework (in WP1) and into prototypes (in WP4). After several models have been encoded, this task will aim to

build **templates** so third-parties can easily build new ones. Feedback from WP5, which will empirically validate some of the models (implemented in WP4 pilots), may trigger changes in the models.

· **WP3: Social Research** (M7-M54) will perform social research (a **survey**) across a wide diversity of CE communities in order to (1) characterize their common features (for WP1), governance and economic models used (for WP2), (2) identify the needs and issues of specific CE communities to be potentially solved with DAOs, (3) formulate hypotheses of solutions to fulfill those needs, that will be implemented as WP4 prototypes (4) build social theory supported by the WP5 empirically validated hypotheses. It will follow a **triangulation** of: **quantitative research** (survey, data mining of available data-sets) and **qualitative research** of case-study CE communities (interviews, participant observation).

• **WP4: Development of Pilots** (M18-M60) will **prototype DAO pilots reflecting different aspects of the Collaborative Economy**. These pilots will not be toys but rather fully fledged DAOs which will be launched in Beta stage and host real users. **3 DAO pilots are expected** to be built, each with a different democratic governance model and economic model. An example could be a DAO-Wiki with a participatory democracy using delegated voting, and a reward system for the reputed contributors. This WP will provide specifications for new requirements to WP1, and receive feedback from WP5.
· WP5: Testing & Community Engagement (M24-M60) will interact and engage with case-study CE communities, test prototypes, and gather feedback. It will empirically validate the WP4 prototypes. It will identify communities interested in larger testing (some are open to this kind of experimentation [54]). It will use **qualitative research** (semi-structured interviews, usability testing) and **Design Thinking** techniques.

• **WP6: Management & Dissemination** (M1-M60) will deal with the project coordination, dissemination, publications, intellectual property management, transfer of knowledge activities and website setup.

Risks & Contingency Plans. The most critical difficulties are (see details in B2): (1) Dependency from Ethereum platform (technical instability) → Libraries will be agnostic so a port to alternative platform is viable. (2) Technical challenges for collaborative DAOs far more complex than expected → Moving personnel from WP4 to WP1 and reducing to 1 pilot, not 3. (3) CE is too diverse for extracting common patterns → Reduce the scope to CE subfield, e.g. peer production. (4) CE participants express discomfort on too technocratic governance → Customization allowed for incrementing social control over automated control. (5) DAO automatic models disrupt CE cooperation → Agent-based modelling aims to prevent it, DAOs may need modifications guided by social research. (6) multidisciplinarity miscommunications → Lean Development aims to minimize it.

Resources. The PI will dedicate the 90% of his time during the 60 months. P2PMODELS will involve 3 postdocs who will lead the tasks together with the PI; 3 PhD students; a user experience designer familiar with Design Thinking techniques; and a project manager with expertise in communication. This will be a multidisciplinary team, including decentralized systems, software architectures, agent-based modelling, socio-economic research and lean development. Additional funding will be allocated for research stays, trips for presenting results, organization of a workshop series to promote the field, and open access fees. Dissemination will be 3-fold: scientific community to experiment with the testbed, engagement with CE communities (where the PI has an extensive network), and blockchain developers to use the framework. The activities of the P2PMODELS proposal will be carried out in the modern facilities of the Computer Science Faculty of the Universidad Complutense de Madrid (UCM).

References

1. PwC, "Consumer Intelligence Series: The sharing economy," *PricewaterhouseCoopers*, 2015. [Online]. Available: http://www.pwc.com/us/en/industry/entertainment-media/publications/consumer-intelligence-series/sharing-economy.html. [Accessed: 17-Oct-2016].

2. T. O'Reilly, "What is Web 2.0: Design Patterns and Business Models for the Next Generation of Software," Social Science Research Network, Rochester, NY, Aug. 2007.

3. Y. Benkler, "Degrees of Freedom, Dimensions of Power," *Daedalus*, vol. 145, no. 1, pp. 18–32, 2016.

4. H. Haddadi, H. Howard, A. Chaudhry, J. Crowcroft, A. Madhavapeddy, and R. Mortier, "Personal Data: Thinking Inside the Box," *arXiv [cs.CY]*, 20-Jan-2015.

5. G. Greenwald, *No Place to Hide: Edward Snowden, the NSA, and the U.S. Surveillance State*. Henry Holt and Company, 2014.

6. C. Anderson and M. Wolff, "The Web is dead. Long live the Internet," *Wired Magazine*, vol. 18, 2010.

7. M. Fuster Morell, "Governance of online creation communities: Provision of infrastructure for the building of digital commons," 2010.

8. M. Bauwens, "Disputing the enclosures of digital commons (1): gaming commons-based reputation systems \ textbar P2P Foundation," 2013. [Online]. Available: https://blog.p2pfoundation.net/disputing-the-enclosures-of-digital-commons-1/2013/06/19.

9. V. W. Pickard, "Assessing the Radical Democracy of Indymedia: Discursive, Technical, and Institutional Constructions," *Critical Studies in Media Communication*, vol. 23, no. 1, pp. 19–38, 2006.

10. A. Shaw and B. M. Hill, "Laboratories of Oligarchy? How the Iron Law Extends to Peer Production," *J. Commun.*, vol. 64, no. 2, pp. 215–238, Apr. 2014.

11. T. Noe and G. Parker, "Winner Take All: Competition, Strategy, and the Structure of Returns in the Internet Economy," *Journal of Economics & Management Strategy*, vol. 14, no. 1, pp. 141–164, Mar. 2005.

12. R. A. Posner, "Social Costs of Monopoly and Regulation," National Bureau of Economic Research, Sep-1974.

13. B. Rogers, "The Social Costs of Uber," May 2015.

14. P. Saint-Andre, "Extensible messaging and presence protocol (XMPP): Core," 2011.

15. W3C, "The Basics - OStatus Community Group," 2012. [Online]. Available: http://www.w3.org/community/ostatus/wiki/The_Basics. [Accessed: 11-Oct-2016].

16. E. Hammer-Lahav, "The OAuth 1.0 Protocol, Internet Engineering Task Force (IETF)," *online at http://goo. gl/eN6VT*, 2010.

17. P. Ojanguren-Menendez, A. Tenorio-Fornés, and S. Hassan, "Awakening Decentralised Real-Time Collaboration: Re-engineering Apache Wave into a General-Purpose Federated and Collaborative Platform," in *Distributed Computing and Artificial Intelligence, 12th International Conference*, S. Omatu, Q. M. Malluhi, S. R. Gonzalez, G. Bocewicz, E. Bucciarelli, G. Giulioni, and F. Iqba, Eds. Springer International Publishing, 2015, pp. 269–276.

18. I. Clarke, O. Sandberg, B. Wiley, and T. W. Hong, "Freenet: A Distributed Anonymous Information Storage and Retrieval System," in *Designing Privacy Enhancing Technologies*, H. Federrath, Ed. Springer Berlin Heidelberg, 2001, pp. 46–66.

19. J. Benet, "IPFS - Content Addressed, Versioned, P2P File System," *arXiv [cs.NI]*, 14-Jul-2014.

20. S. Nakamoto, "Bitcoin: A peer-to-peer electronic cash system," 2008.

21. B. P. Hanley, "The False Premises and Promises of Bitcoin," *arXiv [cs.CE]*, 07-Dec-2013.

22. G. F. Hurlburt and I. Bojanova, "Bitcoin: Benefit or Curse?," *IT Prof.*, vol. 16, no. 3, pp. 10–15, May 2014.

23. G. Vora, "Cryptocurrencies: Are Disruptive Financial Innovations Here?," *Modern Economy*, vol. 06, no. 07, pp. 816–832, 2015.

24. L. H. White, "The Market for Cryptocurrencies," Dec. 2014.

25. M. Swan, *Blockchain: Blueprint for a New Economy*. O'Reilly Media, 2015.

26. W. Suberg, "World Economic Forum: 'DLT' Blockchains Are the Future," *Bitcoin News*, 12-Aug-2016. [Online]. Available: https://news.bitcoin.com/world-economic-forum-blockchain/. [Accessed: 11-Oct-2016].

27. C. Barker, "Is blockchain the key to the Internet of Things? IBM and Samsung think it might just be | ZDNet," *ZDNet*, 2015. [Online]. Available: http://www.zdnet.com/article/is-blockchain-the-key-to-the-internet-of-things-ibm-and-samsung-think-it-might-just-be/. [Accessed: 11-Oct-2016].

28. V. Buterin, "Ethereum: A next-generation cryptocurrency and decentralized application platform," 2014.

29. A. Wright and P. De Filippi, "Decentralized Blockchain Technology and the Rise of Lex Cryptographia," Mar. 2015.

30. P. De Filippi and S. Hassan, "Blockchain Technology as a Regulatory Technology: From Code is Law to Law is Code," *First Monday, Special Issue "'Reclaiming the Internet' with distributed architectures? Rights, Practices, Innovations*, 2016.

31. J. A. Kroll, I. C. Davey, and E. W. Felten, "The economics of Bitcoin mining, or Bitcoin in the presence of adversaries, " *Proceedings of WEIS*, 2013.

32. M. Aspan, *Why Fintech Is One of the Most Promising Industries of 2015*. INC, 2015.

33. E. G. Sirer, "Thoughts on The DAO Hack," *Hacking Distributed*, 17-Jun-2016. [Online]. Available: http://hackingdistributed.com/2016/06/17/thoughts-on-the-dao-hack/.

34. S. H. Ammous, "Can Cryptocurrencies Fulfil the Functions of Money?," Sep. 2016.

35. S. Hassan, "Translating Research into Online Tools to Increase Participation in Collaborative Communities | Berkman Klein Center," presented at the Luncheon Talk Series of the Berkman Klein Center , Harvard University , 2016.

36. J. de la Cueva, B. Guerry, S. Hassan, and V. J. R. Jurado, "Move Commons: Labeling, Opening and Connecting Social Initiatives," in *The Wealth of the Commons: A World Beyond Market and State*, S. H. David Bollier, Ed. Levellers Press, 2012, pp. 319–322.

37. A. Tenorio-Fornés and S. Hassan, "Towards an Agent-supported Online Assembly: Prototyping a Collaborative Decision-Making Tool," in *COLLA 2014, The Fourth International Conference on Advanced Collaborative Networks, Systems and Applications*, 2014, pp. 72–77.

38. V. Jacynycz, A. Calvo, S. Hassan, and A. A. Sánchez-Ruiz, "Betfunding: A Distributed Bounty-Based Crowdfunding Platform over Ethereum," in *Distributed Computing and Artificial Intelligence, 13th International Conference*, S. Omatu, A. Semalat, G. Bocewicz, P. Sitek, I. E. Nielsen, J. A. García García, and J. Bajo, Eds. Springer International Publishing, 2016, pp. 403–411.

39. T. Scholz, "Platform Cooperativism vs. the Sharing Economy," *Medium*, 05-Dec-2014. [Online]. Available: https://medium.com/@trebors/platform-cooperativism-vs-the-sharing-economy-2ea737f1b5ad. [Accessed: 11-Oct-2016].

40. V. Kostakis, A. Pazaitis, and M. Bauwens, "Digital Economy and the Rise of Open Cooperativism: The Case of the Enspiral Network," 2016.

41. A. Chadwick, "Web 2.0: New challenges for the study of e-democracy in an era of informational exuberance," *Isjlp*, 2008.

42. P. Boldi, F. Bonchi, C. Castillo, and S. Vigna, "Viscous Democracy for Social Networks," *Commun. ACM*, vol. 54, no. 6, pp. 129–137, Jun. 2011.

43. S. Hassan and P. De Filippi, "Reputation and Quality Indicators to improve Community Governance," *Available at SSRN 2725369*, 2015.

44. S. Hassan, "Towards a Data-driven Approach for Agent-Based Modelling: Simulating Spanish Postmodernisation. Madrid, Universidad Complutense de Madrid," 2009.

45. N. Turgeon, M. Thai, and G. Epuran, "OSH Start-ups' Business Development Challenges: The Case of SENSORICA from a Total Integrated Marketing Perspective," *Int. J. Econ. Theory*, 2014.

46. T. Lauinger, E. Kirda, and P. Michiardi, "Paying for Piracy? An Analysis of One-Click Hosters' Controversial Reward Schemes," in *Research in Attacks, Intrusions, and Defenses*, vol. 7462, D. Balzarotti, S. J. Stolfo, and M. Cova, Eds. Berlin, Heidelberg: Springer Berlin Heidelberg, 2012, pp. 169–189.

47. A. B. Atkinson, "Public Economics in Action: The Basic Income/Flat Tax Proposal," OUP Catalogue, 1996.

48. S. Davidson, P. De Filippi, and J. Potts, "Economics of Blockchain," Available at SSRN 2744751, Mar. 2016.

49. P. De Filippi and S. Hassan, "Measuring Value in Commons-based Ecosystem: bridging the gap between the Commons and the Market," The MoneyLab Reader. Institute of Network Cultures, University of Warwick, pp. 74–91, 2015.

50. F. Ballé and M. Ballé, "Lean Development," Business Strategy Review, vol. 16, no. 3, pp. 17–22, Aug. 2005.

51. K. Schwaber and M. Beedle, Agile Software Development with Scrum. Prentice Hall, 2002.

52. R. Fuentes-Fernández, S. Hassan, J. Pavón, J. M. Galán, and A. López-Paredes, “Metamodels for role-driven agent-based modelling,” Comput. Math. Organ. Theory, vol. 18, no. 1, pp. 91–112, Mar. 2012.

53. J. J. Gomez-Sanz, R. Fuentes, J. Pavón, and I. García-Magariño, “INGENIAS Development Kit: A Visual Multi-agent System Development Environment,” in Proceedings of the 7th International Joint Conference on Autonomous Agents and Multiagent Systems: Demo Papers, Estoril, Portugal, 2008, pp. 1675–1676.

54. F. Pick, “Decentralizing (part of) OuiShare with blockchain,” OuiShare EN - Connecting the Collaborative Economy, 11-Nov-2015. [Online]. Available: http://magazine.ouishare.net/2015/11/decentralizing-part-of-ouishare-with-blockchain-experiment-1/. [Accessed: 17-Oct-2016].