Community-Centric Innovation

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***Abstract*—The Internet is profoundly transforming the economic and social structures of the 21st century. The ability to instantaneously share data across the globe enables new ways of collaboration and production models. The individuals can join loosely organized working groups and communities and contribute to the evolution and progress of the humankind. By choosing which communities they join and which communities they contribute to, the users can also be participants and producers. Furthermore, this model enables a new way of democracy in which the people vote not only with their ballots, but also with their daily jobs and contributions. In this work we describe examples of bottom-up initiatives in which the users play a central role in the development of the project. These are initiatives by and for the people.**

***Index Terms*—bottom-up broadband, community networks**

I. Introduction

THE growth of the Internet has dramatically accelerated the path of technological evolution. The amount of information and knowledge available on the Net is increasing. Importantly, the number of people that can access that knowledge is increasing as well. The Internet is more than an incremental evolution that brings faster progress. It is a disruptive innovation that is completely transforming the way we organize ourselves and relate to each other.

The fact that the information can be shared with little restrictions in terms of space, time and cost, makes it possible for people to organize in horizontal structures. In this horizontal models, also known as peer-to-peer models, all the participants can access to the information required to contribute to the decision-making process. By removing the barriers for participation, the working force of peer-to-peer projects is reinforced. The benefit is not only the number of participants, but also the variety. The heterogeneous background of the participants makes it possible to consider a wider space of solutions and the extensive scrutiny throughout the discussion and decision-making stage reduces the chances of mistakes.

In this work we consider several examples in which the users organize in communities to construct user-centric networks and networked services.

II. Community Networks

Probably the best example of user-centric networking are community networks. Community networks are deployed by the same users that use them. Consequently, they are carefully tailored to satisfy the users' needs. This needs are not necessarily only about connectivity. The users might be interested in learning about the network, and in researching new services, applications and protocols.

There are cases in which the participants of community networks include not only individuals, but also local organizations such as municipalities or universities [1]. This involvement stems from the fact that community network have been effective in overcoming the digital divide [2].

Community networks are particularly useful in underserved areas with little presence of commercial operators. In rural, distant or poor areas community networks can be the only viable alternative to access the Internet. In these places, the inhabitants have a strong incentive to spend time and energies in acquiring the necessary skills required to deploy and operate a network.

Another aspect that can draw the attention to community networks is privacy. As commercial networks are involved in mass surveillance programs, the citizens see in community networks a way to opt out from privacy-invading campaigns. Finally, community networks are also a means of getting around censorship. Totalitarian regimes build censorship into the networks to control which information is distributed among the population. Filtering the information and Internet blackouts have been used as ways for hindering social movements and placate population unrest.

Compared to commercial Internet, Community Networks are more heterogeneous and decentralized. As a consequence they have properties that complement those of commercial networks. In case of natural disaster, having alternative resilient networks to coordinate rescue and humanitarian help can save lives.

Mesh technologies such as the *quick mesh project* (qmp) are evolving to make it easier for regular citizens to set up a network in a matter of minutes. Friendly configuration web interfaces can be used to abstract the underlying technological complexity. In community networks, local people become familiar with the procedures required to set up, maintain and troubleshoot the network. In case of emergency, the presence of local experts facilitates quick deployments and reparations.

The decentralized nature of community networks greatly helps in fostering organic growth and also in resisting node failures. The absence of central points of failure guarantees that two neighbours will be able to connect to each other as long as they keep their nodes running, regardless of what happens to the rest of the network. Mesh routing protocols, such as BMX6, allow the network to quickly re-configure itself and to route packets around failures to keep connectivity. These protocols are particularly tailored to work in challenging multi-hop wireless conditions. To take down a community network it is necessary to shut down all the nodes.

Community networks are often less stable and more dynamic than their commercial counterparts. The participants of

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community networks are eager to experiment and evolve all aspects of the network even if this results in an increased risk of occasional connectivity cuts. As an example, while commercial networks run mostly on IPv4, qmp networks are native IPv6 networks. Protocols, firmware and topology change on a daily basis to fix bugs, improve the performance or adapt to new situations.

This continuous change that forces to keep the equipment's firmware updated represents an additional layer of protection against spying agencies interested in compromising the network. It is much more difficult to attack up-to-date systems than systems running old unpatched firmwares.

Beyond the purely technological aspects, the importance of community networks is precisely the fact that they are governed by a community. Community governance is drastically different from hierarchical governance. For the network to hold together, it is necessary that the participants reach some kind of consensus at the time of making decisions. It is not uncommon to see different participants or groups of participants having completely different interests, ethical values or methodologies. Still, it is in the benefit of all the participants to reach a consensus and agree in some basic principles. The continuous negotiation, discussion and clashes of completely different positions can reach a level that threatens the integrity of the network.

The participation in a community network trains the citizens in self-management techniques that inherit many of the properties of decentralized networks. The lack of a central authority obliges the participants to take responsibility, exercise their freedom and respect the others. Making concessions is necessary in order to achieve common goals.

All participants are invited to contribute, and contributions are evaluated in an informal process for merit or weaknesses. The participants can progressively build up a reputation by making high-quality contributions and helping others to accomplish their goals. The organization progressively evolves towards a meritocratic systems in which those participants that consistently contribute to the value of the community earn the respect of their peers and emerge as natural leaders. In any case, this is not a leadership which is attached to the person. The leadership is attached to the contributions.

A core principle of community networks is precisely the sharing of the network as a commons good. There is no single owner of the network. Even though the participants may own the pieces of hardware that they contributed to the network, the network as a whole belongs the community. As the value of the network increases with the number of participants, the community has an incentive to share existing network resources with newcomers.

By being part of the community network, the participants agree in altruistically routing traffic for other participants. Besides connectivity services, the community networks can also offer networked services such as email, mailing lists, HTTP proxy services, FTP, collaborative documents and social platforms.

There is a large number of community networks and they are very heterogeneous. They use different technologies such as wireless point-to-point links, wireless multi-point to multi-point links, ADSL or fiber. Even in the case in which two community networks use the same layer-2 technology, it is still likely that they use different hardware, firmware or protocols. The sizes of community networks also vary greatly and can range from few tenths of nodes to tenths of thousands. The amount of documentation, supporting applications and organizational structure is also very different in different community networks.

Despite the disparity of models for community networks, there is an aspect that is common to all of them. All these network are user-centric. They are planned, financed, deployed and maintained by the same users that benefit from them.

III. Networked Cryptocurrencies

Another area that has witnessed the potential for community-centric innovation is that of networked cryptocurrency. The combination of cryptography, free libre software and a data network makes it possible the use of networked cryptocurrencies. In these technologies, a cryptographically secure distributed ledger is maintained by the network. The network is composed of nodes that interact in a peer-to-peer fashion following a common set of rules (i.e., a protocol) to guarantee the integrity of the cryptocurrency. The network not only distributes information about the ongoing transactions, it also provides hashing power that is used as a proof of work. The distributed ledger is protected by the proof of work. In a sense, the nodes vote with their computational work and the majority decides which transactions are included in the public distributed ledger.

Cryptocurrency has some advantages when compared to traditional fiat currencies. Some of the advantages of cryptocurrencies are related to their peer-to-peer nature. One of them is the lack of a central authority. A central authority can make arbitrary decisions and create money at no cost. In cryptocurrencies, the emission of money is controlled by the protocol and governed by publicly known rules. This means that the availability of money at any point in the future is known by all the participants. The emitted money is used to reward the nodes that contribute with hashing power to the security of the network. Hashing power requires hardware and electricity, which means that it is no longer possible to create money at zero cost. In fact, the money generation business (popularly known as *mining*) is, in a financial sense, a risky endeavour. The cost of hashing power required to *mine* can exceed the value of the generated money.

Peer-to-peer networks are extremely resilient. There is no single point of failure or central entity that can be attacked to take down the network. As there are thousands of nodes spread across the network, the currency can survive as long as the underlying data network survives. The risks of blockades or political interference are greatly mitigated. Many Internet organizations such as Wikileaks and Wordpress accept donations and payments in cryptocurrency. In some cases to bypass governments blockades and in others to operate in countries with lacking payment networks.

Some of the advantages of networked cryptocurrencies are derived from their networked nature. The reach of the

cryptocurrency is the same as that of the underlying network. If a cryptocurrency runs on the Internet, the scope is global. As a result, economic transactions benefit from all the advantages of Internet protocols. Sending money is as simple as sending an electronic mail. A cryptocurrency transaction propagates almost instantaneously across all the Internet and is confirmed in a matter of minutes. Payments can be easily automatized using scripts or other software. Any networked device, such as servers, laptops or mobile phones, can be used to send a payment. Furthermore, the payment network is available 24 hours a day and 365 days a year.

There are also properties of networked cryptocurrencies related to their cryptographical nature. These currencies do not require the users to trust a third party. The trust relies on cryptographic primitives that have proven to be robust over the years. The reliance on secret keys makes it possible to save the same money in more than one place at the same time. Even if one of the copies of the secret keys is lost, the owner can still access the money if she has access to a second copy. More sophisticated techniques can be used to achieve greater degrees of security. For example, the secret key can be divided in three parts in such a way that two out of the three parts are needed to access the money. Secrets can also be kept in the brain, with no physical proof of the ownership of the money.

As cryptocurrencies are based on free libre software, anyone can create a new currency. If a currency is used by a single individual it is not very useful. The potential of networked cryptocurrencies materializes when they are used by communities. The communities can create or agree in a currency for their internal exchanges. As a result, the currency is impregnated by the values and ethical standards of the community. In a sense, the value of cryptocurrencies is backed only by the community of users.

The people can choose which currency to use and which community to join. In this choice, there is an implicit commitment to support certain values and principles. By joining a particular community and currency, the user strengthens that particular community by offering productive force and services. The currency is a commons resource used by the whole community.

The use of networked criptocurrencies evidences that flows of money are nothing more than flows of information. Money transactions are simply communications among the involved parties. The freedom to use different currencies is directly related to the freedom to communicate, which is popularly referred to as free speech. The flows of money within a community are communications flows that strengthen the relation between the members of the community and, therefore, the community as a whole.

The value of the currency increases as the number of users and transactions increases. Therefore, the members of a community have an incentive to devote some currency resources to attract new members to the community. It is in their self-interest to make donations that increase the value of the currency. In this regards, cryptocurrencies are a transition step towards a gift economy.

The gift (or reputation) economy is the kind of economy we find on the Internet, in which the participants offer software, articles, music, pictures and all kinds of digital goods for free. This can be achieved using permissive licenses such as Creative Commons. In the information age money is just information and wealth is measured in knowledge instead of material goods. The progressive evolution towards a reputation economy is a natural step.

IV. Community-Centric Innovation

Throughout human history, organizational models have changed, transformed and evolved. As new technologies develop, old models are progressively replaced by others that are more efficient in the context of the new technologies. The invention of information processing and transmission tools multiplied the potential of community-centric models. Initiatives embracing the community-centric model have an advantage compared to those attaching to old hierarchical approaches.

It is natural that we find salient examples of community-centric success in the field of information and communication technologies. The Internet itself is probably the best example of a community-centric endeavour. There is a large number of people fascinated by and contributing to the Internet. The decision-making forums are open and anyone is free to contribute expertise.

Another example of the successful application of the community-centric model is the free libre open source movement. Thousands of programmers affiliate to and contribute to this movement working as a self-managed community. The software produced by this community often outperforms what have been developed using hierarchical models. By making it possible for anyone to contribute, FLOSS projects have an advantage with respect to those that choose more restrictive models.

The Wikipedia is an Internet-based project that has also adopted the community-centric model. The users are not mere consumers of information. On the contrary, the community of users is the one playing a central role by writing, revising and correcting the encyclopedical articles. The community-centric model has allowed Wikipedia to grow in terms of number of articles, languages and quality. In certain aspects, the community-centric encyclopedia has surpassed encyclopedias that were built using more traditional models.

There are also examples of success of community-centric models in hardware initiatives. Both Arduino and BeagleBoard are open hardware projects that are aligned with community-centric innovation. They both share all the information regarding the hardware with the community of users that, in turn, use this information to contribute to the project.

In the case of open hardware, the fact that all schematics and manufacturing details are publicly available on the Internet makes it very economical for a manufacturer to produce the goods. The manufacturer can avoid all research and development costs and focus only in the fabrication. As a consequence, open hardware devices can be found at very low prices in the market. Lower prices translate to a greater community that can contribute to further improve the original product.

V. Projects about Community Networks and Cryptocurrencies

Community-centric innovation such as Community Networks and Networked Cryptocurrencies have attracted the attention of the research community. In this section we detail three European projects that are related to community-centric innovation.

A. Commons for Europe

Commons for Europe is a project focused on stimulating the production of commons resources in the areas of applications and networks. The branch of Commons for Europe related to application is called Code for Europe and invites cities to incorporate programmers to their teams. These programmers bring community and collaborative dynamics to the host institution and write software that later can be shared with other cities.

The other branch of the Commons for Europe project is called Bottom up Broadband. This branch is focused on understanding and documenting the working principles of community networks.

B. Confine

The Confine project emphasizes the links between research and community networks. The goal is to make it easier for researchers to run experiments in community networks. It provides the tools for automatize and monitor the experiments, as well as the hardware distributed across the community network.

Community networks have grown to a size far beyond what can be reproduced in a lab. Therefore, the most effective way to learn and understand this phenomena is by carrying out research directly on the community network. It is a good opportunity for researchers to be in close contact with these networks that are leading the innovation in some areas of networking. At the same time, the community network benefits from the expertise of the research community and from the documentation and dissemination efforts associated to the research process.

VI. Related Work

VII. Conclusions

References

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