In this forum we highlight innovative thought, design, and research in the area of interaction design and sustainability, illustrating the diversity of approaches across HCI communities. **— Lisa Nathan, Editor**

Sustainability and Participation in the Digital Commons

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Just as farmers depend on irrigation, pastures, and water, digital societies depend on networking infrastructures (e.g., the Internet) and digital devices that produce and support connectivity and interaction. We argue that what applies to critical natural-resource systems (e.g., an irrigation system or fishing grounds) also applies to digital resources. This means designing not only sustainable systems and interfaces for the digital world but also systems that require social and environmental awareness, while taking responsibility and recognizing the gaps, limits, and impacts of global-scale digital artifacts.

Economists have studied how communities manage critical resources such as irrigation systems, fishing grounds, pastures, forests, and water. As an alternative to purely private or purely public services and infrastructures, Elinor Ostrom, the 2009 Nobel Prize winner in economics, suggested the commons as a collective management alternative [1]. Common property systems include social arrangements that regulate the preservation, maintenance, and consumption of natural or human-made resource systems, also called common-pool resources (CPRs). These CPRs consist of a core resource (e.g., irrigation system, forest, grassland) that provides a limited quantity of extractable fringe units that can be harvested or consumed (e.g., water, wood, grass). The size or characteristics of CPR goods make it costly to exclude potential beneficiaries from its use. However, CPRs also face problems of congestion and overuse—the "tragedy of the commons."

Yet, according to the Internet Society (http://www.internetsociety.org/globalinternetreport/), the majority of the world's population does not have adequate Internet access. This implies that the Internet cannot provide adequate services to the general public; nor is it able to reach everyone fairly.

Despite the lack of equal access to digital devices and connectivity, somewhat ironically, digital devices are already an environmental problem. There are more digital devices on planet Earth (e.g., desktop computers, laptops, tablets, and smartphones) than people. Electronic waste (e-waste) is the largest waste stream, most of it discarded in general waste, leading to a loss of secondary resources [2]. Therefore, like many other human activities, the production of digital devices and infrastructure is challenging the limits of sustainability within our natural environment.

Insights

→ Interactions between citizens, businesses, and governments create network infrastructure commons that are providing Internet access for digitally excluded communities and rural areas in Europe.

→ If digitally excluded communities become peer-production actors they can effectively acquire secondhand devices and share network infrastructure.

It is well established that there is an access gap between citizens who can afford a digital device and an Internet connection and those who cannot. Citizens unable to access digital tools are too often confined to the lower or peripheral edge of the society for economic or geographic reasons, such as living in underserved areas without access to digital interaction. As a result of this inaccessibility, such groups are denied full involvement in mainstream economic, political, cultural, and social activities. This may also mean restricted access to or exclusion from critical services such as health, education, and other public services—and therefore limited opportunities for development [3].

If access to digital devices and access to connectivity (the Internet) has a critical impact on both social inclusion and our natural environment, we argue for positioning the infrastructure for digital social interaction as a resource commons. Therefore, citizens should decide collectively about the limits, congestion, management, and preservation of that infrastructure. This line of argumentation leads us to consider the governance of these resource systems as common property. Governance issues lead to considerations of human rights and the right of everyone to participate in the governance of the digital world, instead of just the private elite who design and control the fabric of public digital space.

Are we all citizens of the digital world in equal terms (a democracy)? Or instead, are there first-class citizens (with the right to make design and development decisions) and second-class citizens (just users or consumers)? What

do you think? There are multiple sides to this: Researchers try to understand how we interact; designers develop interfaces; device manufacturers build and sell digital devices; telecom and Internet service providers offer connectivity; content providers offer services; and citizens consume these digital devices, connections, and services throughout their daily lives. Is this a democracy or a farm where the feed is free Internet services and the crop is consumer data?

SOCIAL INTERACTIONS AND ACCESS RIGHTS

A commons is governed, according to rules adhering to the commons framework, by a community. This community may comprise several types of actors with roles, rights, obligations, and potential conflicts of interest. The bundle of rights [4] becomes a useful analytical grid to analyze social interactions. The bundle of rights includes rules related to:

• Access: to enter and use, where authorized users (customers, buyers, subscribers) receive access to a resource system of digital devices or a network

• Withdrawal: to extract resources from the system (use, consume, obtain connectivity from a network or interact through a device)

• Management: to regulate usage and make improvements, such as adding features or improving interactions

• Exclusion: to determine who will have access and how this right can be transferred

• Alienation: the right to sell a portion of the resource (e.g., selling connectivity, services, or content to others).

Participants can take different roles that come with obligations: All need to accept the community rules, the general license, to access resources. Some are just consumers, authorized to use resources (withdrawal) under an end-user license. Some are possessors, who bring in or use their devices or connections; they can be volunteers or providers of professional services, both under different terms of participation. All participants are eligible to contribute to manage the digital infrastructure (define and decide on its rules, features, coverage, price, investment, access rights) and its ownership (alienate, resell it).
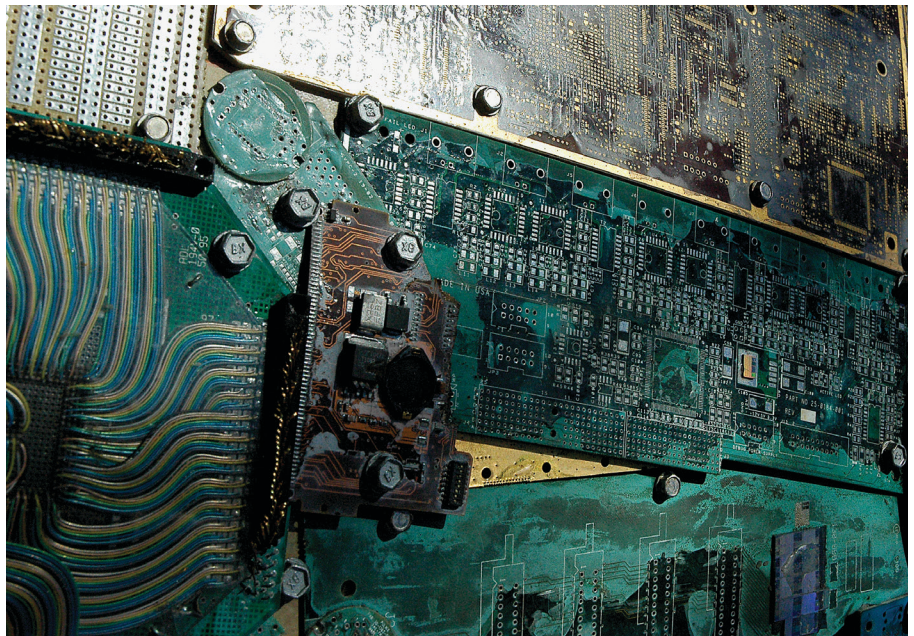
Therefore, due to ownership, control, or economic reasons, many people may be excluded from these interactions in the conventional digital world. To break from these limits, citizens and organizations around the globe are creating resource systems managed as commons (peer production) that enable new types of social interactions and promote (re)designing technology and service norms to make them more locally appropriate and people-centered.

REAL-WORLD PROJECTS EXPLORING COMMONS ALTERNATIVES

Through ongoing projects, we have been looking at two examples of critical infrastructures that can be organized as commons:

• eReuse.org, a circuit of devices: a pool of first- and second-hand devices used and reused by citizens and organizations that work cooperatively to keep these devices operational and in circulation

• guifi.net, a community network: a network infrastructure built by citizens and organizations who coordinate services and share resources to build a network and provide connectivity.

The fundamental principles of a commons, defined to be fully inclusive, revolve around the openness of access (usage and contribution) and participation (development, construction, operation, and governance) of the resource system and its community.

These fundamental principles, applied to a circular economy of digital devices and collaborative networks, result in resource systems that are *collective goods*, *socially produced*, and governed as *common-pool resources*.

The development of a new commons by citizens is *social production*, also called *peer production*, because the participants work cooperatively to build the resource system. The CPR is the model chosen to hold and govern the resource system. The participants (individuals or organizations with their own rules) must accept the rules to join the resource system and must contribute the required resources, but they keep the ownership of their contributions and the right to withdraw.

Below we briefly describe two commons initiatives, eReuse.org and guifi.net, as representatives of a global movement of local communities, organizations, and citizens that deal with collaborative production of digital devices and Internet connectivity, respectively. They cooperate to share digital devices and connectivity under a common governance and specific business models constituting an ecosystem around digital access.

eReuse.org: Moving toward a circular economy. A circular economy is one that aims to keep products in use, unlike recycling, which happens at the end of a product's life (Figure 1). Reuse

is when a product or source part is used again for its original purpose. It can be through repair, refurbishment, or remanufacturing. If products are reused, they last longer, reducing expenditure on new consumer goods, creating jobs, and strengthening digital skills. Refurbishment refers to preparing a device for another user (data wipe, upgrade); remanufacturing creates new devices from source parts and improves the aesthetics. In the world, there are more digital devices than people. The overall potential for the reuse of digital devices can be seen by looking at the number of

devices renewed annually—in the range of billions—but a large fraction are dismantled well before the end of their usable life. This results in most electric and electronic equipment (EEE) being recycled too early, despite the demand for reuse coming from citizens (http://ec.europa.eu/public_opinion/index_en.htm), and particularly from marginalized communities. Considering participation in digital society as a human right [5], a circular economy can also help reduce the digital divide and strengthen institutions and projects for social change.

The eReuse.org commons represents a global federation of local groups, organizations, and communities that deal with the circular life of digital devices in their target communities under specific business models. They cooperate to share information, methods, licenses, software services, and software tools under a common governance constituting an ecosystem around circular electronics.

In Spain there are several eReuse circuits in which public administrations, universities, and companies create a pool of resources (old but usable computers) that are available at attractive prices. Social enterprises refurbish, repair, and upgrade the devices as well as provide maintenance, collect devices, and find receivers. In these reuse communities, receivers pay only the cost of returning a device to circulation, not the cost of the product itself. All stakeholders interact using eReuse.org software tools and services to trace the devices and to optimize refurbishment, promote reuse, and finally ensure recycling at authorized points.

eReuse circuits organize reuse events, such as the outdoor activity shown in Figure 2, where donors bring computers and citizens collect them. Companies, public administration offices, and citizens donate devices to local circuits through a license of their choice, with their preferred terms and conditions (e.g., traceability: return after usage or recycle, not-for-profit receivers). Receivers get devices and must accept the terms of the license, which are as follows:

• Keep devices in use and avoid premature recycling through the repair and upgrading of components
• Facilitate device traceability (including components) using the software tools of the circuit to reduce loss and promote reuse
• Return devices to the circuit, thereby ensuring future donors
• Dispose of devices to authorized collection points for recycling only if there is no demand in a circuit.

eReuse has evolved and matured through several pilots. As a specific example, one eReuse circuit (Pangea.org and its local portal Reutilitza.cat) has 12 social enterprises involved and has facilitated the donation of more than
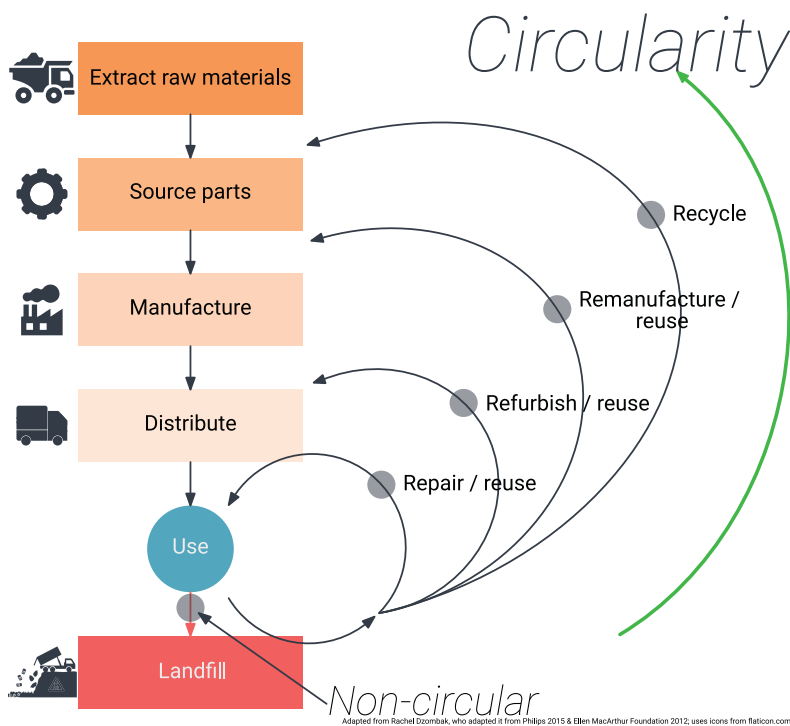

Figure 1. Reuse loops and circular economy of a digital device [8].

Figure 2. An outdoor activity where donors and recipients meet to deliver computers for reuse.

2,000 digital devices to more than a thousand social initiatives (as of January 2017). In 2017, Abacus, a large Spanish cooperative of office and school supplies with 800,000 members, launched a collaborative service to collect and reuse computers from members to schools in collaboration with a cluster of complementary social enterprises.

guifi.net: Opening digital infrastructures. Computer networks provide an artificial medium for digital communication and access to information across distance and time that enhances our natural capacities to hear in the acoustic space, see in a narrow frequency band of visible light, and access information in the physical space around us.

In the past, telecom services and access to the Internet were often seen as optional, a luxury for corporations and those citizens able and willing to pay extra to benefit from these artificial superpowers.

More recently, communities of citizens have developed their own community networking infrastructures for local interconnection and access to the Internet. As one example, guifi.net is an open, free, and neutral network infrastructure built and maintained by citizens and businesses who pool their resources and coordinate their efforts [6]. The guifi.net community network has more than 32,000 connections and a total length of 60,000 km (as of January 2017). Most of their nodes are located in Spain, as seen in Figure 3, but there are many similar initiatives around the world [7].

A CALL FOR INTERACTION
Citizens and digitally excluded communities who become peer-production actors can effectively acquire, build, or repair their own digital devices and gain Internet connectivity at a very low cost. The two projects described here exemplify new forms of interactions between citizens, businesses, and the common-pool resources that can provide digital inclusion to thousands of citizens in Spain and many other countries.

We argue that the future of societies around the world depends on accessibility and participation, that
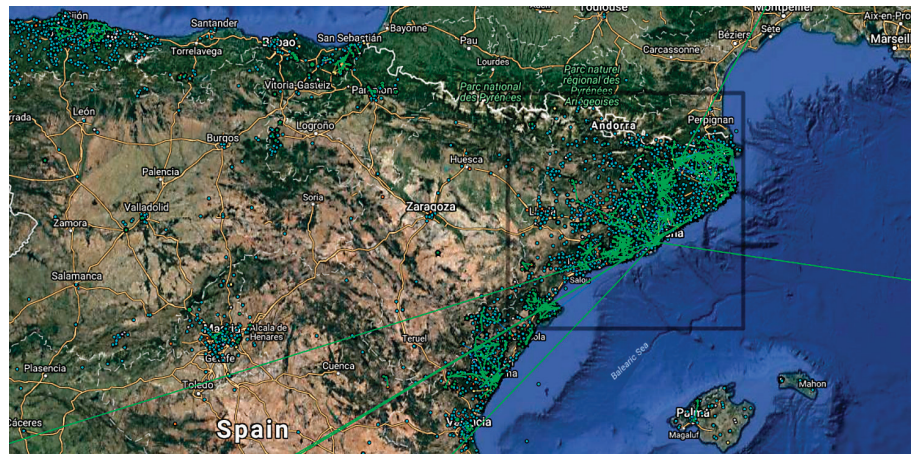

Figure 3. Partial map of the guifi.net community network infrastructure.

citizens must be able to fully engage in the governance of the digital, not only as mere users or consumers. The current model of unequal access to digital devices and connectivity is clearly unfair and unsustainable. Too few participate in the design and governance of the digital world, creating an elite of private interests. A minority of the world's population can enjoy the benefits of sleek devices and fast connectivity. Everyone is or will be influenced by the growing environmental impact of the digital world. If digitally excluded communities become peer-production actors, they will be able to build their own circular devices and sustainable network infrastructures, they will benefit from local reinvestment of surpluses, and they will have the opportunity to become active participants in the interactions of the design and governance of the common digital space.

ENDNOTES
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