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Sustainability and Community Networks

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Abstract
Community networks are IP-based computer networks that are operated by a community as a common good. In Europe, the most well-known community networks are Guifi in Catalonia, Freifunk in Berlin, Ninux in Italy, Funkfeuer in Vienna and the Athens Wireless Metropolitan Network in Greece. This paper deals with community networks as alternative forms of Internet access and alternative infrastructures and asks: What does sustainability and unsustainability mean in the context of community networks? What advantages do such networks have over conventional forms of Internet access and infrastructure provided by large telecommunications corporations? In addition what disadvantages do they face at the same time? This article provides a framework for thinking dialectically about the un/sustainability of community networks. It provides a framework of practical questions that can be asked when assessing power structures in the context of Internet infrastructures and access. It presents an overview of environmental, economic, political and cultural contradictions that community networks may face as well as a typology of questions that can be asked in order to identify such contradictions.

Keywords: sustainability, unsustainability, community networks, Internet access, Internet infrastructure, political economy, information society

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1. Introduction

The sustainability concept has originated and developed in the context of policy. It has first taken on a purely environmental meaning that has later been extended to include economic, institutional and social dimensions. In the context of information technologies, sustainability has played a role in the World Summit on the Information Society (WSIS). This paper deals with community networks as alternative forms of Internet access and alternative infrastructures and asks: What does sustainability and unsustainability mean in the context of community networks?

In Europe, the most well-known community networks are Guifi in Catalonia, Freifunk in Berlin, Ninux in Italy, Funkfeuer in Vienna and the Athens Wireless Metropolitan Network in Greece. The minimal definition of a community network that we can give is that it is an IP-based computer network that is operated by a community as a common good (see Baig, Roca, Freitag and Navarro 2015; Baig, Freitag and Navarro 2015; Maccari 2013, Maccari and Lo Cigno 2014). Community networks can be closed or open: they are either only accessible to a specific community and then form a closed commons or provide "bandwidth resources free of charge to the general public" as an open commons (Damsgaard, Parikh and Rao 2006, 106).

The paper starts with a section that focuses on theoretical foundations and methodology (section 2). There are environmental (section 3), economic (section 4), political (section 5) and cultural (section 6) aspects of the sustainability and unsustainability of Internet access and community networks. These aspects are subsequently discussed in this paper's sections. The analysis is drawn together in the conclusion (section 7).

2. Theoretical Framework and Methodology

The methodology chosen is that the contradictions are analysed with the help of a literature review of works explicitly focused on community networks. The method chosen for identifying these contradictions is a synthesis of expert literature on community networks. These works were identified by a search for they keyword "community networks" in Google Scholar, Scopus and Web of Science. So expert literature should be understood as works located in such databases. Such works tend to be highly specialised. This paper presents such works' core findings and abstracts from them in order to analyse how society's macro-power structures shape community networks' opportunities and risks.

The paper employs dialectical thought as a method of inquiry: Dialectics examines reality as relational, dynamic and contradictory (for a detailed discussion, see: Fuchs 2016, Fuchs 2014b; Fuchs 2011, chapter 2.4). As a methodological approach for studying society, this means to study the dialectics of technology/society, opportunities/risks, and the powerful/the less powerful. Society is therefore analysed based on a critical theory of power. Identifying, understanding and critically acquiring power structures is the key task of a dialectical analysis of society. This paper provides a typology of contradictions and a practical checklist with questions relating to such contradictions that alternative Internet projects can use for critically reflecting on the opportunities and risks they face.

So the aim of this paper is to identify the contradictions that community networks face in contemporary society that is shaped by power structures and power inequalities. Many social theories share a distinction between economy, politics and

culture as the three main domains of society (Fuchs 2008, 2011): The economy is the realm of society, where humans enter a metabolism with nature so that work organises nature and culture in such a way that use-values that satisfy human needs emerge. Given that it is the economy, where the man-nature relationship is established and that the ecological system is closely linked to the economy, one could treat the ecological system as part of the economy. The political system is the realm of society, where humans deliberate on or struggle about the distribution of decision power in society. Culture is the realm of the recreation of the human body and mind in such ways that meanings, identities and values emerge and are renegotiated in everyday life. It includes aspects of society such as the mass media, science, education, the arts, ethics, health care and medicine, sports, entertainment, and personal relations.

Definitions of power used in the social sciences often are based on Max Weber's (1978, 926) understanding as life chances exerted over the will of others. The problem of such a definition is that it cannot account for processes of empowerment and cannot discern between power and domination (Fuchs 2015). In the theoretical approach underlying this paper, power therefore is a process and social relation, through which humans influence change in society.

Based on these foundations, we can now subsequently address each of society's dimensions and have a look at how it relates to questions of community network's un/sustainability.

3. Environmental Aspects of Internet Access and Community Networks

According to estimations, around 50 million tonnes of e-waste are generated per year and predictions are that within four years there will be further growth by 33%[1]. This amount of e-waste is around 7 kg per person in the world. Data on electronic waste in Europe is incomplete. The recycling rate of e-waste has ranged in 2010 between 11.0% in Malta and 64.9% in Sweden (data source: Eurostat). The total waste from electrical and electronic equipment has increased in the EU28 countries from 14 million tonnes in 2004 to 18 million tonnes in 2010 (ibid.). In 2012, the amount was 16 million tonnes. Given the recycling rates, it becomes evident that millions of tonnes of non-recyclable electronic waste are discarded every year in the European Union. The total hazardous waste generated in 2012 in the EU28 countries in the manufacture of computer, electronic and optical products, electrical equipment, motor vehicles and other transport equipment amounted to 2.0 million tonnes in 2010 and 2.4 million tonnes in 2012 (ibid.).

"It is estimated that the total amount of e-waste generated in 2014 was 41.8 million metric tonnes (Mt). It is forecasted to increase to 50 Mt of e-waste in 2018. This e-waste is comprised of 1.0 Mt of lamps, 6.3 Mt of screens, 3.0 Mt of small IT (such as mobile phones, pocket calculators, personal computers, printers, etc.)" (Baldé et al. 2015, 8). The worldwide e-waste generated per capita is forecast to increase from a figure of 5.0 kg in 2010 to 6.7 kg in 2018 (Baldé et al. 2015, 24).

Up to 45% of the total e-waste is treated informally and illegally (Rucevska et al. 2015, 4, 7). "Key destinations for large-scale shipments of hazardous wastes, such as electrical and electronic equipment, include Africa and Asia. In West Africa, a significant recipient is Ghana and Nigeria, but high volumes also go to, but not limited to Cote D'Ivoire, and the Republic of the Congo. South Asia and Southeast Asia also appear to be major regional destinations, including, but not limited to,

[1] Toxic "e-waste" dumped in poor nations, says United Nations. *The Guardian Online*, December 14, 2013.

China, Hong Kong, Pakistan, India, Bangladesh, and Vietnam" (Rucevska et al. 2015, 8).

E-waste recycling is a profitable business. The goal is to extract precious metals such as gold, silver, etc. The problem, however, is that electronic goods contain hazardous materials such as arsenic, mercury, cadmium, bromides, etc., which can easily poison e-waste workers and the soil. "E-waste recycling is flourishing in many parts of the world. South Asia and Southeast Asia appear to be major regional destinations, including, but not limited to, China, Hong Kong, India, Pakistan and Vietnam. In West Africa, common, but not limited destinations are Ghana, Nigeria, and Benin among others" (Rucevska et al. 2015, 38).

The average lifespan of a mobile phone is just 18 months[2] and of a laptop 2 years[3]. Planned obsolescence and lifestyle branding are part of the way in which computers, tablets and mobile phones are presented as a way of life that enforces the generation of even more e-waste (Maxwell and Miller 2012, Lewis 2013). ICT companies such as Apple are at the heart of the computer age's ecological problems. The large-scale production and use of green ICTs that are re-useable and have flexibly exchangeable components are not in sight. The vast amount of e-waste and its negative impacts on the environment makes the information society ecologically unsustainable.

The production and consumption of energy can be measured in tonnes of oil equivalent (toe). One toe is the "energy released by burning one tonne of crude oil. It is approximately 42 gigajoules"[4]. In 2014, the worldwide production of energy was 13.8 billion toe and worldwide consumption 13.7 billion toe[5]. In 2000, these values were 10.0 billion toe for both production and consumption. So the increase of world energy production and consumption was almost 40% in 15 years. Energy production and consumption as such is not a problem as long as it does not harm the environment. One problem is that at the same time, the emission of carbon dioxide increased from 22.8 Mega tonnes in 2000 to 31.2 Mega tonnes in 2014. The world's main energy and electricity sources are oil, gas and coal. Wind and solar energy made up 4.0% of electricity production in 2014.

In 2012, the world energy generation was 21.53 trillion kilowatt hours (kWh) and the world energy consumption 19.71 trillion kWh[6]. Table 1 shows the share of various energy sources in world energy production for the year 2012. Nuclear energy tends to be considered as a renewable energy source. However, the nuclear power plant disasters in Chernobyl and Fukushima have shown how dangerous this energy form is for humans and nature. The share of relatively clean, renewable energy types (hydroelectric, geothermal, wind, solar, tidal, wave, biomass and waste energy) in world energy production was therefore 21.7% in 2012.

Energy type	**Share**
Nuclear energy	10.9%

[2] http://www.thesecretlifeofthings.com/#!phone-facts/c611
[3] What is the lifespan of a laptop? *The Guardian Online*, January 13, 2013.
[4] Wikipedia: Tonne of oil equivalent, https://en.wikipedia.org/wiki/Tonne_of_oil_equivalent, accessed on March 6, 2015.
[5] Data source for all data in this paragraph: Global Energy Statistical Yearbook 2015, https://yearbook.enerdata.net, accessed on March 6, 2015.
[6] Data source: International Energy Statistics, https://www.eia.gov, accessed on March 6, 2015.

Hydroelectric energy	16.8%
Geothermal energy	0.3%
Wind energy	2.4%
Solar, Tidal and wave power	0.4%
Biomass and waste energy	1.8%
Fossil fuels	67.3%

Table 1: Share of energy sources in world energy generation, year 2012, data source: Data source: International Energy Statistics, https://www.eia.gov, accessed on March 6, 2015.

It is essential to consider how much energy the Internet consumes. Running the global Internet "consumed 1,815 TWh of electricity in 2012. This corresponds to 8% of global electricity production in the same year (22,740 TWh)" (De Decker 2015b). By 2017, "the electricity use of the internet will rise to between 2,547 TWh (expected growth scenario) and 3,422 TWh (worst case scenario)" (De Decker 2015b). Given the fact that the majority of the world's energy consumption is based on fossil fuels and nuclear energy, the Internet's growing energy consumption certainly contributes to environmental risks.

De Decker (2015a) argues that long distance Wi-Fi that uses point-to-point antennas for establishing connections of up to several hundred kilometres consume relative low amounts of energy. "Long range WiFi also has low operational costs due to low power requirements. A typical mast installation consisting of two long distance links and one or two wireless cards for local distribution consumes around 30 watts. In several low-tech networks, nodes are entirely powered by solar panels and batteries".

Baliga, Ayre, Hinton and Tucker (2011) analysed the energy consumption of seven different wired (DSL, PON, FTTN, PtP, HFC) and wireless (WiMAX, UMTS) Internet access network types. "At access rates greater than 10 Mb/s, wired access technologies are significantly more energy-efficient than wireless access technologies. […] Wireless technologies will continue to consume at least 10 times more power than wired technologies when providing comparable access rates and traffic volumes. PON will continue to be the most energy-efficient access technology. […] Passive optical networks and point-to-point optical networks are the most energy-efficient access solutions at high access rates" (Baliga, Ayre, Hinton and Tucker 2011, 75-76).

If wireless networks consume much more energy than wired ones, then a world of wireless community networks promises to be more energy-intensive than one of wired Internet access. Community networks do, however, not have to be predominantly wireless, but can to a certain degree also rely on optical fibre cables. Energy production and consumption as such is not necessarily an environmental problem. Nuclear power and fossil fuels are the dominant unclean electricity sources. If community networks want to be environmentally sustainable, then they should strive to base their electricity consumption on wind, solar, tidal, wave and geothermal power.

Wireless communications are part of the rise of mobile communication. The typical user nowadays has not just one computer or laptop, but accesses the Internet from different places for a significant time per day with various devices such as a computer, a laptop, a tablet and a mobile phone. All of these devices consume energy

and given the short average lifespan of the devices also contributes to the production of e-waste and its toxic effects on humans and nature.

The nodes of the Guifi community network use cheap wireless routing devices such as Ubiquity or MikroTik (Vega, Cerdà-Alabern, Navarro and Meseguer 2012). The community networks FunkFeuer and Ninux tend to use devices such as the TP-Link TL-wr841nd or Ubiquiti nanostations (Maccari and Lo Cigno 2014). Freifunk in Germany recommends the use of routers like TP-Link TL-WR842ND, TP-Link TL-WDR3600, TP-Link TL-WDR4300, Ubiquiti NanoStation M2 & Loco, Ubiquiti NanoStation M5 & Loco, Ubiquiti NanoBridge M5, TP-Link CPE210/510[7]. Such routers consume energy and it is a technical task to try and minimise their energy efficiency. Another question is, however, how long such routers are used and if they are re-useable and updateable. If not, then there is a risk that they will end up as e-waste in developing countries, polluting the environment and poisoning e-waste workers.

There is no comprehensive and reliable data available on the average lifespan of wireless routers. We also do not have data on how many routers end up as e-waste per year. Routers are classified as small IT e-waste together with other devices such as mice, keyboards, external drives, printers, mobile phones, desktop PCs, and game consoles (Baldé et al. 2015, 71-72). We know that in 2014, 3.0 Million tons of small IT e-waste was generated globally and that in 2016 35% more e-waste was produced than in 2010 (Baldé et al. 2015, 24). It is therefore likely that also the volume of routers cast away as e-waste has increased.

4. Economic Aspects of Internet Access and Community Networks

Yochai Benkler defines commons the following way: “Commons are an alternative form of institutional space, where human agents can act free of the particular constraints required for markets, and where they have some degree of confidence that the resources they need for their plans will be available to them. Both freedom of action and security of resource availability are achieved in very different patterns than they are in property-based markets” (Benkler 2006, 144).

Vasilis Kostakis and Michel Bauwens (2014) provide an understanding of the commons that is related to the one by Benkler. They argue that the Commons are a “social process” (39) that involves resources, a community that creates use-values, and rules so that they constitute “a paradigm of a pragmatic new societal vision beyond the dominant capitalist system” (38).

Open Wi-Fi systems, such as wireless community networks, would form an “open-access-spectrum commons” (Benkler 2013, 1510). For Benkler (2006, 395), both open wireless community networks and municipal broadband initiatives are opposed to the enclosure of the spectrum and the Internet by private property. Benkler (2002) compares wireless communications based on a spectrum property market to open wireless networks that use a spectrum commons. Open wireless networks are based on end use devices, are an ad hoc infrastructure, scalable, both mobile and fixed (Benkler 2002, 37). Benkler argues that open wireless networks, in which nobody owns parts of the spectrum, tend to more rapidly increase the capacity of users to communicate information wirelessly, are more cost-effective, more advance technological innovations, adapt better to changing consumer preferences, and tend to

[7] https://wiki.freifunk.net/FAQ_Technik, accessed on March 7, 2016.

be more robust and technically secure. These are technological and economic advantages.

Vincent Mosco (2014, 6) argues that in the contemporary world of the Internet and cloud computing, we should think back to the 1950s, when there were discussions about whether computing is a utility. We can say that the Internet as communications networks is just like transportation, water supply, power supply, the education system, the sewage system, the health care system, a clean and healthy natural environment, cultural institutions, housing, food and the political system. Like these the Internet is a public interest infrastructure that is in the common interest of all: All humans need these infrastructures in order to lead a decent life. Turning infrastructures into a commodity operated by for-profit companies increases inequality in society. Those on lower incomes and with little wealth will tend to find it more difficult to access infrastructures or will only get access to second-class infrastructures than the class of the wealthy. It is therefore a matter of justice and equality that infrastructures are treated as public or common goods and not as commodities controlled by for-profit companies.

Internet backbones are long-distance data routes. The world's largest Internet backbone owners include companies such as Telefonica (Spain), AT&T (USA), Hurricane Electric (USA), Telecom Italia (Italy), Zayo Group (USA), Tata Communications (India), Orange (France), Level 3 Communications (USA), Deutsche Telekom (Germany), Global Telecom & Technology (USA, Italy), NTT (Japan), XO Communication s (USA), TeliaSonera (Sweden, Finland), Verizon (USA), CenturyLink (USA), Cogent Communications (USA)[8], and Sprint Corporation (USA)[9]. These are so-called tier 1 networks: They own so much Internet backbone infrastructure that they do not have to make peering agreements with other networks. They rather rent out their own backbone to smaller ISPs[10]. Large for-profit corporations control the Internet's infrastructure.

PSINet and UUNET created the Commercial Internet eXchange (CIX) in 1991. CIX was an interconnection serviced funded by all participating firms. "Each member of CIX paid a flat fee to support the cost of the equipment and maintenance, and each agreed *not* to charge each other on the basis of the volume of traffic they delivered" (Greenstein 2015, 80). Today, the data exchange between networks is established by Internet Exchange Points (IXPs). Measured in average data throughput, the world's largest IXPs are the DE-CIX (Deutscher Commercial Internet Exchange) in Frankfurt, the AMS-IX (Amsterdam Internet Exchange), and the LINX (London Internet Exchange)[11]. IXPs are typically non-profit organisations with commercial Internet Service Providers (ISPs) as their members. Their principle goes back to the CIX: All ISPs want to benefit from network effects: The more users one can reach, the better the network. They therefore have a commercial incentive to be connected to other networks. The larger the Internet's reach, the more users they are likely to attract and the larger their profits promise to be. One can say that Internet Exchanges are a commons for capital: It is a commonly owned infrastructure that serves the interests of capital. It is an example of the "communism of capital": The commons are subsumed under capitalist interests.

[8] See: https://en.wikipedia.org/wiki/Tier_1_network

[9] https://en.wikipedia.org/wiki/Sprint_Corporation

[10] See https://en.wikipedia.org/wiki/Tier_2_network for an overview of important tier 2 networks that buy transit from tier 1 networks.

[11] See: https://en.wikipedia.org/wiki/List_of_Internet_exchange_points_by_size

The Internet's domain name system (DNS) was privatised in 1992. The private company Network Solutions controlled the DNS. In 1995, it started to charge for the registration of domain names. In 1998, the Internet Corporation for Assigned Names and Numbers (ICANN) was created. It is responsible for the Internet's global DNS and top-level domains. Also the domain name service is a capitalist business.

A problem of the argument that community networks benefit areas in which commercial providers cannot make a profit so that the market fails is that market failure not only occurs in serving communications services to remote and sparsely populated regions. The market principle is a failure in itself. In communications markets this becomes evident by the fact that they tend to be highly concentrated, i.e. capitalist competition leads to oligopoly or monopoly. Community networks can therefore be a general mechanism to challenge economic concentration of communications markets.

Sadowski (2014) studied Dutch broadband co-operatives, in which large numbers of local community members joined and paid membership fees in order to set up fibre networks. In a survey of such members of broadband co-operative (N=481), Sadowski found that the motivation to support the co-operative was not just the lack of other providers, but also the associated individual technical support, the idea to pluralise the communications market, the hope for the availability of specific advanced services via the co-operative, the creation of local identity, and the promotion of the co-operative idea. These results provide indications that alternatives to capitalist communications providers have the potential to be accepted for a variety of reasons. Also in situations when they compete against capitalist providers because citizens tend to appreciate co-operatives not simply for obtaining economic advantages, but also for political and cultural reasons.

The question is how one should understand sustainability in respect to community networks. A neoliberal, economic reductionist understanding would be to think about how to make economic profit by creating such networks. Such a position, however, would neglect that the for-profit logic can easily come into contradiction with social issues that concern justice, fairness, equality and democracy. There are indications that community networks tend to be receptive for a different understanding of sustainability. It is certainly important to think about the economic issue of how the necessary resources can be guaranteed and maintained in a community network. But this does imply the necessity of for-profit logic. Klaus Stoll (2005) studied the introduction of Wi-Fi in a remote, poor village in the Ecuadorian rainforest El Chaco. He shows that the people in El Chaco asked: "How can the Internet help us in our schools, in our local government, in the small and medium enterprises, in the ecology, the health services and tourism? How can we make it sustainable not only in a financial but also in a technical, social, cultural and political sense?" (Stoll 2005, 192). The question is do community networks have the potential to "sustain entirely novel communication paradigms that not only break the Telco and Internet Service Providers (ISP) oligopoly in communications" (Lo Cigno and Maccari 2014, 49).

Non-commercial community networks committed to the idea of providing gratis or cheap access as a matter of freedom and democracy, face the problem of how to sustain the service and how to survive if there is competition with commercial providers, who may be able to provide faster and more stable access. Alison Powell and Leslie Shade (2006) discuss this problem in the Canadian context with the example of the Montreal-based community network Île Sans Fil (ISF):

> "Like all volunteer-based groups, ISF must worry about long-term sustainability. The organization is worried that over time their core volunteers will eventually be unable to take on the responsibilities of deploying and servicing a larger number of hotspots. This issue is even more pronounced for a group which aims to provide a specific telecommunications service like free public wireless Internet when technological developments make it likely that cities like Montreal will soon be covered with ubiquitous wireless Internet signals" (Powell and Shade 2006, 399).

The problem such projects can face is that under neoliberal conditions, municipalities and governments tend to use taxpayers' money for attracting for-profit businesses or for-profit private/public partnerships and that co-operation of non-profits with for-profits may require the first one to either commodify access or usage, i.e. to introduce access fees or advertising. In all of these cases, the autonomy and freedom of non-commercial projects is undermined. Alternative, non-commercial, non-profit media and technology projects in general face existential threats in a capitalist environment (Fuchs 2010a, Sandoval and Fuchs 2010). They often lack labour-power, resources, money, influence, attention, and broad participation. Nico Carpentier (2008, 250) argues in this context that like "most alternative media", many "community Wi-Fi organizations remain vulnerable, dependent on a limited number of volunteers". One community Wi-Fi activist remarked in this context: "If I disappear, the network will disappear" (Carpentier 2008, 250). The danger is that resource precarity renders community networks a "secondary Internet" (Sandvig 2004, 596) that always remains marginal and cannot challenge the power of capitalist incumbents.

Douglas Schuler (1996) in his study of early computer-mediated community networks devotes a chapter (chapter 10) to the question of how community networks can survive. He explicitly uses the term sustainability in this context. He however does not just mean economic survival, but also survival of what he considers to be community networks' six core values of conviviality, co-operative education, strong democracy, health and well-being, economic equity, information and communication. He argues that for-profit organisations are ill-suited to sustain community networks because the profit motive contradicts "social, ethical or environmental concerns" and because corporations do not like to be criticised and therefore tend to censor free speech and alternative voices (355). Schuler stresses the potentials of non-profit communities and community/public co-operation.

Schuler discusses as funding options support by direct users or indirect users. The first includes donations, payment for certain services, membership fees, and support by participating organisations. The second entails support by foundations and public funding. Schuler (1996, 370-371) also mentions advertising, but at the same time sees the problem that it is likely to change or even destroy the community character. It results in what Howard Rheingold (2000, 389) called the "commodification of community".

Tapia, Powell and Ortiz (2009) argue that ISF managed to survive in a capitalist communications environment because it was able to create a hybrid public/community model, in which a municipality and civil society co-operate and so provide a "better alternative" (368) to privately owned for-profit networks. The authors suggest that public/commons hybrid networks can be economically sustainable and require that we "think of broadband as a utility and a public service" (369). They stress that grants are needed for funding "broadband deployment for both municipal and citizen groups" (370).

Municipal and community networks have good potentials to help overcoming digital divides. Forlano et al. (2011, 22-23) argue that "[d]igital inclusion has been the impetus behind many municipal and community wireless projects". A survey conducted among 22 community networks shows that overcoming the material access digital divide by providing affordable gratis Internet connectivity is an important motivation for running such projects (Dimogerontakis et al. 2016, Maccari and Lo Cigno 2014). One can, however, not always assume that poor local communities in developing countries consider Internet access as a primary need and in some cases they may, for various reasons, be sceptical including the suspicion of imperialism: that technology is offered to them in order to create economic dependence on the West.

A frequently heard argument is that an advantage of community networks is that this model can provide Internet access in rural and other areas, in which deploying infrastructure is not viable for commercial providers. Community networks certainly have a potential for lowering the digital divide by providing access to underserved areas. If community networks are, however, significantly slower than commercial networks, then a new digital bandwidth divide is created and poor regions then only have a second class Internet. Another problem is that in urban areas there is a tendency that wireless community networks are predominantly used by young, educated and affluent citizens and do not appeal to the poor (Oliver, Zuidweg and Batikas 2010). Oliver, Zuidweg and Batikas (2010) show that the Guifi community network in Catalonia has helped to reduce the geographical digital divide in Catalonia by increasing the Internet access rate in Osona-county.

Whereas free software, as all knowledge, only needs to be developed once in order for one version to exist that can be shared with others, hardware infrastructure has considerable maintenance and renewal costs (Medosch 2015), which makes it more difficult to provide gratis access. Nonetheless creating access to wireless Internet networks tends to be relatively inexpensive (Apostol, Antoniadis and Banerjee 2008; Bar and Galperin 2004): Wi-Fi uses an industry-wide standard (IEEE 802.11), unlicensed spectrum, and relatively cheap equipment. In a wireless mesh network, not all, but only some nodes need to be connected to a fixed lined Internet connection. Problems may arise when this architecture is significantly slower and much more unreliable than competing commercial Wi-Fi networks. In many countries, there are legal limits on the unlicensed use of the channels in the 5 GHz band-spectrum that tends to be less congested than the 2.4 GHz-spectrum. This circumstance puts additional pressures on non-commercial community networks in areas where they have to compete with commercial providers.

Free software guru Richard Stallman (2001) argues that the freedom of free software is that “the users have the freedom to run, copy, distribute, study, change and improve the software. Thus, ‘free software’ is a matter of liberty, not price. To understand the concept, you should think of ‘free’ as in ‘free speech’, not as in ‘free beer’. We sometimes call it ‘libre software’ to show we do not mean it is gratis”. Such an understanding of freedom also underlies, in the realm of community networks, the Guifi Network’s licence (FONN Compact: Compact for a Free, Open & Neutral Network): “You have the freedom to use the network for any purpose as long as you don't harm the operation of the network itself, the rights of other users, or the principles of neutrality that allow contents and services to flow without deliberate interference”[12].

[12] http://guifi.net/en/FONNC, accessed on February 8, 2016.

Armin Medosch (2015) takes a different position and argues for understanding freedom as gratis use. He says that the economic crisis and the precarity it has created should make us see that "[f]ree or at least cheap telecommunications is an important issue of our times". Freedom should also be an issue of being "cheaper and fairer" (Medosch 2015). We can add that providing gratis access to a common resource is a matter of equality that guarantees that certain basic goods and services are available to all.

In 2013, there were reports that the Federal Communications Commission under, its then Chairman, Julius Genachowski planned to free up frequencies that enable free public Wi-Fi (Super Wi-Fi) that uses lower frequencies located between the ones that television channels use (so-called white spaces). Jeremy Rifkin (2015, 180-181) interprets this development very optimistically and sees the future of the Internet as one of gratis access for anyone everywhere: "In the near future, everyone will be able to share Earth's abundant free air waves, communicating with each other for nearly free, just as we'll will share the abundant free energy of the sun, wind, and geothermal heat. […] The use of open wireless connections over a free Wi-Fi network is likely going to become the norm in the years to come, not only in America, but virtually everywhere".

But there are strong capitalist interests that may well be able to impede such future developments because communications corporations fear their profits could be reduced: In the USA, Republicans and companies such as AT&T, Intel, Qualcomm, T-Mobile, and Verizon criticised the free Wi-Fi model with the argument that licensing the airwaves to corporations who then rent it out to customers would be a better approach and warned that free Wi-Fi could harm Internet businesses[13]. In August 2015, the FCC adopted rules that allow the unlicensed use of certain channels in the 600 MHz band for Wi-Fi communication[14]. But it also planned a Broadcast Incentive Auction for 2016, in which TV stations are offered to sell the use rights of channels in the 600 MHz band-spectrum so that wireless operators can bid for the use[15]. So the decision that the FCC actually took is to free up parts of the 600 MHz band for unlicensed use and to auction other parts to corporations.

5. Political Aspects of Internet Access and Community Networks

Armin Medosch (2015) argues that "free networks contribute to the democratisation of technology" because users are involved in the establishment and maintenance of technology. Antoniadis and Apostol (2014) write that community networks can make a contribution to fostering participatory democracy by advancing the right to the ownership of the urban commons, by which they mean "commonly held property, and use, stewardship and management in common of the available and produced resources". The urban commons also include the communications commons. A survey conducted among 22 community networks shows that decision-making tends to be participatory and transparent in such community networks (Dimogerontakis et al. 2016).

Edward Snowden has revealed the existence of global Internet surveillance programmes that have been driven by the collaboration of the US security agency

[13] Tech, telecom giants take sides as FCC proposes large public WiFi networks. *The Washington Post Online,* February 3, 2013.
[14] https://apps.fcc.gov/edocs_public/attachmatch/DOC-334757A1.pdf
[15] FAQ: The FCC's upcoming broadcast-TV spectrum auction. *Computerworld Online*, October 15, 2015.

NSA and American communications companies: In June 2013, Edward Snowden revealed with the help of the *Guardian* the existence of large-scale Internet and communications surveillance systems such as Prism, XKeyscore, and Tempora. According to the leaked documents, the National Security Agency (NSA), a US secret service, in the PRISM programme obtained direct access to user data from seven online/ICT companies: AOL, Apple, Facebook, Google, Microsoft, Paltalk, Skype, Yahoo![16].

The Snowden leaks show that Internet surveillance concerns both the hardware infrastructure of both wired and wireless networks as well as the levels of data storage and applications. Community networks provide a wired and wireless infrastructure, based on which general and network-specific applications operate. Surveillance is therefore for a community network both an issue at the physical layer as well as at layers up to the application level.

It has become evident that Internet surveillance, privacy violations, and lack of adequate data protection have resulted in major threats to democracy. Internet surveillance is a threat to political-democratic sustainability. Thus far no adequate responses of how to effectively tackle Internet surveillance's threats and to strengthen the Internet's democratic sustainability have been undertaken.

Surveillance after Snowden has on the one hand increased the interest in wireless community networks (Antoniadis and Apostol 2014, Lo Cigno and Maccari 2014, Medosch 2015) because decentralised networks promise more security against the surveillance-industrial complex. At the same time there have been countries such as Germany, where complex legal battles have occurred about the question whether a wireless community network can be made legally liable for the illegal use of a network for terrorism, crime, copyright infringement, child pornography, etc. (Medosch 2015). Wireless community networks face a contradiction between privacy-enhanced openness and surveillance. Empirical research shows that privacy may not automatically be larger in wireless community networks than other networks if the majority of the traffic is transported over some key nodes (Maccari and Lo Cigno 2014). The network architecture and routing method therefore play a key role in the question of privacy and security in community networks.

A survey among 22 community networks showed that such projects tend to be concerned about protecting users' privacy (Dimogerontakis et al. 2016). Depending on national legislation concerning user identification, data retention and surveillance, there can be more or less complications for community networks because implementing such measures is expensive (ibid.) and may violate privacy. Wireless community networks tend to use the frequency bands of 2.4 GHz and 5 GHz that are mostly seen as open spectrum, for whose use one does not need a licence. The regulation of spectrum use and the right to build and use outdoor antennas can, however, create legal, administrative and financial problems for community networks (ibid.).

In respect to the political shutdown of the Internet in authoritarian regimes, community networks are "means to communicate independently from the central command of governments and traditional operators. They enable citizen to organize (politically or otherwise) even in the eventuality that the established powers activate the so-called 'kill-switch' and shut down communications networks in a given area" (De Filippi and Tréguer 2015).

[16] NSA Prism program taps in to user data of Apple, Google and others. *The Guardian Online*. June 7, 2013.

The potential that community networks and decentralised peer-to-peer systems for network access and the storage, production, communication, distribution and consumption of information have for guaranteeing anonymity, privacy, security and data, poses at the same time also a problem in a political system that is obsessed with the idea that surveillance can prevent terrorism and crime. There is the danger that given such circumstances, decentralised IT systems that allow anonymity will be outlawed. If access, storage and processing are distributed, then it is legally difficult to argue that the participating peers are liable for certain infringements because one cannot assign intention and awareness to them (Dulong de Rosnay 2015, Giovanella 2015, Musiani 2014).

Melanie Dulong de Rosnay (2015) argues that the problem is that the Western legal system is based on liberal individualism. She identifies the "need for cultural change away from the neoliberal paradigm" so that the law is distributed and recognises "community rights and duties and collective persons as opposed to individual persons" (Dulong de Rosnay 2015). The question is if in the case of illegal use, the individual user, the ISP or the community network should and could be held accountable (Giovanella 2015). Federica Giovanella (2015) argues that it is unlikely that community networks can be held accountable by European law, except if they are organised as associations. She acknowledges the problem of applying "old legal schemes to […] new technology" (Giovanella 2015, 67) and argues that potential solutions are to hold the networks liable and/or to introduce user identification systems. Some community networks, such as Guifi, are already organised as non-profit foundations. The difficulty is that the question arises if a foundation should legally be held accountable for network use that is beyond their control. It could limit liability by prohibiting illegal use of the network by issuing terms of use.

Let us, however, assume that Daesh-terrorists use such a community network for organising terrorist attacks. If the individual user cannot be identified, then the legal authorities and the police may either try to shut the network down or to hold it legally accountable. This can then bias the network towards introducing a surveillance system that may infringe users' privacy and freedom of speech. Another possibility is that the network introduces a user identification system. But of course fake names and addresses could be used. Only identification by an ID or a credit card could guarantee personal identification. The first option, however, can be quite inconvenient because verification can be time and resource intensive. Using credit cards for user identification can bias a network towards charging for access, which may undermine the idea of free and open network access. In a society that is obsessed with monitoring users, it is difficult to run free and open communications networks.

In the ideal case, we could overcome the idea that communications surveillance is a solution to crime and terrorism and instead focus on fighting the social causes of these phenomena. As long as such politics is not in place, community networks are confronted with the danger that the surveillance ideology may lead legal and policing authorities to consider outlawing or criminalising them. They therefore have to think about how to position themselves towards the political contradiction between privacy-enhancing, free, open community networks and the surveillance ideology. The antagonism between privacy and the surveillance ideology also shows that community networks must, by necessity, be political if they care about freedom and democracy.

The Internet is today predominantly a communication system under commercial, authoritarian and paternal control (see Williams 1976). Community networks promise a democratic communications system in Raymond Williams's (1976) understanding,

but at the same time face the problems of an environment governed by the political-economic control of communications.

6. Cultural Aspects of Network Access

A survey conducted among 22 community networks shows that providing local education and training in technical skills is an important activity of such projects (Dimogerontakis et al. 2016). Wireless communities have opportunities for users to engage in participatory learning about "the structure and the functioning of the Internet" (Medosch 2015).

Community networks are not just technical networks, but allow creating neighbourhood communities (Apostol, Antoniadis and Banerjee 2008). Alison Powell (2008) distinguishes between geek publics and community publics in community networks. The first are a community that is brought together through creating and discussing community networks, whereas the second is brought together through local discussions using a community network. Powell found in a study of community networks in Canada that they tended to primarily create geek publics – "social club[s] for geeks" (1078). Everyday users were "not necessarily interested in using technology as a means of creating social links" (1081), but in gratis Wi-Fi access.

Christian Sandvig (2004) concludes in a case study of Wi-Fi co-operatives that the studied cases were communities of technical experts (geek communities) that were difficult to join for outsiders. These communities therefore remained marginal. "Overall, the Wi-Fi co-ops examined here are inward-looking: they emulate Douglas's 'cult of the boy operator' in radio before 1920 more than they provide an outward-looking CN that builds its own internal community through an explicit mission of helping those outside the group that are disadvantaged. […] Indeed, co-ops are in some cases so expert that this makes it impossible to imagine their success as a populist movement" (Sandvig 2004, 596).

In Alison Powell's research, the geek publics were strong communities organised around joint activities and communication, and the community publics were weak communities organised around sharing access to the same network as a gratis resource. One may be disappointed that in this case no strong social user communities developed, but one should not downplay the importance of the fact that users are interested in gratis Internet access, which means that they consider Internet infrastructure as a common good that should be available to everyone everywhere cheap or free of charge. The public these users envision is one of public or common ownership of the Internet infrastructure. That they all use a specific network is a potential for the creation of cultural communities, but it is no automatism and not an absolute necessity.

Tapia, Powell and Ortiz (2009) discuss the example of the community network Île Sans Fil (ISF) in Montreal that managed via a public/community partnership to develop from a geek public into a more outward-looking community. The example shows that it is also not an automatism and a necessity that community networks are "alternative ghettos" of tech-savvy experts, from which everyday citizens feel excluded. In the end, it is an organisational question to which degree community networks are able to reach out to and engage the general public.

7. Conclusion: A Framework for Understanding (Un-)Sustainability and Community Networks

We have discussed four dimensions of sustainable and unsustainable development of Internet access and how they affect community networks. Section 3 showed that community networks face environmental issues in respect to the generation of e-waste and energy consumption. Section 4 indicated that in respect to the economy, community networks operate in a capitalist environment, which poses the question how their existence is confronted and threatened by corporate monopolies, how they deal with this threat and the question of how to obtain the resources necessary for paying their workers and providing the necessary technology without having to use the same logic. Section 5 discussed that community networks have the potential to provide more privacy-friendly communications and at the same time exist in the context of contemporary surveillance societies that are based on the ideology of categorical suspicion an the technological-determinist assumption that surveillance can solve political problems such as crime and terrorism. In September 2016, the European Court of Justice made a decision on a legal dispute between Sony Entertainment and a supporter of the German Pirate Party[17]. Its decision was that open Wi-Fi hotspots are no longer allowed to be anonymous, but need to implement user identification and individual password-based logins. This rule provides a drawback for community networks' quest for privacy in Europe. Section 6 showed that the culture associated with community networks faces questions about being exclusive and limited to geeks or being open to and oriented on a broad public. The discussion showed overall that there are environmental, economic, political and cultural questions that community networks face.

Table 2 provides a checklist that based on the previous discussion identifies key issues that should be considered when thinking about how sustainable development of a community network can best be achieved. It identifies ecological, economic, political and cultural sustainability issues.

At the **environmental** level, community networks face a **contradiction between network effects and environmental problems**: The more users a network has, the better and more attractive it is (network effect). But more Internet use today also tends to mean more energy consumption, more deployed hardware, and more use of digital media devices, which can increase the consumption of unclean energy sources and thereby the depletion and pollution of nature and the generation of e-waste that can harm humans and society. Community networks' environmental challenge is therefore how to attract a large user community, keep the network up-to-date with technological progress and at the same time rely on clean, renewable energy sources and avoid e-waste.

At the **economic** level, community networks face a **contradiction between the monopoly power of large communications companies and the resources required for managing the network as a non-profit, commonly owned and commonly governed, democratic, gratis good and service**: The communications sector is a highly concentrated industry. Large communications corporations own large parts of the Internet's infrastructure. Communications in capitalism is shaped by monopoly power. Communication is a process that is necessary for human survival. In contemporary society, the access to communications networks and the Internet is therefore of importance for organising everyday communication. If means of

[17] Wi-Fi providers not liable for copyright infrigements, rules top EU court. But judgement spells trouble for anonymity on wireless networks, warn MEPs. Ars Technica, September 15, 2016. http://arstechnica.co.uk/tech-policy/2016/09/wi-fi-providers-not-liable-for-copyright-infringements-cjeu/

communication are privately owned, then inequalities in access and use tend to emerge. Non-profit community networks can challenge the power of corporate communications corporations. They can be foundations of an alternative organisation of the Internet. But they also require resources such as hardware, labour-power, money, users, attention, reputation, influence, support and volunteers, etc. The history of alternative media has not just been a history of spaces for alternative, democratic communications, but also a history of resource precarity and unpaid, highly self-exploitative volunteer labour. The danger for alternative media is that they cannot economically survive or that they develop into privately owned for-profit companies that turn access, content or users into commodities and thereby foster inequality and exploitation. Community networks' economic challenge is to run community networks as democratic, non-profit, gratis commons that challenge the power of corporate monopolies and the economic concentration of communications, but can at the same time economically survive and do not exist as second-class Internet that is marginalised.

Dimension	**(Un-)Sustainability issue**	**Sustainability questions**
Nature	Energy use	To what extent does the community network rely on relatively environmental-friendly energy sources (wind energy, solar power, tidal power, wave power, geothermal energy, biomass and waste energy)? To what extent does the network rely on suppliers of such energy forms? What is the share of the total energy consumed per year by the network that is based on relatively clean power sources?
Nature	e-waste	What is the average lifespan of different hardware types used in the community network? Can measures be taken for ensuring the long-term re-use and update of hardware? If hardware devices have to be replaced, is it possible to recycle the old ones? How? If hardware devices have to be trashed, is it possible to do so in a way that does not threaten humans and nature? How? If hardware devices have to be trashed, is it possible to do so in a way that avoids the creation of e-waste that is shipped to developing countries where it poses threats to e-waste workers, humans and nature? How? If old hardware devices that a network no longer uses are donated to other networks, can it be ensured that this does not result in a two-tier Internet access structure, in which poorer communities have slower Internet access than others?
Economy	Monopoly power and corporate concentration	How strongly concentrated is the Internet access market in a specific region, country and the world? What share of users and financial resources (revenue, capital assets, profits) does the incumbent Internet service provider have in a specific region, country and the world? Does the operation of the community network help to challenge the financial and market power of dominant Internet service providers? How? What are the dangers and what happens when a

		community network suddenly faces competition by a private for-profit Internet service provider?
Economy	Survival and resources	Will the community network manage to survive economically, i.e. to afford the necessary hardware and labour-power necessary for running the network? How does it do that? What are its financial sources? Can the community network ensure that it has enough resources, supporters, workers, volunteers, and users? Can the risk be avoided that the community network is a "secondary Internet" that is marginal, slower and less attractive than other services? How? What strategies can be used for avoiding marginalization and resource precarity? Are there possibilities for the community network to obtain public or municipal funding or to co-operate with municipalities, public institutions or the state in providing access?
Economy	Economic democracy	Is the community network collectively owned and controlled by its members as a common good? How can the community network best ensure that it is a not-for-profit project that is democratically owned and controlled? Are those who work professionally for the maintenance of the network, fairly remunerated for their labour so that they can lead decent lives? To what extent does the network rely on community control, municipal control, or private corporate control? What are potential dangers of collaboration with or inclusion of private for-profit companies? How can they be avoided?
Economy	Tragedy and comedy of the commons	Is the network large enough to attract significant numbers of users so that this community can have mutual benefits from network effects? How can possible congestion and slowdown of the network best be avoided if it is very popular?
Economy	Network wealth for all	How can the community network provide gratis/cheap/affordable network and Internet access for all? Can it help to lower the digital divide? How? How can the community network help to avoid a two-tier Internet with slower Internet access for some and faster for others? How can the community network avoid the commodification of a) access (i.e. using access fees) and b) users (i.e. using advertisements) that bring about a) inequality of access and b) the exploitation of users' digital labour?
Politics	Participation	How is the community network governed? How does it decide which rules, standards, licences, etc. are adopted? Does the community network allow and encourage the participation of community members in governance processes? How? Are there clear mechanisms for conflict resolution and for proceedings in the case of the violation of community rules?
Politics	Privacy-enhancement and protection from surveillance	How can a community network best be designed and governed so that the privacy of users is guaranteed, is technically secure, and protects users

		from corporate and state surveillance? How can privacy-enhancing and privacy-friendly community networks best face the threat that, in a culture of law-and-order politics and a surveillance society in which governments believe that surveillance is a way of preventing crime and terrorism, they are outlawed? How can they best challenge the argument that they provide a safe harbour for the communication of criminals and terrorists? How does the community network deal with actual crime occurring in its network? How can it best minimise the occurrence of crime?
Culture	Conviviality, learning and community engagement	Does the community network provide mechanisms for learning, education, training, communication, conversations, community engagement, strong democracy, participation, co-operation, and well-being? How? To which degree is the community network able to foster a culture of togetherness and conviviality that brings together people? How?
Culture	Unity in diversity	To which degree is the community network a "geek public" that has an elitist, exclusionary culture or a "community public" that is based on a culture of unity in diversity? How can a culture of unity in diversity best be achieved?

Table 2: Checklist for sustainability issues in community networks

At the **political** level, community networks face a **contradiction between open, privacy-friendly participation and political control**: Community networks have the potential to be inclusive, allow open participation, to be democratic and to enhance privacy and the protection from corporate and state surveillance. At the same time, given the prevalence of surveillance ideologies ("surveillance helps to fight and prevent crime and terrorism"), they face the threat of being shut down or criminalised by the state. They also face the problem of how to avoid openness and being misused by criminals. Community networks' political challenge is how to be open, participatory and privacy-friendly and at the same time challenge the surveillance ideology and respond to actual criminal abuse.

At **the cultural** level, community networks face a **contradiction between geek publics and community publics**: Community networks have the potential to be open public networks for learning, training, community engagement, togetherness and communication. But studies have shown that there is the danger that they develop a self-centred, closed geek culture dominated by techies that is unattractive for others and has an exclusionary and elitist character. There is also the danger that tech-experts develop into a power elite inside of such networks. Community networks' cultural challenge is how to foster a culture of unity in diversity and to be a community public.

Community networks in a society, in which power is asymmetrically distributed, face environmental, economic, political and cultural contradictions. They have potentials to foster sustainability in the information society, but at the same time face the problem of how to survive and not become part of powerful mechanisms that advance unsustainable development. Establishing a sustainable information society is not just a question of introducing new technological networks and organisation forms, it is also a question of changing the existing distribution of communication power and to foster struggles that question this power's asymmetrical distribution.

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