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A TOPOLOGICAL SPACE FOR DESIGN, PARTICIPATION AND PRODUCTION. TRACKING SPACES OF TRANSFORMATION

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'Space of transformation' is a concept borrowed from Serres' communication theory and here redefined after the evolution of the post-digital milieu and the materialistic critique of the same. Hackerspaces, fablabs, medialabs and other shared machines shops are defined here as spaces of transformation, places for the encounter between humans and non-humans, where disciplines are bridged together, hitherto severed, giving place to collective practices related to education, production and society.

Shared machine shops are sited locally but also connected globally. Online, they share innovative forms of production, education and collective organization, giving place to a complex ecosystem. This article presents an analysis of the topology of this ecosystem conducted by means of tracking and visualizing the online interactions between the hackerspaces listed at the platform Hackerspaces.org. The application of network analysis is aimed to answer the research questions: First, how shared machine shops are locally and globally connected? Second, what links hackerspaces among them and these with new social issues? The concept of shared machine shops as spaces of transformation and the study of their mutual relations allows for an understanding of the transformative capacity of these spaces and how they are producing a new space for social innovation through its mutual interchange of information.

Keywords: hackerspaces, network analysis, design, social innovation, space of transformation

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By Sandra Álvaro Sánchez

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INTRODUCTION

'Shared machine shops' is the name proposed by Maxigas and Troxler to denominate the "*new spaces of citizen participation and alternative production*" (Maxigas and Troxler, 2014). The spaces for the encounter of "embodied communities organised in research and production units of physical and logical goods" (Troxler and Maxigas, 2014). Originating in the margins of the 'networked society' and occupying the wasted spaces of the post-industrial urbs, 'shared machine shops' have evolved from hacker culture to became laboratories for the development of new organizational forms related to peer-production, and the prototyping of new material products, linked to entrepreneurship and innovation, as well as, of new educational projects.

Shared machine shops are characterized by their locality and material labour (Ames et al., 2017), however they are also linked to the internet, not only as a preferred communication medium but because the internet is part of its history and evolution.

Hacking has become the logic of the knowledge society, the creative endeavour of freeing information of its material constraints to produce new possibilities (Wark, 2004). Linked to the digital revolution, the origin of the word 'hack' is attributed to the members of the Tech Model Railroad Club at

MIT, to refer to an "innovative fix for a problem characterized with technological virtuosity and pleasure" (Levy, 2010). In this environment, programming and the production of software appears as the power of abstraction to produce new things, a new opportunity at the hands of anybody willing to work with a computer to change the world. Furthermore, information was considered a common good and the production and hacking of software, for the purpose of adapting it to new needs, was an open and sharable activity. The open production of software was facilitated by the spread of the internet. On the communication networks arose a new organizational system, characterized by decentralized command and motivated by social commitment. The peer-production of free software and projects as Wikipedia are accomplished examples of large-scale volunteer production, organized on the internet and without market incentives, neither managerial hierarchies (Benkler, 2006). Hackerspaces came into the scene like a physically located manifestation of these online communities.

Maxigas situates the origin of hackerspaces in Europe around the sphere of influence of the Chaos Computer Club, and considers them closely related but differentiated of the earlier hacklabs (Maxigas, 2012). The hacklabs were linked to the squad movement emerging in Europe in the 1980s-1990s and aimed to appropriate the capitalists' structures of power to produce public spaces in both the city and the cyberspace. Hacklabs' members considered the internet as a new public sphere and the place for a new digital democracy, at this way, they provided free access to internet and workshops aimed at training in the use of computers and the recycling of hardware. They were engaged in the development of free software, copyright critique, and related to movements like hacktivism, media critique, alter-globalisation and indie media. The Chaos Computer Club is a civil group of hackers initiated in 1981 and aimed at the liberation of technology knowledge. They are characterised for a more pragmatic perspective incorporating research, innovation and the realization of projects. In 2007 a group of hackers including Mitch Altman, travelled to Europe to visit some hackerspaces and participate in the 24th Chaos Communication Congress. This conference introduced a series of patterns based on already working hackerspaces and aimed to guide the creation and administration of these spaces (Ohlig and Weiler, 2007). Back in San Francisco Altman took part in the foundation of the Noisebridge, and extended hackerspaces to the United States. Since then, hackerspaces have spread all over the world; one important impulse in the growth of 'shared machine shops' as a movement was the support provided by Maker Media (the organizers of the Makerfaires and editors of the Make Magazine) to the spread of makerspaces. Makerspaces use machines such as 3D printers and open micro-controllers for digital fabrication and hardware experimentation. Makerspaces are defined as "learning environments rich with possibilities", where maker communities can experiment with new technologies and traditional tools to work in personally meaningful projects (Hlubinka et al., 2013).

Makerspaces approximate 'shared machine shops' in the context of education, hobbyist use and entrepreneurship, but with a more open definition and variety of purpose. For example, makerspaces are not necessarily related to new technologies and set apart by political aims, and this blurs the boundaries between the different kinds of machine shops – concurrent with hacklabs and hackerspaces a variety of other community-based projects emerged, including media labs, citizen labs, real-life laboratories, repair cafes, fablabs – and has promoted their institutionalization.

Makerspaces have become attached to cultural institutions like universities, museums, cultural centres and public libraries as well as big enterprises and entrepreneurial projects such as start-up accelerators, co-working spaces. The evolution and diversification of hackerspaces has not followed a linear schema but exist as a complex network, linking a variety of agents, technological artefacts, and spaces.

Shared machine shops are of special interest due to: first, their commitment to the experimentation with the components of our techno-social milieu; second, their openness. They are non-hierarchical collectives integrated by people from different backgrounds that meet to produce things and create sharable knowledge; third their diversity. Hackerspaces are project-oriented places, where people engage in tasks that link multiple agents, who contribute either in situ or online. Due to these characteristics hackerspaces are giving birth to a new form of collective research and production that is sited on the borders of the system and able to incorporate noise, meaning, going across the established boundaries between disciplines to produce new things with transformative potential. It is these three characteristics that mark hackerspaces as 'spaces of transformation'. This article tracks their mutual online relations in order to analyse how they are contributing to a global culture of social innovation.

SHARED MACHINE SHOPS AS SPACES OF TRANSFORMATION

Hackerspaces are defined as "spaces where people meet to do things together"(hackerspaces.org), spaces where physical production converges with new forms of sociability, the celebration of workshops and social events; and where the experimentation with technological and traditional tools meshes with the testing of new forms of education and societal organisation. It is precisely the openness of these spaces what allows a pluralism of relations, and its transformative potential. Depending on the different encounters between tools, practitioners, learners, artists, societal and local needs, these spaces have been transformed into spaces for media criticism, digital literacy, techno-politics, laboratories for smart urbanism (Díez, 2014), real-life laboratories (Dickel, 2014), studios for experimental artistry and new learning spaces in museums and public libraries (Babybroke, 2017).

In *Conversations on Science, Culture, and Time* (1995) Latour interviewed Serres about his work to explain how this author defined a new function for philosophy – the creation of the possibilities of future inventiveness – and proposed a new form of reasoning, based in algebra and topology and aimed to understand the complex relations that form our contemporary world, beyond the boundaries imposed by disciplines and the logic of representation. Accordingly, Serres' conception, the world is not formed by defined singular entities, but by the mobile nodes of a network, defined by their relative relations and positions. In this space, knowledge will not be a process of verification but a risk-taking activity, the inventiveness. The task of philosophy will consist in the creation of concepts that allow the accumulation of sense by means of bridging across disciplines. Concepts do not interface, the interface supposes that the junction between two sciences or two concepts is perfectly under control, or seamless, and poses no problems. Opposite, concepts navigate from one field to another, establishing new relations and new meaningful possibilities.

Introduced by Serres in *The Parasite* (1982), the 'space of transformation' navigates the fields of literature, mythology and mathematics to make understandable the transformative power of communication and the potential of information transmission for building human communities and produce new things. In this way, 'space of transformation' is an ontological concept. It opposes the system, defined as a set of codified and black-boxed messages to become the in-between systems, space where codification ends, and the message becomes noise. Using the author's image, the space of transformation is the torus or infinite space spreading in the border of all system, the space of encounter or interference where noise becomes message and vice versa. In this space of encounter the noise can penetrate into the system to transform it – "The noise is the end of a system and the formation of a new one" (Serres, 1982: 67) – by virtue of this encounter, the black-boxes open themselves to what is not codified in an interchange of information which result may produce the

transformation of the system into something new.

In addition to being the space of creation where new things can be produced by the experimental encounter between already existent entities outside the borders of purpose and function, the space of transformation is also a process of intersubjectivity. The quasi-object (another name for the space of transformation) is circulating matter. Working as a token in a children's game, the quasi-object assigns objects and subjects circulating from hand to hand, meanwhile, it is weaving a non-hierarchically organized collective, in which nobody is sovereign but all become involved parts. To participate is to be complicated in the meshwork of legacies, assignations, loans and transmissions that codifies the group of individuals. In this schema noise is the parasite, the newcomer able to disrupt the system making apparent the accepted codification, at the same time, that starts new processes to re-codify the system. In this sense, Serres says that the parasites are the producers of history.

The quasi-object will be adopted by Bruno Latour to designate a non-fully codified nor obfuscated object, an object from where could be traced the multiple relations that sustains it. The study of the formation of this complex object will become the basis of Latour's Network Theory (Latour, 2005) which links science to society becoming a politics of technological artefacts. The unveiling of the collectives of human and non-human agents assembled around the construction of facts and the research of how these are resulting from the multiple relations among people, instruments, institutions and the work of translation that allows moving them from one codification system to another.

Hackerspaces are 'spaces of transformation', producers of intersubjectivity and new things by means of assembling multiple relations. 1) relations among different objects in experimental research aimed to produce new objects or products; 2) the relations between the materials at hand and the individuals working on them through a process of experimentation in which a sharable knowledge is also produced; 3) the relations between the involved human agents that participate in a process that modifies their environment at the same time that their subjectivities, producing new forms of collective organization.

This lattice of relations is produced locally, inside a hackerspace where a group of individuals become self-organized working together in the experimental assemblage of different materials to produce a new object. However, the materials, practices and organizational schemas assembled in these relations are also connected to more global networks. It is the linking with these more global networks what allow shared machine shops to become a source of transformative practices.

TRACING THE TOPOLOGY OF SPACES OF TRANSFORMATION

Despite hackerspaces being deeply entangled in their immediate surroundings, they do not emerge in isolation, but from the convergence of multiple agents. We have previously noted that one of these agents is the internet, which was first one of the artefacts to experiment with, and more recently, one of the vehicles behind the fast spread of the movement. Since the aim of this research is to study the global relations that define hackerspaces, we consider the web as our field site.

Networked ethnography allows building the field site useful to study social practices which take place on the move, across great distances and linking up disparate entities. The application of configurations as "follow the object" and "follow the metaphor" lend and overarching cohesion to multi-sited ethnographies (Burrell, 2009). To build the field site of the global phenomena of hackerspaces "following the things themselves" (Latour, 2005), computational methods will be deployed. More specifically, I will use a web crawler to discover how hackerspaces are linked among them, at a global and local level, and what other entities link hackerspaces globally.

From the study of the discovered websites, I concluded that hackerspaces are connected to the web for multiple purposes:

- promotion and visibility,
- communication with members, using tools as calendars to schedule events, the application 'we are open' to show the members when the hackerspace is accessible, wikis to document previous activities and ongoing projects
- communication with other hackerspaces, sharing definitions, purposes, manifestos which contribute to insert the space in a wider community.
- contribution to collective projects located on the web

From all these uses we can deduce that hackerspaces are inserted inside an ecosystem of cooperation that builds a sharable knowledge base. At the same time, hackerspaces share an identity identifiable on the analysis of their websites (see Figure 1). Most hackerspaces' websites share a common design, use the same tools to organize information, and link to shared definitions of their functions and objectives. To discover this identity and how local communities become 'spaces of transformation' we will track the online relations between the hackerspaces listed in the platform hackerspaces.org.

THE OBJECTS WE FOLLOW, FIRST CORPUS

> Hackerspaces are community-operated physical places, where people share their interest in tinkering with technology, meet and work on their projects, and learn from each other.
>
> *hackerspaces.org* is an informal volunteer network of such spaces, maintaining community services – including a wiki for everyone who wants to share their hackerspace stories and questions, mailing lists, XMPP services, a blog and a feed aggregator, and many others.
>
> *www.hackerspaces.org*

Hackerspaces.org was founded in 2007 to be a collective online platform for the hackerspaces and their users. It is a platform that agglutinates available tools for collaborative work as wikis, blogs, RSS feeds, Freenode channels and so on, to improve communication among hackerspaces. In addition, the platform maintains a set of available resources, a user-maintained list of hackerspaces, and sites to communicate events, residence opportunities, on-going projects looking for collaborators and hackathons. These resources aimed to facilitate the local development of these spaces by means of a feedback network that shares tools, fosters collaborations, and facilitates the mobility of people.

Hackerspaces.org has been chosen for two reasons: First, antiquity, it was founded in 2007 the year that saw the global spread of hackerspaces. Second, because it is a collaborative site built from the collective contributions of its members, the hackerspaces list is not curated but freely contributed by the members of this collective.

After crawling the URLs of the hackerspaces' list, I will apply network analysis to answer the two research questions:

- How hackerspaces relate between them at the local and global level?
- What other things link hackerspaces among them?

The research questions will conduct to the discovery of the geography and the ecosystem of hackerspaces, what constitutes them and how they integrate inside its local space. How are they entangled with new collective practices and conceptions and how these practices have the potential to transform our socio-technical system.

Methodology

The tools used for this analysis are Hyphe a crawler aimed at community detection in the generic web

and Gephi a graphical application for network analysis.

Hyphe is in development at the Media Lab of Sciences Po and offered in its website for free testing (http://hyphe.medialab.sciences-po.fr/). It is a web crawler, an internet bot that systematically browses the World Wide Web for the purpose of web indexing, some well-known examples are the web indexing tool deployed at archive.org. Hyphe is designed to detect communities, this is a usual method in sociology, especially in platform studies. Social networks as Facebook and Twitter provide APIs which allow downloading of posts and user profiles. The analysis of these data is aimed to discover how information is spread inside these platforms and answer questions related to social behaviour (Jacomy et al., 20016). Otherwise, Hyphe is a non-API-based tool aimed to browse the generic web. The generic web is rarely studied in itself thought it contains crucial aspects of the embodiment of social actors (Jacomy et al., 2016) this is due to the complexity and the big diameter of the internet network. To manage this complexity and big size, Hyphe has been conceived as a curation-oriented tool. Hyphe allows constituting a corpus of URL's step by step. The discovered URLs could be close read and selected, before adding them to the final corpus. Once the entities are defined and the corpus constituted, the entities can be tagged for their classification and study. Applying these tools to crawling the URL's of the hackerspaces contained in the list maintained by hackerspaces.org will allow building a corpus we will arrange in different networks for the study of the research questions.

Network analysis is a procedure used in sociology since Jacob Moreno developed its 'sociograms' to study the mutual relations inside human collectives (Lima, 2011). Assembling sociology and mathematics (to create graph theory) this graphic technique is designed to explore social phenomena by mapping them on a network, where nodes are in the place of entities and the edges of their relations. Furthermore, network analysis is not a representational method but an exploratory technique, which allows discovering how things are connected among them by means of applying algorithms that calculate the characteristics that define the topology of the network. For example, the deployment of a force-directed spatialization algorithm – this applies a physical analogy; nodes are charged with a repulsive force that drives them apart, while edges act as springs binding the nodes that they connect, the algorithm changes the disposition of nodes until it reaches a balance of such forces (Ventury et al. 2018). This operation creates regions where nodes are densely assembled and other less crowded regions, this topography characteristic allows to detect clusters of agents.

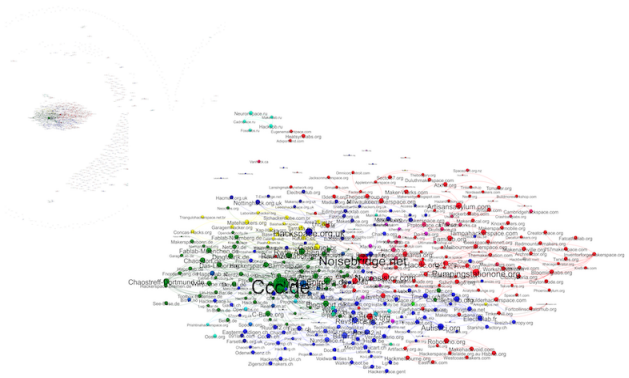
The second network characteristic used in this analysis is the 'in-degree', which ranks the nodes accordingly the number of edges directed to them, the nodes with a major weight, this is the nodes assembling a bigger number of connections are called authorities and are represented bigger, the size becoming relative to the number of edges directed to each node. Finally, we will apply different hues to see the nodes accordingly the classification assigned by the applied tags.

Analysis

We will consider that the cultural phenomena related to hackerspaces emerge from a topological space, which is not formed by points or identities but as a conglomerate of local spaces and the contiguous connections between them. The visualization of this topological space will allow to consider this culture in its making and understand a series of questions: how hackerspaces connect between them? Which are the global and local networks that this phenomenon is distributed upon? Are there connections where the history and evolutions of these spaces can be traced? Finally, which clusters are locally and globally formed around specific subjects of research and how they are connected among them?

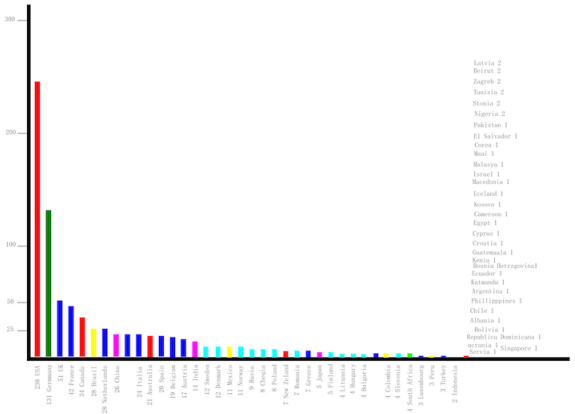
Global and Local – the geography of shared machine shops

What are the relationships between hackerspaces at the local and global level? To answer the first research question, I proceeded by crawling the list of hackerspaces until deep 1 (this means, only URLs directly linking to the ones contained on the list are retained). After I eliminated all the URLs not corresponding to shared machine shops, I tagged the remaining entities accordingly with the country in which they are located. These operations resulted in a corpus counting 941 nodes. The first graphic features the network resulting from the spatialization of this database.



The first topology shows a densely connected centre surrounded by a concentric distribution of less connected URLs, the nodes in the periphery corresponding to hackerspaces that are only connected to the platform Hackerspaces.org, and not link to other hackerspaces in its websites. Analysing the densely connected centre, there are two big nodes or authorities that stand out, these correspond to the ccc.de (Chaos Computer Club), located in Germany and the noisebridge.net (the Noise Bridge) located in San Francisco in the US. The two big authorities are surrounded by the nodes from its same country first and in a second moment by clusters of nodes from other countries, belonging to Europe, The United States and Canada, South America, Australia, Asia and Africa.

This first analysis unveils that 'shared machine shops' are a global phenomenon; they are distributed all over the world, but with a greater presence in Europe and the United States. Looking at the distribution of hackerspaces by countries (see Figure 2) we see that hackerspaces are distributed among 71 countries. The largest number of hackerspaces is found in the United States of America with 238 nodes, this is followed by Germany with 131. Considering the relative sizes of these two countries, we can conclude that hackerspaces are a more important phenomenon in Europe, this fact is coherent with the history of the development of hackerspaces. Following in importance by the number of hackerspaces we find the United Kingdom with 51 hackerspaces, France, with 42 and the Netherlands with 28. Then we must highlight the European countries Italia (24), Spain (20) Belgium (19) and Austria (17). Brazil has the largest number of hackerspaces in South America with 28 nodes, and China the largest in Asia with 26. South Africa is the largest in the African continent with 4 nodes. At the end of the line, we find a large amount of countries from all over the world which have only one listed hackerspace, this could be interpreted as an indication of that this is a growing phenomenon.



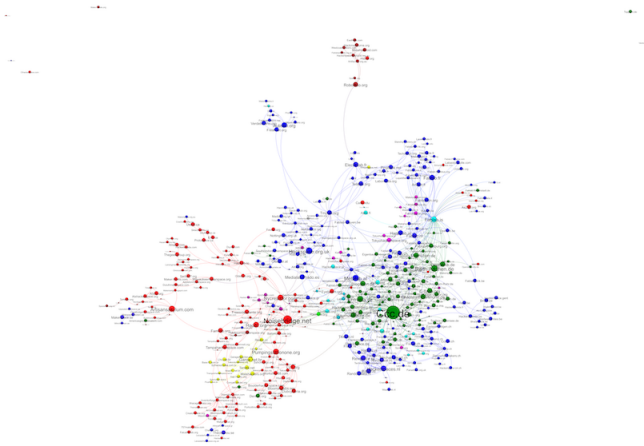
A closer analysis of the network reveals two main nodes: ccc.de (in green and situated at the left of the densely connected central cluster) and noisebridge.net (at right coloured in red). Between both, there is the Metalab, also important in size and coloured in blue. The Metalab from Austria is

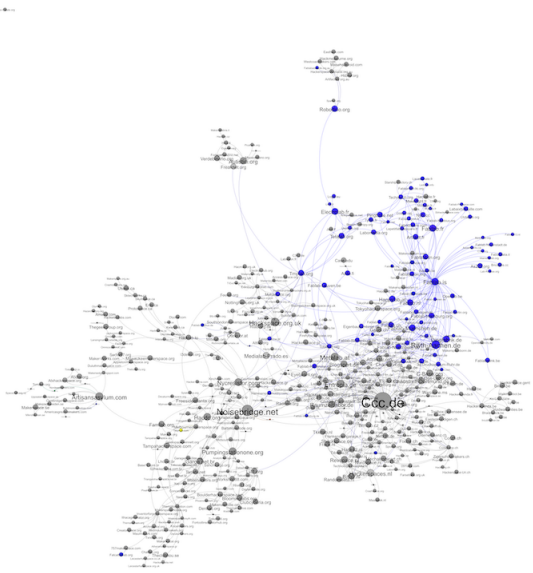
considered one of the first hackerspaces, other hackerspaces had followed its organizational model, the reason for the authority it displays in this analysis. The ccc.de and the noisebridge.net appear surrounded, first by hackerspaces from their respective countries, Germany (all coloured in green) and the USA (all in red). Second, these main clusters appear surrounded by groups of nodes from other countries, the reason for this distribution is that there are nodes connected to the ccc.de and the noisebridge.net that works as hubs in their respective countries, this is coherent with the history that narrates the spread of hackerspaces from Germany to the United States in 2007 after the 24th Chaos Communication Congress.

Analysing the German cluster formed around the ccc.de, we find other nodes with prominent in-degree, between them the URL of the historical C-Base, initiated in 1995 in Berlin, another highlighted German authority is entropia.de. Below the German nodes are the hackerspaces from Switzerland, clustering around chaostreff.ch and ruum42.ch both connected to the ccc.de. Following right clusters the spaces from the Netherlands, densely connected among them and near the ccc.de because spaces as ackspace.nl connect to the main German hub. Still going right, we find the node totalism.org, which occupies a central position in the network because is highly connected internationally, this hackerspace, situated in the Canary Island (a region that administratively belongs to Spain but is far away of the peninsula) is not connected to other Spanish nodes, which appear very distributed along the network. We then find the clusters formed by Belgium nodes, Italian nodes and French nodes. The French cluster connects to the noisebridge.net through the URL of the tmplab.net. Above the German cluster, there is the cluster formed by the Brazilian nodes (coloured in yellow) united to the ccc.de through the node corresponding to the Garoa hackerspace. From left to right, are clustered the hackerspaces of the United Kingdom, around the main UK node the Hackspace.org.uk, which is also connected to the tmplab.net from France. Around and near the Noise Bridge node we find another big node corresponding to the New York Resistor, one of the first hackerspaces in the USA, founded by Bre Pettis, also the pumpingstationone.org the URL by Pumping Station: One, the older hackerspace in Chicago. Around the American nodes cluster the Australian Hackerspaces, and the Canadian ones, the nodes from Asia (coloured in pink), including the well-known hackerspace Xinchenjian (considered the first hackerspace in China) are disseminated above the noisebridge.net confused with American and Canadian nodes, which indicates that these nodes are more internationally connected, especially with USA nodes than inside their countries. Finally, above the main cluster, near but unconnected of it appears a small cluster of Russian nodes (coloured in light blue) connected between them but not internationally.

Concluding, Hackerspaces cluster inside their countries and around some nodes that appear as international authorities for historical reasons. Another interesting discovery of this first analysis is the variability of designations, looking at the websites of the studied nodes we find a big number of spaces that describe themselves as hackerspaces, but also an important number of spaces self-denominated makerspaces, for example, the Artisan Asylum, from Massachusetts, one of the highlighted nodes from the USA, we also had noticed that most of the hackerspaces offer hardware, 3D printing and digital manufacturing workshops, that makes the distinction between both kinds of machine shops more historical than functional. ‘Hackerspaces’ being a more used denomination between older shared machine shops.

Following the first research question I performed a second analysis in a more extended corpus. For this purpose, I conducted a second crawling in the first obtained corpus and found the hackerspaces linked to the hackerspaces originally listed at the platform hackerspaces.org but not directly included into the list, nor connected to the platform. Crawling the corpus more deeply I increased the corpus to 1034 nodes and obtained a more clustered network.





The local clusters appear now more differentiated because we have found new nodes that contribute to link the hackerspaces inside their respective countries. For example, Medialab Prado in Spain, not exactly a hackerspace but that contributes to clustering the Spanish nodes because it connects with other spaces inside the country.

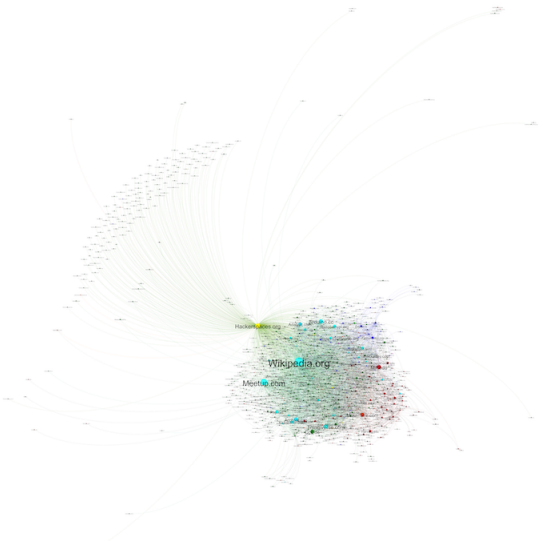
In addition to the defined cluster, we find a region above the German nodes (in green) at right with a cluster of international nodes. Examining these nodes, we can see that they correspond to fablabs, not present in the first corpus. See the graphic 4, where the fablabs are coloured in blue.

The Fablabs are part of a project started in the Centre for Bits and Atoms at MIT to bring their machines to new users who could foster their development by means of proposing new uses. These labs rely on the distribution of a standardized set of manufacturing machines through a network of physical spaces communicated through the internet, at this way this is an international project connected on the net by means of dedicated places like the Fablab Foundation, a platform that provides support, mentoring and educational materials to all the fablabs.

The shared machine shops ecosystem

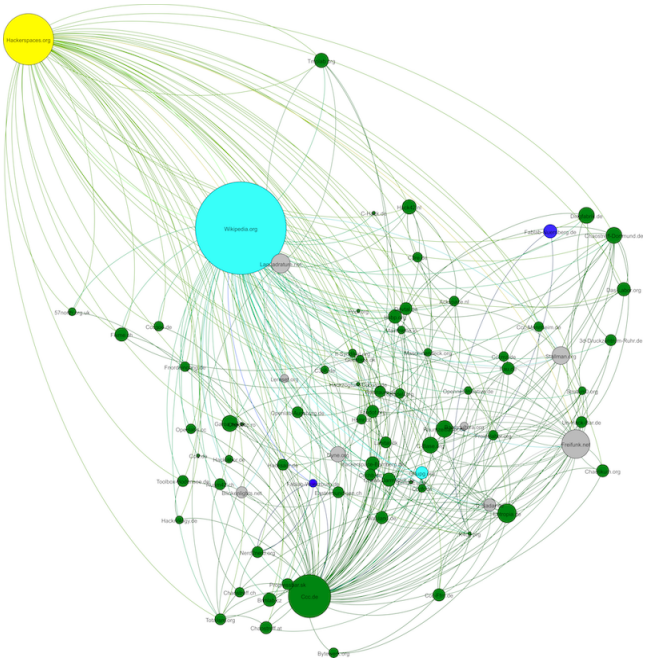
What other things connect hackerspaces among them? Addressing the second research question requires adding to the corpus the URLs discovered during the process of crawling and not corresponding to hackerspaces. The resulting corpus contains 1331 nodes classified accordingly their activities. For the classification of the nodes, I established nine groups of tags.
Different kinds of shared machine shops: hackerspaces, makerspaces, fablabs, citizen labs, media labs, repair cafes, artists and artisan collectives, communities and co-working places.

Cultural institutions: art centres, museums, public libraries, foundations and governmental institutions.
Platforms working as hubs for the shared machine shops and offering services: platforms, forums, the Fablab network and the maker network.
Personas: including personal websites linked to hackerspaces.
Educational centres: universities, research centres or research communities, educational services – v.gr. online schools.
Publications: magazines and news sites, web repositories
Events: fairs and camps
Projects
Tools

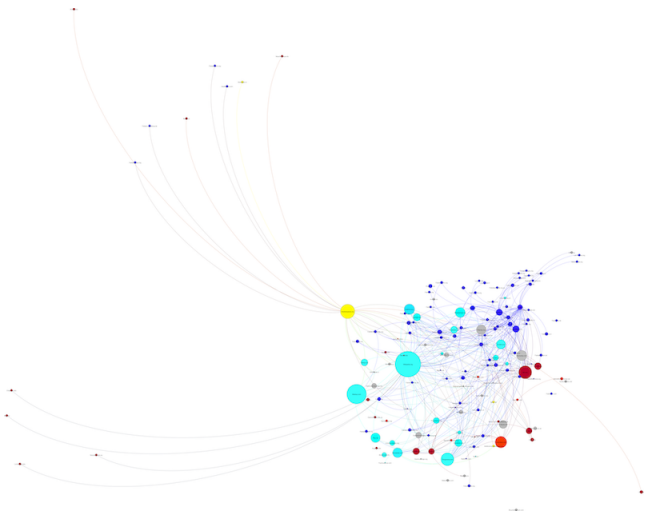


The obtained network appears divided, in the middle we find the node corresponding to the platform hackerspaces.org (coloured in yellow), on the left there are a group of unconnected nodes mainly corresponding to hackerspaces and fablabs. On the right there is a big cloud of densely connected nodes. The bigger nodes standing out in this cloud belong to tools and services used by the most part of hackerspaces (coloured in light blue). Among them feature the Wikipedia, Meetup, Arduino, Thingiverse, Kickstarter, Archive.org, Raspberry Pi, Adafruit. Other less linked but also important tools are Blender, Apache, php.net, Makerboot. The links to these websites are indicative of the different activities and projects performed in hackerspaces, also are testimonials of the persistence of a commitment with open knowledge and free software. Wikipedia stands out because hackerspaces tend to link to this collective encyclopaedia to provide definitions, especially when defining their aims and scope in the section 'about' of their websites. In addition, there are a lot of shared machine shops -e.g. the c-base – that harbour groups of contributors to this project. Meetup is also highlighted because is the preferred tool to organise events, meanwhile, the Thingiverse, Makerboot and Kickstarter integrate the digital manufacturing ecosystem, closely related to the spread of makerspaces. Another authority in the network is the Makerfaire (coloured in orange) and the website of the MIT (Massachusetts Institute of Technology), the university related to the Fablab project. In green, we find the shared machine shops, among them, stand out the ccc.de and the noisebridge.net, as described during the explanation of the first research question.

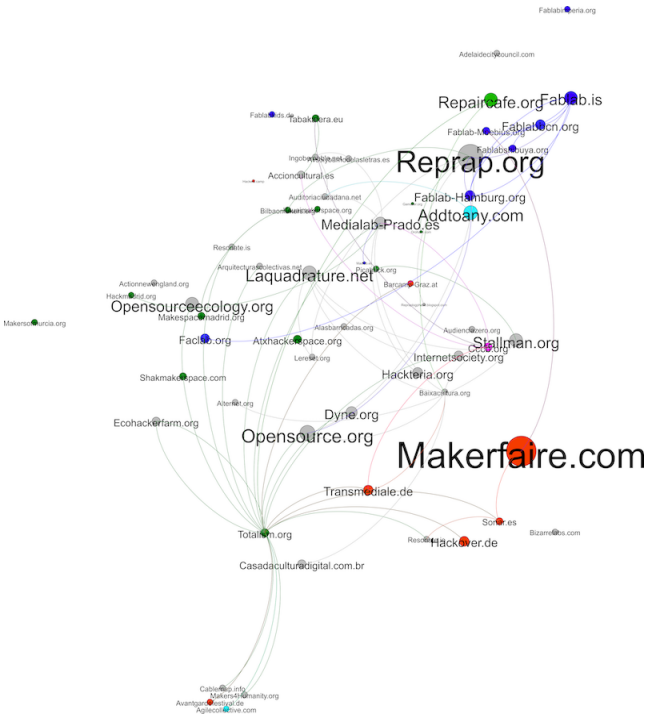
Continuing with the analysis I will add some filters to better understand the topology of this ecosystem.



The graphic 6 shows the nodes immediately linking to the ccc.de, in this section of the network, we find different hackerspaces from Europe, also some fablabs. The ccc.de also links to the Wikipedia and to the platform hackerspaces.org, – both of these nodes link to the most part of hackerspaces. Besides the hackerspaces and these two authorities, we find some projects that contribute to link the hackerspaces among them locally and internationally (coloured in grey). This is the case of the well-known project Blinkenlights, the interactive luminous facade started in 2001 at the Hause des Lehrers in Alexanderplatz in Berlin. Bigger than Blinkenlights is the node of Freifunk, the project aimed to build a decentralized and free internet service. Another local project is c-radar, the radio of the Chaos Computer Club. The ccc.de is also related to projects from other countries, among them, La Quadrature du Net, a French project aimed to defend the fundamental rights of the digital environment, an association created to fight surveillance and online censorship and promote a free, decentralised and empowering internet.



The graphic 7 shows another partition of the network, this time to examine the relations between the fablabs. The Fablab network is big, and it clusters around the Fablab Foundation, but also links to the global network through different tools, related to open hardware such Adafruit or Raspberry Pi, also open source software projects as Blender, Processing and Linux. Finally, it links to digital manufacturing websites as the repository of 3D models Thingiverse, the Makerboot and the historical project RepRap, the first self-assembling 3D printer. Another tool standing up is the platform for crowdfunding Kickstarter, which shows the relation of fablabs with entrepreneurship. the fablabs appear also connected to Universities, the MIT is the most highlighted but also appear the Cornell, New York University, Berkeley and UCLA (the place where Casey Reas the co-creator of Processing teaches). Fablabs also are linked to the Maker Faire, and to some barcamps, showing that fablabs participate in the events organized by either hackers or makers. The fablabs are also involved in international projects where meet with other shared machine shops, among them the opensourceecology.net. The objective of the Open Source Ecology project is creating an efficient open source economy, for this purpose they share online designs of low-cost commercial machines. Another project we can see is Hackateria, a wiki-based web resource for people interested and working in bioart. There are also already described projects as Freifunk. In addition, fablabs are also connected by means of several platforms, the hackerspaces.org, the fablabfoundation.org and the Hackaday.com, a curated platform that publishes new hacks every day.



Finally, we will isolate a regional network to perceive which things mediate in the local and international connections of hackerspaces. Figure 8 features the portion of the network integrated by Spanish nodes. In the lower part, we can see the hackerspace Totalism, a very active hackerspace that links to local projects, such the cablemap.info and hackers4humanity.net, and international projects like the already described Open Source Ecology, Hackateria and La Quadrature du Net. In addition, the opensource.org, the initiative to promote and protect open source software; the Eco Hacker Farm, an organization focused on sustainability by the promotion of projects combining hackerspaces with permaculture and "Arquitecturas Colectivas" international network for projects related to architecture and urbanism, This hackerspace also links to international events like the Transmediale in Berlin and the Sonar, the festival of advanced music from Barcelona. In the superior right corner, we find the Fablab Barcelona which links internationally to other fablabs. Spanish hackerspaces are scarcely linked among them however, the cultural centre Media Lab Prado contributes to networking them, among others this institutionally founded centre links to the ingovernable.net a feminist laboratory for peers and the commons and other cultural centres as the CCCB in Barcelona and Tabacalera in Madrid. These cultural centres link also to universities, events and institutions like accioncultural.es aimed to promote and founding Spanish culture. Media Lab Prado also links to local projects, like auditoriaciudadana.com, a citizen platform aimed to analyse and publish the evolution of the Spanish debt.

ANALYSIS RESUME

To conclude this analysis, Hackerspaces are connected to the net for different purposes related to communication, documentation and peer production. The interchange of information produced online contributes to form a shared identity and to define common objectives. The network formed by the studied web entities shows a common evolution of hackerspaces and the constitution of a common space of possibilities, defined by the sharing of tools and documentation. We can conclude that shared machine shops form an ecosystem of shared knowledge and cooperation.

Hackerspaces and other shared machine shops are connected at the local level between them and with cultural institutions, like the Medialab Prado and the CCCB in Spain, the ZKM in Germany and Eyebeam in New York, as well as to events, enterprises and projects. These local connections allow the hackerspaces contributing to the transformation of its techno-social milieu. In what refers the global level, hackerspaces are connected, first, by other hackerspaces that feature authority due to its history and its contribution in the starting and spread of this movement, second, by means of dedicated platforms that work as hubs for this movement as hackerspaces.org, the fablab foundation, the maker foundation and repaicafe.com, among others. As a remark, in the studied network do not exist a division between different kind of hackerspaces which link ones with others, and to the different platforms, equally,

Finally the shared machine shops also connect internationally by means of tools, events, big institutions and projects.

The projects linking to hackerspaces display the ideas and ideologies traditionally attributed to this movement. Among the projects displaying a bigger in-degree, we find the RepRap, the first collectively produced 3D printer and at the beginning of the spread of digital manufacturing, the most used in hackerspaces (Moilanen and Vadén, 2013). Other important nodes demonstrate the generalized use of open software tools, among them the nodes of the websites of, Blender, Linux, Android and so on. We can also track the change towards physical production with projects related to open source hardware – e.g. dangerousprototypes.net – but this tendency has not substituted the commitments that characterized this movement at its beginnings. Among them the development and promotion of free software, which is demonstrated by the authority of the node opensource.org; the open access to the internet by the development of free and not centralised networks – with projects as Freifunk or espora.org; and the defence of net neutrality and the criticism of surveillance and censorship – the aims of the project La Quadrature du Net. Conjointly, the objectives at the foundation of the hackerspace, we can find projects that show new aims, these promoted by the incorporation of the technologies working with hardware and physical prototypes, like digital manufacturing. Furthermore, the attraction of practitioners and institutions from different disciplines and fields of knowledge, facilitated by the spread of this movement has also contributed significantly to the layout of new projects. At this way, we can find projects related to local issues concerning democracy, citizenship and the preservation of urban spaces like “Auditoria Ciudadana” and “Arquitecturas Colectivas”. In addition, an increasing interest for sustainability and new economic models featured in projects like Open Source Ecology and the Eco Hacker Farm.

Finally, we may highlight the existence on the network of artistic projects, such Blinkenlights and Hackateria, showing the relation of this movement with experimental creation, and the development of new and interdisciplinary artistic genres as new media art, bio art, post-digital art.

CONCLUSION – A SPACE FOR DESIGN, PRODUCTION AND PARTICIPATION

The featured analysis has shown the networked evolution of hackerspaces, its origins linked to located gatherings of people and technologies- the historical hackerspaces, nowadays displaying a prominent authority on the network- and its evolution by means of the progressive incorporation of projects, services, tools, institutions and events into the network. We stated at the beginning that it is precisely this openness and capacity for linking and integrating, what allow hackerspaces a plurality of relations and the transformative potential.

Hackerspaces are ‘spaces of transformation’, what is to say, not-fully-codified spaces, sited in the intersections of other systems where ‘people meet to do things together’. The gathering of people from all walks of life, technological and more traditional tools, needs, purposes and desires in a non-hierarchized space allows for the emergence of novelty. In both dimensions, the production of new things and the promotion of new collectives.

The projects, we have encountered on the analysis and the meshwork of relations they are involved, we can conclude: 1) In hackerspaces people become hands-on involved in the production of new things; 2) these material or immaterial things are produced collectively and shared online; 3) at this way, they become experimental outputs that evolve through a collective process in which are redesigned and reproduced at the same time that the involved agents look for and incorporate the needed resources – knowledge and materials, venues, funding, institutional support to maintain and spread the project.

This project-oriented process generates a network which links this movement globally and with its local

environment. The weaved net becomes a space of possibilities for the future inventiveness, which is socially produced and maintained. From this space, the continuous connections that maintain this phenomenon emerge new products, educational proposals and organizational patterns. This emergence is produced around the social engagement in the local and global issues that confront the diverse practitioners gathering in this movement. The empowerment of people in front the technological systems shaping our reality, by means of the spread of digital literacy; the knowledge and collective control of these technological systems and the guaranty of its openness and neutrality; the preservation of democracy; the conservation of the natural environment, and the improvement of the habitability and accessibility of urban space, quoting some of the concerns involved in the studied projects discovered in the network. These are collective issues that require collective involvement for its study and improvement. The networks generated by the interactions between shared machine shops provide a possible space for the social innovation, required to manage the collective issues we are facing nowadays.

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