Searching for a solution to the Rubik's cube: Internet as a complex set of commons

SEARCHING FOR A SOLUTION TO THE RUBIK'S CUBE: THE INTERNET AS A COMPLEX SET OF COMMONS

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1. Introduction. The Internet, a multi-faceted Rubik's Cube breaking into the commons scenario.

According to economic literature, solving the problems of the commons usually entails two distinct elements: restricting access to the resource and creating incentives for users to invest in it - instead of overexploiting or incorrectly using it - for instance by assigning them individual rights or shares of the resource. As far as the Internet is concerned, this mechanism works on a different stage, as it entails the search for a proper balance between regulation (that is to say the multi-layered governance model of the Net and the role of the local, national and international bodies in charge of the administration of the resource), individual rights (freedom of expression and thought, the emerging and debated fourth generation right to have access to the Internet and to its contents) and the access to Net resources (individual responsibility and the limits applicable to one's activity on the web). As it will be argued, today the Internet is not facing widespread problems of exclusion and depletion anymore. Still, its ontological complexity raises several debated questions, which have to be carefully addressed.

The Internet, as an essential and strategic resource, is under many points of view the target of several forms of (direct and indirect – global and local) forms of control and appropriation, despite its global aspirations. This issue reflects the multi-layered institutional governance model of the Net, in relation to both general policies and the management of network infrastructures, but also the significant commercial potentialities of the web.

The article is based on these premises and tries to suggest a reading of some of the most controversial issues the scholarly debate is focused on. In particular, the reference point of the analysis is the category of the commons, which has been to a

certain extent applied to the Net.

First of all, we will sketch an overview of the evolution of the notion of commons and its sub-sets, such as common pool resources, global public goods and club goods. The second step is a review of the main visions expressed in literature as to the inclusion of Internet resources among the commons. Indeed, it has often been listed among the new commons, due to its technological-driven essence, but its increasing complexity allows for a more detailed approach.

The fourth paragraph is then focused on the multi-layered structure of the Internet, whose nature must be read through the de-composition of the various and highly different goods it is composed of. In fact, the Internet cannot be considered a commons itself, but must be scrutinized in the light of the specific features of its material backbone, of the technical standards and protocols he is based on and of the different kinds of contents users can benefit from. Each of these goods has different characteristics and sheds a light on some of the key-challenges the Internet is facing.

To this respect, the final remarks are intended to suggest further reflections on such questions, in particular the interconnections between private property and public goods in the daily functioning of the network; the status of technical standards and protocols which enable the Internet to perform communication processes among computers; the end to end architecture and the attacks to the principle of network neutrality, the centralized and collective management of the domain name system. All of these question are analyzed from the perspective of the dichotomy "private appropriation – open public goods", as a possible criterion for the interpretation of the current challenges the Internet is undergoing.

Since one of the core arguments is centered on the complexity of the Internet, we propose to apply to compare it metaphorically to a Rubik's Cube, a multi-sided and multi-colored switch puzzle whose layers and pieces can move independently from the overall structure and whose solution is much less evident than it seems.

2. The public goods and the Rubik's Cube: the evolution of the category of the commons.

2.1. Commons, common pool resources and club goods: different combination of excludability and subtractability.

There is no clear vision in literature as to the most suitable definition of the commons. This is mainly due to the variety of the entities at hand and to the extremely flexible and rapidly evolving boundaries of the notion. Nonetheless, the commons are usually characterized by a series of distinctive factors, which we can detect in most of the examples considered by scholars.

The notion of commons refers to a set of resources which are conceived to be neither private nor public, but commonly owned or managed. In particular, Elinor Ostrom has stressed the importance of distinguishing between commons and common property, the latter being represented by formal or informal sets of rules allocating rights and duties to a group, usually by the means of public institutions (Ostrom, 1990).

In general, this is mainly due to their peculiarities and to their strategic (and in many cases essential) cultural, social, environmental, economic, political importance for a community, being the latter a small village or mankind as a whole. The concept then avoids the traditional idea of public or private property, embracing the sharing of a

resource by all the members of a community.

The key biophysical features of common goods are non-excludability and non-rival consumption. Therefore, they are easily accessible to any user and difficult to exclude, but they cannot – or at least shouldn't – be enclosed by individuals, corporations or by the high aims of national sovereignty. In fact, they are conceived «*the shared heritage of us all*» and should be granted for everyone's benefit (Rowe, 2001).

Accordingly, everyone should take advantage from the preservation of these resources, which should be at the same time kept for the benefit of future generations and, in case, properly consumed by individuals, in order to avoid their depletion (Shackelford, 2009). People should then exhibit mutual trust, habits and skills of cooperation, public spirit and rational approach in order to sustain common resources against the risky tendency to abuse or enclose them (Levine, 2001).

The last point is particularly important, since the spread and individualized exploitation of a shared resource by each member of a group, by private companies or public authorities risks to undermine at the roots its preservation or its quality. The danger inferred by the sharing of a resource necessary for the individuals of a community was defined as "The tragedy of the Commons", the well-known title of an highly influential article by Garrett Hardin dating back to 1968 (Hardin, 1968).

According to Hardin's argument – which in these decades has been thoroughly scrutinized, traditionally upheld, but often criticized or developed further on (Feeny, 1990; Aquilera-Klink, 1994) – the users of a commons are the main actors of the tragedy on the stage. Being unaware of the overall situation and of the costs suffered by their fellows and the community as a whole because of their conduct, they make demands on a good until their needs are satisfied at the expected costs. This process leads to the destruction of the resources the individuals depend on or take benefit from and it is therefore necessary to search for an effective solution in order to avoid such tragic and undesirable finale of the play.

While Hardin's proposed solution was to search for a shelter under the encouraging paradigm of property regime – either on a socialist or a free market basis – several commentators have underlined the urgent need for a proper balance between individual expectations and community needs. Their main argument is the existence of remarkable examples of efficiently jointly managed commons in various different local communities.

The struggle between comedy and tragedy then takes place on a fine thread, which proves to be particularly thin in relation to some of the goods traditionally considered in literature: natural, essential and limited resources, such as freshwaters, fisheries, forests and grasslands.

This kind of resources has gradually led to a further attempt to find its marks, by setting up different categories in relation to the combinations of the two mentioned key-factors of the commons. To this regard, economists started to conceptualize the idea of common pool resources (CPRs), as from the middle of the fifties (Samuelson, 1954). The definition is a metaphor which evokes the problems of congestion and over-exploitation deriving from the difficulty to manage systematically individual uses and ambitions of enclosure with regard to some goods (Ostrom, Gardner, Walker, 1994). CPRs, therefore, are characterized by subtractability and by the risk of over exploitation. Excessive consumption derives from the difficulty – often in terms of costs and infrastructures – in preventing unauthorized beneficiaries from using them and

results in rival consumption.

A notable contribution to the subject has been brought by Elinor Ostrom, whose analysis has shown a feasible and economically efficient alternative to public or private property, that is to say self-management of the resource by local communities, with due respect of social, cultural, economic and environmental features of each area concerned (Ostrom, 1999). In particular, Elinor Ostrom has tried to translate into generally valuable theories and empirical models the cases she has been considering. In particular, she has proposed the adaptive governance as a sacheme for the management of CPRs, grounded on five fundamental pillars: collecting up-to-date and comprehensive information; dealing with conflicts and solving them quickly; enhancing rule compliance; providing infrastructures; encouraging adaptation and change.

A further combination of the constitutive elements of the commons has originated the concept of club or toll goods, which are excludable but non rival. Indeed, the category entails all circumstances in which the chance to benefit from the use of a resource is in theory unclosed, but in practice subject to the owner or manager's authorization. The latter is usually dependent on the payment of a fee or further conditions allowing for the selection of the users. In this perspective, the access to telephone communication infrastructures appears to be a widespread example. By boosting its boundaries to the maximum extent, some commentators have even applied the category to the Eropean Union, due to the procedures and criteria which candidate Member States need to meet to join the international organization (Ahrens, Hoen, Ohr, 2005).

2.2. The broad application of the notion of commons: new sides of the Rubik's Cube?

Even if the categories under consideration have often been linked to natural elements and to the subsequent risk of man-made damages, the notions have gradually evolved, thus also embracing "new commons", such as artificial or immaterial goods (Hess, 2008).

As from the nineties, the deepening of the interdisciplinary studies has then given shape to a new era of the subject, characterized by the attempt to apply the traditional paradigm to sharply different elements. New commons are mainly represented by human-made and technology-driven phenomena, but also resources related to individuals' fundamental rights are now taken into consideration, as in the case of health-care commons (Cassel, Brennan, 2007). Indeed, a general overview of the scientific literature on the matter shows a certain degree of creativity, together with the tendency to expand the borders of the concept to the largest extent possible. According to social scientists, for instance, commons should include surfer's waves (Rider, 1998), sports (Bird, Wagner, 1997), public radio (Brunner, 1998), traditional music (McCann, 1995) air slots (Sened, Riker, 1996), campus commons (Boal, 1998); urban commons such as apartment communities, residential community associations, streets, parking places, playgrounds and reclaimed buildings (Oakerson, 1999); highways and transboundary transportation systems, (Van Vugt, 1996); tourism landscapes (Healy, 1995); cultural treasures (Sax, 1999); car sharing institutions (Prettenhaler, Steininger, 1999) and sewage (Svderberg, 1997).

The set of commons has then be read in conjunction with health-care resources, among which some authors enumerate antimicrobial resistance (d'Oronzio, 1994) and with the so called neighborhood or hometown commons, that is to say public spaces,

squares, green and gardens, or even security and the respect of tolerable levels of noise in urban contexts (Foster, 2006). Also, the existence of several cultural commons has been promoted, involving public art, music, spiritual heritage, landscapes; another category can be represented by knowledge commons, whose importance has increased sharply in modern societies.

Finally, some scholars have detected a group of global commons – usually referred to as global public goods – whose importance places them at the top of the pyramid of the resources which must be preserved for the benefit of the future generations (Buck, 1998). This category includes financial stability, climate change-related issues, biodiversity, atmosphere, global genetic commons and so forth.

The flourishing of the commons has put traditional theories under pressure. In particular, some of the new resources clearly show peculiar features, whose connection with the mentioned biophysical characteristics of the commons is feeble, thereby highlighting the need for a more attentive analysis. The definition itself of "new commons", indeed, is to a certain extent troublesome, since it has been used with different meanings in literature, in order to include resources which go far beyond the barriers of Hardin's paradigm.

From a terminological point of view, the notion of new commons may raise negative connotations which obscure the fact that "old" resources are in any case the result of dynamic institutional choices and governance schemes, subject to constant change thanks to internal or external factors and to technological development. A more cautious theoretical reading of the phenomenon would then suggest the need for a reinvention of the category, in favor of the challenges brought by institutional and cultural debate and by technological development.

Some scholars have argued on the increasing importance of technology for the content of the notions of commons, common pool resources and club goods. Many of the newly classified elements «*have until recently remained unclaimed due to the lack of technology for extracting their value and for establishing and sustaining property rights*» (Ostrom, 1992). Inevitably, the categories are then reinvented mostly thanks to the new frontiers of technology: some resources can be captured only through modern technologies (space, or even the Arctic region and its hidden natural treasures have recently become a strategic land of conquest); others are priced and empowered by technology (renewable energies, irrigation methods); many man-made resources are to a large extent dependent on technology and its landings.

3. Even more complex than a Rubik's Cube? The Internet: a multi-layered technology-driven and human made set of commons.

3.1. The attempts to solve the twisty puzzle: Internet complexity in multi-disciplinary literature.

In this entangled and movable context, the Internet appears to be the most complex and challenging of the new (or, we may say, technological) commons. Its complexity derives first of all from the interlinked system of technologies, contents and multi-layered legal or institutional regimes. Secondly, the model of governance of the Net, characterized by the coexistence of national sovereignty claims and the universalistic ambitions of the resource, as well as by the contribution of several international bodies to its development, reveals the continuous search for a proper

balance between enclosure, shared management and exploitation (Oddenino, 2008).

Once again, as from the nineties, many authors have proposed different views of the Internet from the perspective of common resources. This is mainly due to the evoked factors of complexity, but also to the fact that the operational potentialities of the Internet have increasingly (and sometimes surprisingly) grown in a very brief lapse of time, thanks to what has been defined a true scientific revolution (Dyson, 1999). Besides this, the first comments on the nature of the phenomenon sometimes manifested a certain degree of ideological transport: according to Lessig, «*Internet is an aberration in a property obsessed era, [a] space anyone can enter and take what she finds without the permission of a librarian or a promise to pay*» (Lessig, 1999).

An overview of the main issues raised in literature highlights two different trends. On the one hand, as already mentioned, Internet has been considered a set of specific common resources, such as information commons, social commons and technological infrastructure commons (Cahir, 2004; Zdarsky, Martinovic, Schmit, 2006). The Net would play a prominent role among knowledge commons, since users benefit from free access to huge amount and variety of information and contents. In the meanwhile, it has also been listed – together with transportation systems and communication networks - among the infrastructure commons, due to the technological material backbone it is based on (Little, 2005). To a certain extent, Internet has also been identified as a global public good, a powerful source of knowledge sharing, communication and development for the entire world, in particular for less developed countries, where the digital divide represents a stumbling block (Fattal, 2004).

On the other hand, some scholars have tried to apply to this context the traditional notions. The latter have identified the classic failures of overuse and mismanagement in the collateral effects of free-riding, such as information pollution, misuses for committing crimes, individual overexploitation (Hess, 1995).

Accordingly, some commentators have pointed out the risk of a congestion of the web, being individual users fully unaware of the comprehensive status of the system and not charged with adequate responsibilities in proportion to their uses (Huberman, Lokose, 1997). Under this point of view, the originally limited possibilities to accumulate indefinite and contextual individual uses brought some commentators to focus on the reach of the bandwidth: «*Key common resource is not an open pasture, but bandwidth*» (Kollock, Smith, 1996). On the contrary, Hess prophesied the overtaking of these technical limitations negatively influencing the access to the Internet and the availability of its contents, thereby defining the bandwidth as a community commons which could have been properly managed and developed for the benefit of any user (Hess, 1995). As we will see, such concerns are still relevant today, because of the harsh debate over the appropriation of the structures providing for the large bandwidth.

At the same time, it has been argued that the institutional and technological branches which compose the growing tree of the Internet are not balanced, since the fast development of the latter is not accompanied by a parallel rush by legal institutions, unable to adapt and catch it up (Benkler, 1998). This point has gained particular consensus as to wireless communications, with a widespread criticism on the delay of outdated and inappropriate regulatory institutions to deal with new spectrum technologies. More in general, the two-speeds evolution of technical standards (and potentialities) and of the institutional approach to Internet-related questions has raised the attention of the scholars, who have always been attentive in scrutinizing the role played by ICANN and the other global institutions and bodies for Internet

administration.

3.2. Solving the Cube layer by layer: a feasible method to address Internet commons.

The multidisciplinary approach to the commons and to the complex essence of the Internet itself draws an extremely heterogeneous and composite scenario. This complex background allows for some reflections on the main features of the Net as a shared resource.

First of all, even if in the past it was argued that «*congestion of the Internet is a present and potentially paralyzing public bad*», claiming for strict regulations and adequate tariffs to control individual uses (Gupta, 1997), the traditional paradigm of the tragedy of commons is hardly applicable to the access to the web. Unlike ordinary common pool resources – and in particular natural resources – the Internet usually is not characterized by subtractability, a feature that Gardner and Ostrom list among the fundamental conditions for a common pool resource dilemma (Gardner, Ostrom, 1990). In relation to many resources available electronically, modern technologies allow for the overtaking of any fear for excessive exploitation and subsequent exhaustion, as it occurred for bandwidth at the beginning of the Internet revolution. Instead, the logic underpinning the offer of contents on the Internet is reverse: web sites try to maximize their use, by attracting as many users as possible, in order to widely disseminate the information they provide or increase revenues through advertising. Moreover, on many occasions cyber-resources seek for the active contribution of each user.

On the one hand, individuals' participation is often requested in case of open-source software, commonly shared websites or other digital products, whose development and improvement is highly dependent on the sharing of knowledge, comments and experiences by users. On the other hand, the Internet is a powerful vehicle for information sharing and knowledge diffusion. Some scholars have in particular resumed these characteristics theorizing the role it is playing in fostering global democracy (Levine, 2002). Obviously, access and participation lean on different levels of the stage: while it is relatively simple to provide facilities and contents for the access, positive contribution entails the sharing of rules, behaviors and sometimes even values distinctive of an Internet community.

If considered from this perspective, the Internet could be seen as a commons which meets the requisites Elinor Ostrom enumerates to identify a non-problematic common pool resource, where contents are to a certain extent shared by users without limited access or benefit dilemmas asking for external solutions and limitations to individual expectations (Ostrom, 1990).

The size and complexity of the Internet are therefore at the same time factors allowing individuals to take benefit from it without the risk of exclusion, but also represent an obstacle for the analysis of its essence. The presumed absence of evident "tragedy of the commons" concerns actually doesn't mean that the Internet is immune to problems and limitations under the perspective of its fully shared management and development.

The potentialities expressed by the Internet in terms of increasingly massive amount of shared information and infrastructural management have in their turn inspired the need for a distinction among different common Internet-related resources. Actually, before analyzing the features and the limits of the Internet as a commons, it is interesting to note that literature has granted to it a fundamental importance in the

attempts to sketch a taxonomy of modern shared resources.

Many authors advance the Internet as a key-pawn on the undefined and evolving chessboard of the scientific study of the subject. In fact, it is a subset of a general category and it is included in the groups of technology-driven commons, but at the same time it implies and fosters different sub-categories of resources. Such internal complexity first of all entails the layer of the physical and material facilities through which technology is expressed, the backbone of the whole system (Hess, 1995). Secondly, technical standards, domain names, applications and software represent the logical subset, thanks to which the Internet is enabled to work and is managed (Abbate, 1999). Lastly, some scholars mainly focus on the contents of the Net, that is to say immaterial information exchange and knowledge commons (Greco, Floridi, 2004).

These three distinct levels embody essential components of the Internet, but reveal extremely different features (Benkler, 2006). Moreover, in their turn, they involve further subset of goods, each of them functioning as a single colored piece of our metaphoric Rubik's Cube, capable of moving independently from the others.

In conclusion, the Internet turns out to be an autonomous habitat where a variety of species of different resources – material and immaterial; private, public and common – live and flourish. As a consequence, any in-depth analysis of such phenomenon leads us to avoid a unilateral approach: the notion must be broken down in all the pieces it is composed by.

Therefore, bearing in mind the extensive solutions proposed in literature, we propose to solve the ambiguity of the notion of commons referred to technology-driven and human made resources by considering step by step each of the three levels which the Net can be de-structured in: infrastructures layer; functional layer and content layer.

4. Twisting each piece of the Cube: Net complexity in the perspective of common resources.

4.1. The backbone of the Net: infrastructures and material equipment.

According to a scholarly wide definition, the Internet can be described as a system allowing for communication of several kinds of contents between users (Solum, Chung, 2003). If we look at the Net from this point of view, the first step of the analysis must be focused on the nature of the physical devices which enable communication. Hardware components include an increasing number of tools, which intervene at different levels in the communications process: wires, wireless networks, routers, mobile devices and, of course, computers.

In most cases, almost paradoxically, the key-components allowing for netsurfing and all the subsequent activities reveal a surprising combination of the biophysical features of the commons: they are at the same time characterized by excludability and rival consumption. In a few words: they are purely private goods.

This is in particular true for computer hardware, which are usually devoted to individual use or owned by private or public organizations, where access is authorized only to a set of specified beneficiaries. Nonetheless, if we take a closer look, we may notice that, when connected to the Net, these strictly private resources are transformed into bridges for the sharing of contents, knowledge or even disk storage. Moreover, some peer to peer communities take benefit from the powers of the computers hooked to the Internet. A perfect example is represented by Skype community, run by a company

which exploits the users' devices to set up VoIP connection, thereby allowing for free phone or video calls and for the commercial provision of such activity (Hofmokl, 2010).

Telephone cables are private goods as well, but the management and maintenance of the whole infrastructure implies huge costs, which make personal property impossible. In practice, the material skeleton of the network is owned by large telecommunication companies, enjoying an oligopolistic or even monopolistic position on the market. Due to this situation, companies are strictly supervised by public authorities and the commercial exploitation of such peculiar private goods is highly regulated.

The picture is further diversified by wireless networks. Originally, the limits imposed by technological development made such networks a clear example of CPR. In fact, they interfered with radio waves spectrum, which is a scarce resource rivalry exploited. Nowadays, wireless networks are undergoing a significant evolution, since more efficient receivers are able to distinguish between the different sources of signals and certain frequencies can therefore be shared (Benkler, 2006). Technological development has then sketched a fragmented painting, where commercial wireless networks provided by telecommunication companies are accompanied by municipal networks freely used by citizens and by open, bottom-up networks. In conclusion, WiFi networks can show both the features of a club good or a public good, depending on the provider of the service and conditions imposed in order to have access to the infrastructure.

4.2. The functional immaterial level: technical standards, domain names, software.

Several immaterial resources are at the core of the communication process between computers. Technical standards and protocols enable hardware to interact, fixing the rules of communication.

Protocols and standards were originally created as public and non-rival goods, available to any user of the Internet community, in order to help to build an increasingly complex and widespread network. The Internet Engineering Task Force (IETF) established under the auspices of the Internet technical community, the primordial attempt to set up a governance framework of the Net, from the early eighties developed such protocols and left them open and public. Moreover, the Internet Society copyrighted them, in order to preserve their openness from any attempt to subtract them to free access.

The Internet itself is then based on nonproprietary standards allowing for its end to end architecture to work, freely available to anyone and traditionally conceived as global public goods. For instance, HTTP protocol and HTML programming language were kept open by the inventor Tim Berners-Lee, in order to let other users help to develop them.

On the contrary, many standards or technical aspects at the basis of file formats are covered by patent law or copyright. Indeed, they are usually essential to exploit exclusively a software on the market. In these cases – such as .doc other Microsoft formats – the resources are necessarily private and excludable, if not exclusive. They can be eventually shared only in case a license is given after the buying of the software and can therefore be included among the club goods.

Key-elements of this layer are also IP addresses and domain names. From a taxonomic perspective, they can be considered private goods, since they are exclusively

managed by the Corporation for Assigned Names and Numbers (ICANN). ICANN is a non-governmental organization which is allowed to confer the right to use a certain domain name, according to the first-come, first-served rule, as an expression of the absence of formal hierarchical relationships in the Internet community.

Another highly influential group of resources at this level is represented by applications and software, that is to say all the resources which allow the computers to perform productive tasks, translating the contents from machine calculations to human language. As it can be easily understood by this wide definition, software and applications are not exclusively web resources: on the contrary, many of them work without an Internet connection and perform tasks which are fundamental to the functioning of the computer machine (i.e.: operating systems, video and audio software and so forth).

The nature of such resources is highly controversial. In fact, the initial impulse to the Net, during the seventies, was grounded on the open access principle, according to which the global Internet structure should have been strengthened by the contribution of the users themselves, thanks to the establishment of an increasing number of local networks. The open access to source codes also permitted an easier solution to certain flaws of the software and a more efficient configuration of computers to safeguard individual needs. Nonetheless, the promising commercial value of such resources fostered a diametrically opposed vision, expressed by Bill Gates in his "Open Letter to the Hobbysts" in 1976. In that document Mr. Gates laid the foundations of the software industry, explaining his view on the main reasons for limited access to source codes and the detrimental effects of open access principle for service providers. From that time on, the software layer has always developed on a dual basis, boosted at the same time by private commercial initiatives of IT companies and the efforts to promote freely available software. The debate is also reflected in literature: some scholar underline the urgent need for protection of IT intellectual property rights, also in relation to Internet software; according to others, the immaterial resources of the Internet should be supported by citizens'-led knowledge and consensus building process, asking for everyone's contribution to find collectively solutions and further developments for growing social, cultural economic challenges (Greco, Floridi, 2004).

This is the reason why this category of immaterial resources can be numbered among private or public goods, on a case by case approach. Certain software –even essential to the daily activity of an user such as Internet Explore, Mozilla Firefox or Adobe Reader – are distributed for free, while several others are need to be bought and licensed. Instead, they hypothetically share an interesting common feature: being immaterial goods in digital format, their codes could be copied without significant costs and loss of quality. This is in particular true for public access software; on the contrary, companies usually restrict the possibility to reproduce the codes by the system of licensing. In a word, software are theoretically non-rival consumption goods. Therefore, open source software can be classifies as public goods, while private ones are club goods.

4.3. The content layer.

Information is an essential component of the resources included into this layer. Thanks to technological development, the digitalization process has led to a sharp change in the access to such resources, either in their quality and quantity. Internet contents are immaterial goods in digital form and take the shape of different expressions

of human intellect: texts, music, videos, images, opinions and so forth. Hess and Ostrom have underlined the difficulty to develop an exhaustive analysis of this category, due to its fuzzy boundaries and continuous evolution. Nonetheless, they have tried to select three different kinds of information goods: artifacts, facilities and ideas. Artifacts are the expressions of an idea; facilities store and make them available; ideas are the immaterial core of an artifact and can be caught to understand the creative content, knowledge or information at the basis of an immaterial human-made product.

Traditional physical artifacts are private goods, but their digitalization allows them to be copied without loss of quality. From a theoretical point of view, the same file could be contextually used by several netsurfers, since the access by one of them does not entail exclusion to the detriment of the others. Nonetheless, the simple fact that information is non-rival doesn't automatically neutralize all the normative grounds for exclusion and their enforcement i.e. through judicial remedies or public authority. Indeed, in this field non-rival consumption has to be balanced with individual's property and privacy. Personal artifacts can therefore be protected from external exploitation, depending on the sensitivity of the ideas expressed. On the contrary, many artifacts are commercially exploited or even freely edited on the web, as in the case of wikis, where users can share information and contribute to their development. In conclusion, access to artifacts – as well as to the ideas they express – can be strictly denied, regulated by intermediary solutions or totally free. According to the conditions set for the access to artifacts and their copies, these resources can be considered either public goods, club goods or definitely private goods. The same trend is shown by digital stores and repositories, the facilities through which artifacts and ideas are made available. They typically fall among the club goods, but an increasing number of open access databases can be detected.

5. From individual attempts to solve the Rubik's Cube to general applicable algorithms. Internet commons, something more complex than a twisty puzzle: conclusions, challenges, perspectives.

5.1. The interconnection between private property and public Internet goods.

The analysis we have conducted till now has shown the main elements increasing the complexity of the Internet as a set of multi-faceted goods. If we take a look at this scenario from a general perspective, our eyes are first of all captured by a minimum common pattern: the constant interconnection between public and private essence of the resources involved.

On the one hand, this feature refers to each good individually concerned. First of all, the several combinations of the two key-biophysical elements of the commons reveal the surprising absence of the option non-excludability/rival consumption. We can as a consequence point out that Net related resources can hardly be qualified as CPRs, one of the most frequent and highly investigated subset of common goods.

Secondly, on the contrary, easy exclusion combined with non-rival consumption is widespread. It means that club goods, which have traditionally been playing a secondary role in the masterpiece of the commons, are a core element at each of the three layers of the Net. Moreover, the category of club goods itself has been strengthened and widened. In the past, it was mainly applied to low-scale and locally based communities, such as private parks or clubs, which were treated by scholars as a

sort of impurely private goods. Technological development has gradually led to expand the notion to almost public resources, which can gather millions of users all around the world at the same time. Nowadays, it embraces even globally spread resources: satellite services (on-pay television; GPS mapping), electronic repositories of data or articles and, of course, many Internet clubs, including the use of certain software or the access to the network infrastructures.

Thirdly, many of the components of the three layers enjoy a dual essence. The same goods, with different institutional arrangements and in diversified situations, show the features of either private or public goods. Some of them can even fall into three categories – private, club and public goods – depending on the choices of the formal or informal actors responsible for their creation and the subsequent access policies.

Fourthly, the functioning of the Internet shows a constant interaction between public and private dimensions. For instance, a privately owned computer, once connected to the Net, becomes a positive contributor to the ongoing communication processes and a powerful tool to link individual's personal sphere to the web community.

Another even more relevant example regards the search for a proper balance between public protocols, private commercially licensed software and private networks. Indeed, the Internet is a sum of privately owned and administered networks, highly heterogeneous because of their different owners: families, companies, associations, public authorities, even Internet service providers. Internet protocols facilitate the interoperability between such huge amount of exclusive networks, thereby allowing for privatization and decentralization of network management and policies. At the same time, the close link between common standards and local networks translate into practice the end to end rule, a fundamental Internet architectural principle according to which the network provides for basic communication tools only, while the implementation of the users' specific applications is left to the devices connected to the ends of the network itself (Saltzer, Reed, Clark, 1984).

The principle permits the Internet to work as a neutral platform, where individuals can perform their activities, provide and benefit from applications and services independent from the immaterial backbone of freely available technical standards and protocols (Mueller, 2002). As already mentioned, for instance, communication capabilities of Skype can be implemented without the permission or any interference by the network providers, who just enable the coordination between different individuals' ends. In conclusion, at the individual end level of each users' computer, the Internet is private and exclusive; at the protocol layer, instead, it is nonproprietary and open: the private sphere (either the individual one and the stage of commercial exploitation of material devices and software) and the public goods complement each other in order to foster the Internet growth and the reduction of barriers to access.

5.2. Common resources, the broadband and the principle of network neutrality.

Despite its fundamental importance, the end to end principle seems to be at stake. Since the diffusion of new technologies on broadband, a highly controversial debate has been reflecting a magmatic search for a renegotiation between the private and public components of the Internet.

In the recent past, the narrowband technology confined the Internet to asynchronous exchange of data. In such a context, a single regulated monopolistic

company could provide basic infrastructures for web communication on a fundamentally equal basis to other companies. On the contrary, under this perspective, broadband technology is highly critical, as it allows for competition among networks. Therefore, large sized companies con establish their own network, competing with other providers. The capital-intensive investments needed to set up alternative infrastructures make a significant selection of the actors on the stage, so that only a few companies compete. Moreover, in several States the exploitation of broadband is not regulated and supervised by a public authority, since this regime is usually left for telecommunication services. Institutional choices therefore foster this rush to the top among selected market actors, indirectly putting under pressure the principle of neutrality of the network.

The arguments raised by the supporters of the opposing views to a large extent reflect the traditional grounds for privatization or openness of digital resources.

Efficiency, reduction of costs, better management and improved services are the main points remarked by opponents of Net neutrality, who sometimes even stress the importance of a stricter control over the contents in order to maximize the value of the communication processes and of the applications available for consumers (Yoo, 2007). Besides this, also spurring technological innovation and safeguarding free market competition are listed as critical values. In fact, it has been argue that neutralizing networks means standardizing products and services, thereby preventing competitive differentiation and creating stumbling blocks to capital investments for the construction of new facilities. Another interesting theme is the possibility to transpose competition among networks also in the field of the contents of the Net, the resources the users price the most and expect to have access to on nondiscriminatory basis.

On the other side, supporters of Net neutrality remark that this principle is not property of the Internet: instead, it is Internet, as it expresses its core essence and the main impulse to its gradual growth, as from its origins till now. Common property of Internet protocols then has been and is the premise for any technical improvement of the network and the possibility to benefit from its resources freely and equally. As a matter of fact, Internet has evolved thanks to a series of informal rules which have always oriented and inspired its development: decentralization; individuals' contribution to its technical growth and to its contents; the attempt to break down limits to access to the network; respect for minority views; strong efforts to reach consensus; involvement of public authorities or international specialized organizations in the management of the key-resources for the common benefit.

Once again, the duel takes place on a fine thread representing the balance and the interconnection between the private and public sides of the Internet, the expectations of a bottom-up and decentralized Internet community and the attempts to subject it to the chains of exclusivity and subtractability.

5.3. Domain names and IP addresses: advances and pitfalls of the centralized management of common resources.

The policies concerning the allocation and assignment of domain names and IP addresses are another critical question, which mainly refers to the problem of the model of global governance of the web (Oddenino, 2008). This is due to the fact that they are the only identifiers enabling the direction of data through the Net. Being unique, they need to be coordinated at global level and assigned exclusively to specific users, in order to ensure the uniformity and compatibility of the whole system.

Since the beginning of the Internet revolution, the strategic importance of such

immaterial resources was clear. Their management entailed significant policy choices, but also huge economic expectations deriving from the markets of domain names and IP addresses registration. Therefore, the US Government decided to award on a temporary basis the function of domain names registration to a small company – the Network Solutions Inc. (NSI) – under the scrutiny of US public authorities. In 1997 the contract expired and the US Government had to choose between the privatization of the sector and its maintenance under the aegis of public power. In the first case, the NSI would have inherited a *de facto* monopoly: therefore, potential competitors and other civil society bodies claimed for the second solution.

The Government actually walked the second way, by awarding a central role to the ICANN, a Californian non-profit corporation established *ad hoc* to perform the task to neutralized such strategic resources and supervised by the US Government, namely the Department of Commerce. Even if the organization is subject to Californian law, the effects of its activity are global, since it is responsible for the administration of the domain name system and Internet addressing system roots (Mueller, 2009). The roots were recognized as common resources, in relation to which no private property could be conceived, but a centralized system of allocation based on trusteeship at any level of the Internet global community. The same institutional choices were taken as to second-level domain names, whose regime is once again focused on the role of the ICANN.

The establishment of a collective governance of the domain name system was not intended to replace private market in domain name registrations, but to facilitate it, in particular providing a neutral institutional background for the global regulation of domain name registries and users, granting equal access to the registry. The system also aimed at avoiding the raise of dominant and exclusive property rights in a delicate sector for the whole functioning of the Internet.

The activity of ICANN has resulted in a partial success, but is currently facing major challenges. Despite remarkable outcomes in the market of second-level domain name registration, spread criticism has been raised as to the functioning of the commons-oriented governance system it leads. The main question is therefore the effective implementation of globally uniform policies, which has often proven to be controversial and difficult, due to the various and often opposing interests at stake. The need to search for accountability and to reach consensus of influential interest groups has resulted in powerlessness and stasis. Such situation is almost paradoxical, if we consider the rush of the Internet towards always new winning posts.

At the same time, while ICANN strives to maintain the unity and global dimension of the Internet, the web is a battlefield for national sovereignty, which overlaps its claims of control and policy choices over the resource. States are then allowed to play a double-hat role. On the one hand, they often aim at imposing a direct contribution to the management of the Internet – for instance through the administration of country codes – causing the phenomenon of balkanization of the web. On the other hand, according to their legal orders, they can limit or deny access to the contents of the web, built parallel and autonomous infrastructures to secure and control users' activities, but can also censor, control or delete its contents. Therefore, even if the ICANN follows complex multi-stakeholders deliberative procedures and is supported in its activity by further international bodies representing the various social categories at stake, the administration of the resource is still quite far from fitting the specific features of the Internet as a commons well.

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