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Lilian Coelho de Freitas
(Organizadora)

Engenharia Elétrica e de Computação: Atividades Relacionadas com o Setor Científico e Tecnológico 3

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APRESENTAÇÃO

A Atena Editora apresenta o *e-book* "*Engenharia Elétrica e de Computação: Atividades Relacionadas com o Setor Científico e Tecnológico 3*". O objetivo desta obra é mostrar aplicações tecnológicas da Engenharia Elétrica e de Computação na resolução de problemas práticos, com o intuito de facilitar a difusão do conhecimento científico produzido em várias instituições de ensino e pesquisa do país.

O *e-book* está organizado em dois volumes que abordam de forma categorizada e interdisciplinar trabalhos, pesquisas e relatos de casos que transitam nos vários caminhos da Engenharia Elétrica e de Computação.

O Volume III tem como foco aplicações e estudos de atividades relacionadas à Computação, abordando temas variados do *hardware* ao *software*, tais como automação e robótica, arquitetura de redes, Internet, computação em névoa, modelagem e simulação de sistemas, entre outros.

O Volume IV concentra atividades relacionadas ao setor elétrico e eletrônico, abordando trabalhos voltados para melhoria de processos, análise de desempenho de sistemas, aplicações na área da saúde, entre outros.

Desse modo, temas diversos e interessantes são apresentados e discutidos, de forma concisa e didática, tendo como base uma teoria bem fundamentada nos resultados práticos obtidos por professores e acadêmicos.

Boa leitura!

Lilian Coelho de Freitas

SUMÁRIO

CAPÍTULO 4

SUBMARINE CABLES, GLOBAL CONNECTIVITY AND HUMAN RIGHTS: THE INVISIBLE BORDERS OF THE INTERNET

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ABSTRACT: Some 400 submarine cables weave an invisible yet crucial network for our connected world. 1.3 million kilometres long, they are essential to the proper functioning of the Internet and account for 99% of intercontinental trade. International backbone providers play a key role in global connectivity in interconnecting national and international networks into a complex network of submarine highways, which make the Internet not as decentralized as it is commonly said. In fact, submarine cables belong to a few private companies operating without any identified regulatory agency or international norms. The industry of submarine cables has experienced an enclosure movement with consequences for the physical structure layer and the logical infrastructure layer as well. This movement has led to deregulation in the telecommunication sector, which explains why we need to think another governance of Internet infrastructure, if we want to address key issues such as monitoring network interferences for protecting human rights violation, developing affordable and inclusive connectivity and providing a platform for gathering deep-ocean and seabed data for a range of environmental issues. This article demonstrates that, in order to address these distinct issues, we need to develop a comprehensive approach of submarine infrastructures focused on human rights issues.

KEYWORDS: Connectivity, infrastructures, submarine cables, network interferences, commons goods, human rights.

RESUMO: Cerca de 400 cabos submarinos tecem uma rede invisível mas crucial para o nosso mundo conectado. Com 1,3 milhão de quilômetros, são essenciais para o bom funcionamento da Internet e respondem por 99% do tráfego intercontinental. Os fornecedores de backbone internacional desempenham um papel fundamental na conectividade global e interconexão de redes nacionais e internacionais em uma complexa rede de rodovias submarinas, o que torna a Internet não tão descentralizada quanto é comumente dito. Na verdade, os cabos submarinos pertencem a poucas empresas privadas que operam sem agência de regulação ou normas internacionais identificadas. As ações da indústria de cabos submarinos impactaram a camada de estrutura física e a camada de infraestrutura lógica. Esse movimento levou à desregulamentação do setor de telecomunicações, o que explica porque precisamos pensar em outra governança de infraestrutura de Internet, se quisermos abordar questões-chave como monitoramento das interferências da rede para impedir violação de direitos humanos, ampliar o acesso e inclusão e

atuar em prol de questões ambientais. Este artigo demonstra que, para abordar essas diversas questões, precisamos desenvolver uma visão mais abrangente a respeito das infraestruturas submarinas voltada para agenda de direitos humanos.
PALAVRAS-CHAVE: Conectividade, infraestruturas, cabos submarinos, interferências de rede, bens communs, direitos humanos.

1 I INTRODUCTION

The digital world is often reduced to its software and semantic layers, to the detriment of the physical layer. The physical layer of all computer networks is essential to the functioning of cyberspace, defined by the "communication space made up of the worldwide interconnection of automated digital data processing" (ANSSI, 2019). Almost all international interconnections go through submarine cables. Because of their reliability, security and low cost, compared to satellite connections, they are considered as critical infrastructures for the Internet. The establishment of a worldwide telecommunications network constitutes one of the major developments of the contemporary era. Since the first telegraph cable was laid across the English Channel in the 1850s, the development of this network has continued to the present day with the setup of constantly improved and increasingly numerous intercontinental telephone links. (GRISET, 1992, p.19) Some 400 submarine cables weave an invisible yet crucial network for our connected world. 1.3 million kilometres long, they are essential to the proper functioning of the Internet and account for 99% of intercontinental trade. International backbone providers play a key role in global connectivity in interconnecting national and international networks into a complex network of submarine highways, which make the Internet not as decentralized as it is commonly said. Hence our research questions: What kind of actors own and control submarine cables? what kind of physical threats endanger this network of global communication? How submarine cables can be used to fulfil sustainable development goals such as inclusion and prevention of climate change? We provide therefore a general overview of these issues divided into three parts. If submarine cables are strategic infrastructures for the development of the Internet understood as a globalized, private-owned and concentrated market (I), they remain fragile state-control infrastructures poorly protected by international treaties, especially in wartime, and constantly targeted by various network interferences (II). Therefore, we need to consider submarine infrastructures as global facilities that must be managed as common-pool resources meant to reach sustainable goals such as digital inclusion and ocean protection (III).

2 I THE STRATEGIC INFRASTRUCTURES OF A GLOBALIZED, PRIVATE-

OWNED AND CONCENTRATED INTERNET

While the routes of submarine cables have not changed much since the invention of the telegraph in the 19th century, they face challenges that have evolved considerably with the exponential development of the Internet, leading to increased dependence on these infrastructures. They are the physical vectors of information flows and contribute to the disruption of the notion of distance by virtually bringing together the nodal points of the global Internet network. Combined with commercial transportations, they encapsulate the nexus of the digital and globalized economy as international division of production processes. Because cables are largely dependent on the geography of the sea and the oceans, access to maritime areas, detroits, and landing points are determinant for the connectivity of a country. This economic pattern was established in the second half of the 19th century, when the colonial powers deployed the first telegraph networks to defend their strategic and commercial interests over long distances. Great Britain, then the first maritime power, has embarked on a vast program of submarine cable construction to feed what has become the nerve centre of the world economy and communications: London. The expansion of this communication system was necessary for the growth of the capitalist economy, which largely financed the construction of cables. Private companies initially contributed to develop the domestic network, before putting this experience at the service of the global expansion of the colonial powers. After first tests in 1838, the first functional cable was laid in 1851 between the French and English coasts, and served first and foremost to exchange financial rates. The first transatlantic cable was laid in 1858, the first trans-Pacific cable in 1902, both analogue. In 1870-71, London was connected to India, Hong Kong and Australia. In building the world's first instantaneous information transmission network, Britain took a conceptual and operational advantage over other major powers (WINSECK and PIKE, 2007).

In the 20th century, the United States took over from Britain and did play a key role in the technological advances that have allowed the rapid expansion of the Internet over the last thirty years. A breakthrough is achieved when the first fibre optic cable (TAT-8, transatlantic) is laid in 1988: transmission capacity increases rapidly, multiplying the number of fibres per cable, plus a multiplexing to pass through several signals on the same colour of the fibre (BOULLIER, 2014). The capacity of fibre-optic cables, developed since 1988, is incommensurate with those of their distant ancestors. They are opening a new era, that of very high speeds, where cables are gradually preferred to satellites for sustaining the global information and communication network. Thanks to optical technologies, submarine cable capacity has increased by a factor of more than 10,000 leading, in the year 2000, to transmission equivalent to more than 100 million simultaneous telephone calls across the ocean on only one cable (CHESNOY, 2016). For instance, the MAREA cable between Europe and the USA is now able to carrying 160 Tbps (terabits per second, equal to 1 million megabits per second). The ELLALINK cable connecting Brazil to Europe will carry 72 Tbps, which might be enough to cover the current needs of all Latin American countries. In 2008, the International Telecommunication Union noted that it had taken more than 100 years for telecommunications to reach one billion users worldwide and less than five years to reach the second billion, essentially through mobile phone. The geography of the users of these cables has also changed. At the end of the 19th century, there were indeed a few thousand users of the telegraph, mainly located in areas already connected with domestic lines. In fact, John Pender and Julius Reuters, the biggest investors in transoceanic connections, parlayed their early domestic experience into the conquest of global markets. (WINSECK, 2007) By the end of the 20th century, there were already 400 million regular Internet users, or about 5% of the world's population. The figure is 4.2 billion today (Internet World Stats, 2019). In 1997, the United States accounted for 56% of the autonomous systems that manage computer networks connected to the Internet, for only 5% in the BRICS. In 2017, there were 39% in the US, and 17% in the BRICS[1]. Latin-America, Asia and Africa have been passing through a request of huge transformation of their infrastructure, with the construction of new submarine cables, national backbones and internet exchange points (IXPs), linking Brazil, for example, to Europe and Africa. But if the technologies and their uses have evolved, the geography of submarine cables is similar to what it was at the beginning, since the routes taken in the 19th century are still today. The world map of cables thus highlights the current predominance of the hierarchy between places of globalization. It shows a high concentration of cables connecting the United States to Asia and Europe (Telegeography, 2019). At a time when dozens of cables connect the United States to Europe, Latin America still has no direct connection with Asia.

In this context, the distribution of private investment in submarine cables represents a major challenge for states, as the ownership and control of infrastructure is a decisive element for the control of cyberspace. For example, some states have invested in new cables and adopted US bypass strategies, which are also due to the explosion of data traffic and current forecasts. According to the CISCO Visual Networking Index, overall IP traffic is expected to increase by 30% by 2021, or nearly 200,000 petabytes per month and 127 times the volume of traffic traded in 2005 (CISCO, 2019). In this context of explosion of demand, the composition of investments in transoceanic cables has been profoundly transformed. During the

1 ITU Broadband Commission, The State of Broadband 2017: Broadband for Catalyzing Sustainable Development, 2017

first decade of development of new fibre optic systems, the cable industry relied on consortia of national operators, including many state monopolies. This situation changed after the adoption of a principle of regulated competition, which was adopted by many countries in the wake of the Telecommunications Act passed in the United States in 1996. Between 1990 and 2000, the number of regulatory agencies on telecommunications has increased from 14 to 90, then to 166 today. On this occasion, the share of capital held by public operators fell considerably, to less than 1% of the total investment.

A new wave of investment has been underway since 2008, favoured by the spatial multiplexing of optical fibre (which makes it possible to simultaneously borrow a wider spectrum of colours). These investments initially concerned the Asia-Pacific region before expanding to Africa, Latin America and the Middle East. Between 2008 and 2015, $ 11.8 billion was invested, of which 57% in the BRICS ($ 6.7 billion), and more particularly in the Asia-Pacific region[2]. 25% of investments took place in Africa ($ 2.9), where four cables were built on the West Coast, three on the East Coast. Four new cables now connect India, the Middle East and Europe. Finally, several cables are under construction in the South Atlantic. On the other hand, the inter-BRICS cable project, announced in Brazil in 2014, was abandoned. While the financial participation of the States remains modest, it continues to increase to reach 10% of the investments since 2010. The States of the South, in particular in Asia, invest alongside the international banks of development, with the capital of operators national or regional public, but also that of the giants of the Internet (Google, Facebook, etc.), whose share of investment has significantly increased (WINSECK, 2017).

Who benefits from these investments? Historically, mostly operators like Verizon, AT & T, Sprint or Level. Less known than Google, Microsoft or Yahoo, these companies were nicknamed by Edward J. Malecki the “old boys” of the Internet, because they have been for a long time quasi-monopoly on the main information highways (MALECKI, 2002). They have also benefited telecommunication companies that have specialized in international bandwidth access, such as Level 3, Global Cloud Xchange or Tata, or Content Delivery Networks, which are 90% owned by a few companies including Amazon, Akamai, China Cache and Level 3. Finally, Internet giants like Google and Facebook began to invest heavily in the 2000s and are now involved in several projects to ensure their independence in the transportation of data.

For these reasons, consortia are today much more heterogeneous than in the past, traditional operators (private or public) facing increased competition with

2 UNITY (2010) ; the South-East Asia Japan Cable (SJC, 2013) ; the Asia Pacific Gateway (APG, 2016), and FASTER (2016).

the arrival of new types of operators who have significant financial leeway. These investments raise a number of challenges to the principle of common carriage (or net neutrality), which has long prevailed in the management of the physical infrastructure of the Internet. We must take them into account to better understand the recent evolution of the FCC (Federal Communications Commission) in the United States (Tebba Von Mathenstien, 2017). Net neutrality ensures that all data circulating on the Internet is processed with the same speed of transmission. The term was used for the first time in a 2003 article by Tim Wu (2003). Net neutrality debates must be understood in the context of this battle between traditional operators like Verizon, Comcast and AT&T, and their rivals native to the Internet age, like Google, Facebook and Netflix. The battle is fueled with the financial windfall of advertising and online video services, which will account for nearly 80% of Internet traffic in 2020. Conventional operators are concerned about the cost of transporting billions of data from other companies at low cost. In order to stand out, Microsoft, Google and Facebook are investing heavily in their own subsea infrastructure, while Amazon and Apple are investing in data centers at cable landing points. Google and Facebook have sought to compensate for the bandwidth demand by taking shares in four major submarine cable projects, launched during the previous decade (Unity, SJC, APG, and FASTER) which are needed add The New Pacific Cross Cable (NCP) and Pacific Light Cable Network (NCP).

3 I FRAGILE AND UNREGULATED STRUCTURES TARGETED BY VARIOUS NETWORK INTERFERENCE

The underwater cables constitutes a network which was costly to install and difficult to maintain. Cables, which form a physical connection between two points seeking to communicate, necessitate rigorous control: they require supports along the chosen route, as well as a fleet capable of laying, protecting and repairing the conductors. However, cables remain fragile infrastructure suffering from accidental or intentional physical aggressions, all of which are not sufficiently prevented from happening by international legislation. These interferences are of different kind: accidental or intentional physical breaks (notably for political purposes). It is estimated that about 300 physical interferences (BLANC, POZNANSKI, 2018) per year on cables between 1959 and 2006, most accidental (44% by fishing and 15% by anchoring due to maritime traffic) but 21% remain linked to unknown causes, among which intentional attacks on telecommunication lines (HEADRICK 1991).

In Somalia, for instance, the cut of a cable in July 2017 has disconnected the whole region during three weeks and caused financial losses estimated to 10 millions dollars/day (KHADIM, 2017). Similarly in early 2017 in Cameroon, in the midst of an internal conflict between Anglophone and Francophone ethnic groups, the government did not hesitate to cut Internet access for 4 months in the English-speaking part of the country (which represents 20% of the population), directly landing point of a submarine cable, again leading to significant economic losses and serious human rights abuses[3]. These state interruptions deserve great attention, because they can contribute to the outbreak of violent conflict, or even civil wars[4].

The maritime environment has always posed a threat to the preservation of telecommunication lines – especially in wartime. In 2005, the International Cable Protection Committee (IPCC) estimated the economic loss of a cable cut at $ 1.5 million per hour. This figure has almost doubled in 10 years and could continue to increase as the digital companies become more interdependent in the 21st century. The IPCC estimates that 300 interferences, voluntary or involuntary, disrupt every year the Internet traffic passing through these cables. The consequences of a submarine cable break-up can have a severe impact on a country's economic activity, either in terms of a slowdown in the actual flow or in terms of financial loss (MOREL 2016). In 2008, two cable breaks in the Mediterranean have affected Egypt, the whole of the Arabian Peninsula and even India, which has lost 40% to 50% of its capacity on the network.

Submarine cables, the physical layer of cyberspace, constitute in this context a privileged target for cyberattacks, whether in the China Sea, the North Atlantic, the Mediterranean or the Indian Ocean. This vulnerability is directly due to incomplete protection in international law. In its forward-looking Future Shocks study, the General Secretariat for Defense and National Security (SGDSN) (French government body attached to the services of the Prime Minister), has emphasized that "submarine cables providing digital communications become potential targets in the game of power (SGDSN, 2017). NATO's military leadership has warned in recent years that the Russian navy is aggressively probing undersea communications cable networks. Consequently, an attack that would cut submarine cables coming into the United States or Europe could significantly harm access to the global internet (MATIS 2012).

Is international law sufficient to protect these cables against such high risk of interferences? In France, interference monitoring is done first through operators such as Orange, who are able to detect and locate a possible cut or degradation on a submarine cable. The French Navy patrols the French maritime areas, particularly in the exclusive economic zones (EEZs) (CABIROL, 2017). The main international body protecting submarine cables remains the Convention for the Protection of Submarine Telegraph Cables of 1884, signed by 40 countries agreeing on a punitive

3 "Access to information: the worrying case of Cameroon submitted to the UN" https://internetwithoutborders.org/access-to-information-the-worrying-case-of-cameroon-submitted-to-the-un/, Accessed on January 10, 2019

4 Brazil, elections 2018: the risk of an Internet shutdown must be taken seriously. Available in: https://direitosnarede.org.br/p/brazil-keep-it-on/. Accessed on 11 mar. 2019

measure in case of aggression to cables. In 1958, the Geneva Convention of the High Seas Act states that third states cannot prevent the construction of cables in international waters. Finally, in 1982, the UN Convenvention on the Laws of the Seas determined that cable protection should be a priority. The convention offers certain legal protections, but is today considered obsolete or limited in its real scope, especially in wartimes. In fact, submarine cables carry both civilian and military data, which seems to make them legitimate targets in the event of armed conflict. As recently noted by Roxana Radu, submarine cables are not internationally protected as non-military targets in wartimes[5].

In addition to physical interference, intelligence agencies perform mass surveillance programs conducting network interferences all over the world. As revealed by Edward Snowden in 2013, the US government from submarine cables carries out bulk data collection through submarine cables and landing points, via interception programs such as Upstream and Tempora (coordinated by the Five Eyes alliance), as well as the program Quantum Insert, especially turned to submarine cables (HOURDEAU 2014). Just as Russia's underwater activities foster a climate of general mistrust, which contributes to the collapse of international standards, the Snowden revelations cast an enduring suspicion on the core networks of the Internet. Consequently, some states try to escape the systematic surveillance of the United States, fuelling unilateral dynamics of fragmentation of the Internet. As a result, control of landing and interconnection points is highly strategic for state agencies. In the United States, for instance, the President has the authority to grant or withdraw licenses for the landing of submarine cables. Since 1921, the Cable Landing Licenses Act has exempted this type of decision, passed in the greatest secrecy, from the control of the American Congress. In 2014, the National Security Agency (NSA) allegedly hacked the SEA-ME-WE 4 submarine cables management and management site (linking France to Singapore), confirming the strategic nature of these landing points, which remain state prerogative (AFP, 2013).

The vulnerability of these infrastructures gives power back to state actors who use strategies of piracy or military intimidation, and reveals in a problematic way the insufficiency of the legal framework in force, like the United Nations Convention on the Law of the Sea (BARKER, 2018). The revelations about Russia's naval strategy, alongside with the NSA's mass surveillance programs, demonstrate the inadequacy of existing international standards, which do not provide enough protection for states, companies and citizens against the abusive interference practiced on the physical networks of the Internet. Whether in the form of systematic data collection or physical cutting of submarine cables (including for domestic purposes), these practices

5 IGF 2017 - day 2 - WK XII - WS128 - The future of Internet governance (intervention of Roxana Radu). Available in https://www.youtube.com/watch?v=i9uedpjiFg0. Accessed on 11 mar.

could constitute violations of international law (crimes of aggression, etc.) (Internet sans Frontières, 2017). International regulation of network interferences is all the more important that submarine cables are essential facilities to fulfill sustainable development goals.

4 I ESSENTIAL FACILITIES TO FULFILL SUSTAINABLE DEVELOPMENT GOALS

In this last part, we would like to demonstrate why submarine cables should be considered as essential facilities meant to fulfil sustainable developments goals (SDGs) as digital inclusion and prevention of climate change.[6] The current laying of submarine cables is a tremendous occasion to reduce the inequalities of Internet access. The cost of Internet access is often considered one of the most important factors in explaining the digital divide. In 2008, the costs of accessing international bandwidth were 1,000 to 2,000 times higher in Africa than in Europe or the United States. (INTERNET SOCIETY, 2017) Additional access to the international network of submarine cables is often considered a good way to reduce the digital divide of the continent. For instance, over the past ten years, additional submarines were landed on the African continent (Manypossibilities). The creation of interconnection points (IXPs) has also made it possible to create open access to new operators and to foster the development of the internal network, improving the connectivity of several countries, such as Ghana, Senegal or Kenya. In Africa, as in other continents, coastal countries hold a position of strategic superiority over landlocked countries (INTERNET SOCIETY, 2018). In this respect, the example of the relations between Chad and Cameroon is emblematic of the geopolitical tensions around access to the Internet (BLANC, OWONO, BOAKYE, 2014).

Even if the costs of access to international bandwidth are not as high in Latin America, they still remain ten or even twenty times higher than those practiced in Europe (BOUDREAU, 2017). To remedy this situation, several cable projects have been put in place, such as the SACS cable, which links Angola to Brazil since last February, or the ELLALINK cable, which will connect Portugal to Brazil, via Cape Verde where it must interconnect with West African cables. The Seaborn Networks consortium is also building a cable linking Fortaleza (Brazil) to New York (U.S.). Called Seabras-1, this program must eventually link African financial centers, via South Africa. The southern Atlantic coastline is therefore becoming one of the new routes to digital globalization. But inequality remains important. According to information provided by the ITU, which ranks Internet indicators by country, 49.43% of the population has Internet access worldwide (A4AI, 2017). In Brazil, despite the

6 Submarine cables deals with several SDGs such as Goal 9 “Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation”, Goal 10 “Reducing inequalities” and Goal 13 “Climate action”.

proliferation of cables in recent years, only 61% of homes are connected to the Internet (NIC.BR-CGI, 2018). That being said, while two-thirds of Internet users lived in the United States in 1996, they now account for only 11% of the total, while China now accounts for 20%. But while the number of people connected around the world has increased and diversified, the rate of increase is slowing and there is a strong expectation that a ceiling will be gradually reached once areas with market interests will be connected.

From this perspective, it is worth noticing that increasing the number of submarine cables or their capacity does not have necessarily a direct impact on global connectivity and inclusion. Depending on their geographical distribution and the local infrastructure, submarine cables can have impacts on universal access, increasing digital divide in poorly equipped areas, located far away from landing points, especially in landlocked regions such as Central Africa or Amazonia. However, paradoxically, some countries with populations sparsely distributed over large or landlocked territories might exhibit a larger spatial digital divide after the laying of additional submarine cables. This can be due to the change of scale between international broadband access and national limitation of cables infrastructure to distribute the bandwidth capacity (CARIOLLE, 2018). This observation, which can seem paradoxical, can be explained in two ways.

First, in terms of connectivity, the demand for cables satisfies two complementary requests. On the one hand the increase of international bandwidth for more connection in remote areas and, on the other hand, the satisfaction of a demand for ultra-connectivity in central areas to meet the needs of new data centres. They ensure the provision of better browsing quality by eliminating latency or strategies such as smart cities, demanding a large portion of bandwidth. Mostly private investments, their deployment requires a large number of interconnected ISPs. The population density decreases and the distance to landing points increases, the margin for commercial exploitation decreases or becomes negative. Thus, once the cable is installed, it is mainly the public support of national broadband plan and points of interconnection that will ensure the proper distribution of bandwidth over the territory. This step is often made difficult by the absence of commercial regulations clearly identified (CARIOLLE, 2018).

Moreover, the decrease of investment costs led the cable industry to reduce the number of investors. As a consequence, there is a shift from consortium owned cables with multiple landing points, such as the ACE or the WACS in West Africa, to private owned cables connecting directly financial and digital hubs, such as Seaborn connecting directly São Paulo to New York, or the SACS and MONET cables connecting the US to Angola, via Fortaleza. This trend might contribute to increase the digital divide at the regional and global levels. It appears also that without a better regulation in interconnection with national infrastructures, the increasing of submarine cables won't really help to connect the next billions of inhabitants. Rather than meeting sustainable development goals such as reducing inequalities, the increase of submarine cables may only meet new demands of bandwidth in already connected areas (5G, connected objects or connected citizens).

For instance, Brazil is about to welcome a new submarine cable (ELLALINK) to connect Latin America directly to Europe, with a capacity of 72 Tb/s equivalent to all of the international bandwidth that connects actually the country through the other cables actually connected. The ELLALINK cable deserves special attention because its history testifies to the evolution which are played out in the South Atlantic. A few months after the revelations of Edward Snowden, this project was presented by President Dilma Rousseff as a way to restore the digital sovereignty of Brazil. This project owes its impetus to the National Network for Research (RNP), created in 1989 to set up a university network across the country. Along with Brazilian Internet Steering Committee (CGI.br), created in 1995, RNP is one of the pillars of the Brazilian model of Internet governance, which aims to guarantee the inclusion of all sectors involved in the development of the Internet in Brazil and to limit the influence of private interests on the management of traffic and content. The impetus for the ELLALINK project came from the RNP who bought a part of the bandwidth capacity for its own communication (RNP, 2019). The cooperation of the South American and European astronomical laboratories indeed requires an efficient, reliable and independent network, especially since the launch of the Cerri Paranal Observatory in Chile, which will soon produce 70% of the world astronomical data, up to 20 Tbs of data per night of observation. This cable is representative of the challenges facing the governance of the Internet. First, notwithstanding the remarks made above, it might contribute to lower prices for international bandwidth access, as the cost of accessing global data traffic through the United States is still ten or even twenty times higher for Latin America than for Europe. This cable will also open a new route for global traffic, largely controlled by the United States, by directing it to the European Union and Brazil, whose personal data protection legislation is often an example. Finally, the pairs of optical fibres will be dual-use, granted on the one hand to telecommunication operators (EULALINK), and on the other hand to non-commercial operators (networks GIANT Academies for Europe and Red-CLARA for Latin America). The arrival of non-profit institutions in the management of these infrastructures could open the international bandwidth to an entire digital ecosystem based on cooperation and sharing, such as community networks or mesh networks, in full expansion. This distribution of bandwidth is a good example of the role that non-commercial actors could play in the management of Internet traffic and restores some meaning to the notion of common carrier, which has been undermined by private operators in the recent debates around net neutrality. This cable is also an issue for the redistribution of power in the Atlantic Ocean. It opens a new route for transoceanic data traffic, previously largely controlled by the United States, by directing it to Brazil and the European Union, whose laws on the protection of personal data appear more only in other parts of the world.

There is another initiative that might be of interest to fulfil sustainable development goals. It consists in using submarine cables in the fight against global warming. For several years, the International Telecommunication Union (ITU) has been coordinating an initiative involving some 100 partners to promote the implementation of scientific sensors along submarine cables, in order to measure in real time the climate changes, which depend on the traffic oceans (ITU, 2019). The temperature and salinity of water are indeed the elements that govern the density of water and, with the cumulative effect of wind and solar energy, the circulation of the oceans. Rising temperatures make some greenhouse gases less soluble in water, preventing their natural storage in the oceans. If these variables could be measured at various points on the ocean floor, climate change would be better monitored. However, as the International Cable Protection Committee notes, only a tiny fraction of submarine cables are currently used for deep-sea scientific observations. To generalize this dual use of submarine cables would make it a powerful instrument for measuring global warming, accessible to the scientific community.

Thus, submarine cables provide a platform for gathering deep-ocean and seabed data for a range of environmental issues. Our oceans and climate are experiencing global changes, including warming, acidification, and sea-level rise, that affect us now and in the future. A standard telecommunication system includes an electro-optical seabed cable with optical repeaters approximately every sixty kilometres. By adding environmental sensors to the repeaters, we could have access to a global network of real-time data for environmental threats and disaster mitigation. An early-warning system for tsunamis could save lives and prove invaluable, particularly for developing countries, where the comprehensive coverage of all subduction zones is not viable. Since tsunami waves often arrive less than thirty minutes after offshore earthquakes, every minute counts. To bring this concept to fruition, the international Joint Task Force of three United Nations agencies – the International Telecommunication Union, the World Meteorological Organization and the Intergovernmental Oceanographic Commission of UNESCO (ITU/WMO/IOC-UNESCO JTF), established in 2012, is working towards incorporating environmental monitoring sensors into trans-oceanic submarine cable systems. Telecommunications industries now have a heavy responsibility to pool their networks with climatologists, as with tsunami prediction centers, caused by deep-water earthquakes. This initiative is all the more important since cable construction generates a significant environmental impact since it requires the extraction of rare mineral elements. with repeaters composed of erbium-doped fibers (CHESNOY, 2016).

CONCLUSION

In conclusion, the Internet technology was initially praised for making possible the attainment of decentralization, self-determination and democratization by enabling small groups of constituents and individuals to become users — participants in the production of their information environment — rather than by lightly regulating concentrated commercial mass media to make them better serve individuals conceived as passive consumers (BENKLER, 2000). In the meantime, the industry of submarine cables has experienced an enclosure movement with consequences for the physical structure layer and the logical infrastructure layer as well. This movement has led to deregulation in the telecommunication sector, which explains why we need to think another governance of Internet infrastructure, if we want to address key issues such as monitoring network interferences for protecting human rights violation, developing affordable and inclusive connectivity and providing a platform for gathering deep-ocean and seabed data for a range of environmental issues.

Therefore, we need to think about an alternative economic model to private market for managing the core infrastructures of the Internet. Elinor Ostrom's researches has now established that common resources – forests, fisheries, oil fields or grazing lands – can be managed successfully by the people who use them rather than by governments or private companies (OSTROM, 1990). The Internet has already produced common-pool resources such as the digital commons, with the major examples of free softwares and Wikipedia, whose value comes from commons-based peer production. Similarly, community networks provide now common-pool connectivity infrastructures for an increasing number of Internet users (BELLI, 2017). The purpose and the underlying values carried by such examples offer a sustainable alternative to the production by the state or private companies. Similarly, we would like to demonstrate that submarine cables could also be managed as common-pool resources, building on existing initiatives promoting non-commercial uses of submarine infrastructures.

Last, the above-mentioned obsolescence of international treaties for the protection of submarine cables demonstrates the need to raise these difficult issues in the public sphere. Infrastructures are not only communication tools; the way they are designed and managed have also political implications. Usually unnoticed by most of their daily users, submarine infrastructures should be discussed more often in the public discussions surrounding Internet governance. Otherwise, invisibility will remain a market strategy used by private companies to foster deregulation and monopolies, or by state agencies to monitor and eventually disrupt strategic networks. Taking back control over submarine infrastructures is a matter of public interest. This move is crucial for the development of open, inclusive and community-based networks. We need to start managing submarine infrastructures as common-pool resources, because they are essential facilities to fulfil sustainable development goals and keep the Internet without borders.

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