Future Paths of Evolution in the Digital Ecosystem

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1 Introduction

The term digital ecosystem was coined by Fransman (2010), who understood it as all the activities created around the technological development of the Internet, ranging from network infrastructures to applications and end-user services. Since its origins, the digital ecosystem has undergone expansion and growth of new business models, social relationships, and exchange of information which were previously unheard of. Many of the new economic agents that have emerged as a result of new opportunities brought by network development have broken with the conventional model of business growth and evolution. We are witnessing a relatively recent process, which particularly began in the 1990s. The process shows one particularly relevant feature; it is a system that evolves very rapidly and in which conventional order and power patterns have changed significantly.

It was in the 1960s that the US Department of Defence began to develop the Arpanet project. The research project was originally a communications network to connect university computer groups to share computer resources that were only available at certain research centres. The development of the Internet architecture and the new communication protocols, such as TCP/IP created by Cerf and Kahn (vid. Cerf and Kahn, 1974), that were later improved (vid. Leiner et al. 1985), to create the World Wide Web (another work of individual genius by Tim Berners-Lee at CERN) in 1990, was a complex process.

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The design of the Internet as an open shared network with standards and open protocols, and a structure designed to be scalable, where new nodes could be added without altering its essence (Leiner et al. 1997), has proved to be a technological and economic success. The Internet has been a wonderful laboratory for research, fostering communication and innovation. Open collaboration has strengthened the power of the network in this virtuous circle although the big leap toward the digital ecosystem as we know it today was boosted by two key aspects. Without them, the Internet would have merely remained an interesting academic experience and never have become a social and economic phenomenon of paramount importance. These aspects were the expansion of telecommunications infrastructures and the availability of the resources to guarantee permanent connectivity anywhere, the ubiquity of the network, and also the necessary development of reasonably priced user-friendly terminals, the user interfaces with connection capacity and access to the Internet. Internet offers a new space to host the information, providing new services and contents demanded by users. The Internet has caused disruption in numerous scopes. It is not only a technological advance, but also an economic one, as it alters the conventional relationships established in the classic supply and demand model, and also what could be considered a more subversive element, that of human relationships. This new immediate global connection model has changed social relationships, from the closest family nucleus to relations at work, and brought a new political and social order.

There is a great deal of literature from the field of economics on different theories that help to explain the changes driven by technology development (see Chapter "Introducing an Epigenetic Approach for the Study of Internet Industry Groups" in this book by Gómez-Uranga et al.). The development process of economic and scientific models shares many similarities with it. The paradigm of technological progress understood from the conventional approach, as pointed out by Kuhn (1962), determines not only scientific-technological research but also innovative thinking. As Kuhn stated, the evolution of ideas in the scope of science traditionally occurs due to the accumulation of discoveries which are largely works of individual genius. When there is an exception to the model that significantly prevents it from fitting in the traditional paradigm, a disruption is created that will lead to a change in the system. The new paradigm enables explanation of the disruption in an orderly manner. In this sense, the arrival of the Internet and the enormous development in telecommunication technologies in recent decades have allowed the creation of a new ecosystem: the digital one whose rapid development we are witnessing. The new approach we are introducing in this book, Epigenetic Economic Dynamics (EED), enables us to explain the dynamics occurring in the digital ecosystem from a disruptive perspective as regards conventional models. The new ecosystem is distinctive for carrying a strong innovation component in various scopes: technology, economic and social. Another feature of the new model represented by the Internet is the speed at which the ecosystem itself evolves. This may be analysed in terms of a new disruptive phenomenon which a new paradigm such as the epigenetic one can reasonably explain.

The environment of the so-called digital ecosystem shows some particular characteristics that mark a change in comparison to traditional innovation models and the frameworks of the paradigms they are set within. These characteristics have determined their development and will affect their evolution in future. Some of the most outstanding of them are: (i) It is a global phenomenon; (ii) It has an open architecture; (iii) It embraces high creativity and innovation levels; (iv) It changes and adopts innovations quickly; (v) It eases user interactivity with technologies and applications and (vi) It produces economies of scale and scope.

The firms in this ecosystem operate in an environment which offers constant opportunities but demands ongoing efforts to keep pace with the ecosystem's growth and capture the value it is continuously generating. The concept of EED makes it possible to analyse the dynamics and processes that companies are subjected to as the ecosystem evolves.

2 Technological Progress and Expansion of the Digital Ecosystem

Technological evolution occurs at different levels in the ecosystem. The Internet ecosystem as we know it today would not have been possible without the network infrastructures, the operability of critical Internet resources and the backing of governments, particularly that of the U.S., which took an active role in the Internet's evolution and development.

The digital ecosystem has evolved in recent decades although, in essence, the Internet has maintained its original open architecture. It is a model which facilitates interactivity of the agents that form the ecosystem. Internet architecture is tier-based with the communication capacity distributed in each node. It transfers basic information units or packets via packet switching technology by using specific protocols developed for the Internet (the TCP/IP model). This is done via multiple communication channels so that access to the information can follow many alternate routes to reach the destination.

One of the recent key phenomena is greater transmission and reception capabilities in mobile services. Driven by users' demands and the availability of equipment and terminals permanently connected to the network, mobile wideband services are the ones showing the highest global growth in recent years. In 2014, mobile data traffic increased by 69 % over the previous year, reaching 2.5 Exabyte per month at the end of 2014 (Cisco 2015). Projections indicate that mobile data traffic on the Internet is expected to continue growing. In 2014, mobile data traffic was nearly 30 times the size of the entire global Internet in 2000. Mobile video traffic is the most demanded service by network users at the present time, with over 497 million new connections and mobile devices (e.g. smartphones, tablets, etc.) added in 2014.

The Internet is a global phenomenon. The total number of global connections in 2014 (number of devices) reached 7.4 billion (Cisco, 2015). The demands of

new users accessing the network, plus those who are already connected, mean that higher capacity mobile wideband is needed. Mobile wideband is expanding parallel to the development of new services and applications in the Internet environment. In this new environment, firms operating in different fields of production should work together. The success and expansion of many of the latest innovations and developments (i.e., applications, operating systems, terminals, etc.) is based on their capacity to interact, ensuring that the new products are compatible with existing ones.

Mobile wideband expansion requires a limited resource, or public commodity, which is the radio spectrum. There are several possible technology solutions to guarantee such high connectivity levels without compromising the quality of the service. More bands should be enabled, jointly with other complementary solutions such as re-use of the spectrum resources currently being used, improving spectral efficiency and increasing performance and capacity of the channels per megahertz of the spectrum used, particularly for the applications and services most demanded by users in certain geographic areas. 4G LTE (Long-Term Evolution) technology-based wireless communications and new developments make it possible to improve and increase the network's capacity (see Chapter "4G Technology: The Role of TelecomCarriers" in this book by Araujo and Urizar on this very matter).

The Internet is a connection, information and exchange platform. As the digital ecosystem expands, it includes new services on a daily basis; new connections are being made to devices and connectivity is added as everyday objects integrate technology. The need for better connection and wideband capacity is an indication of future tendencies. High-speed Internet connections currently generate more average traffic on the network than slower ones. This situation seems reasonable insofar as 4G users report higher quality and satisfaction with their mobile devices when accessing to web services and online content. Growth in the use of new connection devices is mostly related to smartphones (which only accounted for 29 % of devices in 2014 but 69 % of total handset traffic) and tablets (74 million connections in 2014), vid. Cisco (2015). Globally, there were nearly 109 million wearable devices in 2014 generating 15 petabytes of monthly traffic.

In developed nations, where a higher percentage of the population is connected to the Internet, users normally access the network with more than one mobile device. Mobile Wi-Fi, (also called Mi-Fi) is undergoing dramatic growth. Many smartphones have an integrated Wi-Fi hotspot that other Wi-Fi enabled devices can use to connect to the Internet. These devices may use the same mobile phone number or telecommunications operators may not assign telephone numbers to all the devices that connect via their networks. This is the case of devices which are not designed for voice communication, but only data transfer, such as e-readers, tablets, laptops or modem cards and mobile Wi-Fi hotspots. Use of these devices has increased sharply in recent years and projections predict continued growth in future. Services providers and operators compete against each other and also with other companies (with different genomic instructions), different sales strategies (some of which may be set within the EED paradigm framework such as their genetic footprint), in technical aspects such as speed, coverage and price of

the services, or with mixed models that offer users other devices and terminals. Service providers and operators often set up alliances with other business groups (i.e., equipment providers) in the ecosystem and create synergies in groups that have opted for vertical integration of business activities, adding new roles to the DNA, according to the EED approach. Machine-to-machine (M2M) connections are also increasing. M2M systems include transport management systems, vehicle tracking and fleet management, security in homes or businesses, other telematics services or smart grid devices.

Some recent studies point to a disparity between users' demands for mobile wideband and the increases in capacity that technology can actually reach, taking the spectrum's limited nature into account and the current allocation (Clarke, 2014). This imbalance is due to economic factors, infrastructure deployment and improvement costs; oversight related to the changes required in regulations and adoption of new standards; and political aspects related to public policy and social welfare. If the necessary adjustments are not made, the wireless network capacity may hinder expansion in some regions, widening the digital divide between countries.

2.1 Development of New Networks

The digital ecosystem's growth is based on one essential pillar that supports the entire system: infrastructures. This is a vital factor which has fostered and affected the network's expansion and evolution from the beginning. The digital ecosystem should not be limited by geographical boundaries on a scenario like today's where the available existing technology guarantees connectivity. Nevertheless, there is a considerable digital divide between countries. Whereas networks have expanded greatly in developed nations and the coverage ratios for the entire potential population are slightly above 90 % in urban areas (i.e. reaching a potential of 99.7 % in the case of the USA—Federal Communications Commission 2014a), there are still over 4000 million people that have no access to the Internet. Expansion of the digital ecosystem to the entire world population raises a challenge. Nearly 3 billion people had access to the Internet in 2014 and two-thirds of them were living in developed nations. The remaining third is the population of developing nations. Of these user connections to the Internet, 2.3 billion were mobile wideband, although in this case the distribution between users in developed and developing countries was more proportionate. Figures in 2014 were 45 % for the former and 55 % for the latter (ITU, 2015).

Ideal access to the network can be defined as that which allows Internet connection at the appropriate speed to access the desired content when and where the user chooses. From a strictly technical point of view, connectivity is strengthened by the availability of different technologically suitable solutions to achieve global deployment that guarantees connectivity. Furthermore, development will be fostered if the deployment is economically competitive. Guaranteeing connectivity and mobility are some basic requirements for the Internet to evolve.

There are different types of new available broadband networks. The most outstanding are the 4G LTE/Wimax wireless networks that require, as mentioned above, the use of the radio spectrum which is a limited resource. However, deployment of broadband network architectures using fiber optic cables (for instance, Fiber To The Home, FTTH) offer high speed and good performance. Other technology solutions such as the DOCSIS 3.1 cable modem, copper-based xDSL and even PLC power lines provide high-speed access. The technology now available enables global coverage to be provided. Examples include satellite networks, which have currently improved their speed, or undersea fiber optic cables. A variety of technology mixes are available and offer alternative scenarios at the same time. Mobile systems are competing with and replacing fixed networks, which is boosting development of the latter. The quality of the service, either via fixed or mobile connections, is not expected to be an issue in the future. The most suitable technology solution will depend on the characteristics of the demand; based on the services that will be provided, the orography, population density, cost, future maintenance, etc. The optimal deployment choice in each case is a compromise between different technical, socio-economic and political factors.

Backhaul services link mobile services with switching centres within the core network, and the rest of the world, i.e., the public switched telephone network (PSTN) or the Internet. In mobile networks the majority of backhaul services have cell towers connected via fiber optics. In countries that have these ultra-fast connections via optical fiber cables (i.e. in the U.S.), agile deployment of new technologies such as 4G LTE is easier (Federal Communications Commission, 2014a). The need for mobile broadband backhaul support will continue to increase as operators deploy the latest technologies for 4G access that enables users to make intensive use of data via their mobile devices connected to the Internet. Some widely demanded services, such as video streaming, require high-speed connections. In some cases, projections for future growth have been very high, as have been the costs involved in carrying out these investments, which raises new challenges for digital ecosystem firms.

2.2 Emerging Technologies and Future Platforms

Numerous applications and developments appear in the digital ecosystem on a daily basis. This is an environment in which certain actors, which act as gatekeepers, determine the evolution of the ecosystem's dynamics to a great extent. The EED approach helps explain systemic evolution, although changes in the digital ecosystem are often fast and disruptive. The new developments occur at different levels within the Internet: in service infrastructures, integrated platforms, apps, software development and new devices.

Operating systems are one of the factors having the greatest impact on development of new applications. Companies that provide enabling services and solutions to access the Internet, play a key role as gatekeepers in the network. Some

years ago it was PCs whereas today smartphones are users' favourite connection interface, which means that a smartphone's operating system is one of the factors that most affects firstly, development, and later access and use of network services based on mobile applications. In the future, the Internet of Things (IoT) will introduce new devices. Two large platforms are outstanding in the digital ecosystem, which are partners with two of the largest business groups nowadays. On the one hand, Apple's operating system with its iOS, and Google (Alphabet) with the Android system.

Thanks to the development of the fourth-generation technology, television broadcasting over the Internet with high-quality video online is changing the multimedia industry, which is facing new challenges and opening new experiences to the users. The arrival of new agents in the ecosystem is changing the audio–visual industry, TV and cinema, similar to what occurred some years ago in the music industry with new business formulas and viewer interaction. The dynamics of these new groups can be analysed under the EED model.

Cloud services (i.e. cloud, TV, etc.) are undergoing rapid growth in the digital ecosystem. Cloud providers have been called the way of the future in network development and access to content such as storage platforms and interconnection of large amounts of content, particularly multimedia. Interconnection and operability between the different cloud services platforms and storage are essential to guaranteeing the plurality of service providers, acting to stop future oligopolies in this field.

The emergence of Big Data enables treatment and analysis of huge amounts of data accessible on the web, resulting from users' interaction on social networks, use of applications, sensors, smart city deployment, traffic mobility patterns, access to public services, energy consumption, distribution networks, smart grids, etc. Available analytical tools enable us to make use of information in very different fields: professional, commercial, operations, intelligence, etc.

The IoT is a new arrival on the digital ecosystem scene that shows the most potential for the near future, particularly for business groups that already form part of the ecosystem.[1] The IoT also shows good prospects for new firms in the ecosystem that want to penetrate a new market with their solutions. The connection of multiple devices used daily or regularly, such as clothes, accessories, health monitoring systems, vehicles, etc. will mean an enormous increase in the number of interconnections and will most likely accelerate infrastructure development. Application of solutions in the healthcare field is transforming medicine, where operation and interaction models with users are evolving.

M2M networks to connect small devices and other equipment are undergoing considerable growth in developed nations. This increase is expected to continue in other areas of business, such as home security, care and other financial, education and leisure services, etc.

[1]These companies only need to add functions to their DNA under the EED model, and a growth opportunity through external knowledge to their genomic instructions.

Interconnection and operability between different platforms is a key factor in the digital ecosystem's development. Adoption of standards, homologation of devices and applications have fostered growth and development of the digital ecosystem and have made possible this new environment. This new diversity faces pressures imposed on the ecosystem by big firms, with their pioneering innovative developments, which are ultimately proprietary, and create even greater customer loyalty, as their users unawaringly give their consent.

Security in an open environment like the Internet has become an increasing concern to system users and agents. Progressive encryption of communication via the networks is one of the most accessible solutions. Some cases in point are the development and use of proprietary protocols such as the combination of the protocol developed by Google in 2012, SPDY, with the use of Google's own CPD proxy server. With the use of encrypted data streams and the new protocols, technological advances improve existing security solutions on the Internet. The new procedures make it possible to verify user authentication but also present new problems for global and local security authorities such as government access to communication encrypted by private firms, which have the encryption algorithms, codes and passwords. Technology is aseptic although its use is not. The drive to achieve approval and adoption of the HTTP 2.0 protocol as an open shared standard for all the agents in the Internet value chain can be seen as the response of some system agents to Google's initiative with SPDY. Responses in such a rapidly evolving competitive environment should be even faster or else companies will be left out.

Technology makes it possible to intercept communication by following users' movements from the different communication interfaces to the network. An intrinsic part of the ecosystem is that users must give their formal consent and accept the companies' privacy policy for the servicers used, without feeling they are being controlled by any business organisation.

2.3 End of an Era: An Open Net of Networks?

The Internet model as a sole, open and horizontal network has been evolving since the big business groups achieved control of large enough market shares to secure customer loyalty and capture the users that chose their platform. The development of APIs, open interfaces and standards, or free software are technical features that prevent an abrupt break with the original model of the Internet. Instead, we are witnessing a smoother evolution of the digital ecosystem toward what is practically already a reality in the digital environment. These could be considered small and large fragmented islands in the digital ecosystem. The main ones, which are identified by the operating systems they are based on, still maintain the interconnection between platforms.

These interconnections could break during the ecosystem's evolution. For reasons of security, exclusivity or special features, the networks' isolation and opacity

may be accelerated, meaning the de facto break from the model of theoretical freedom that the Internet represented in its origins.

Rules and regulations applied by governments in their scope of jurisdiction (Open Internet Rules) normally refer to both fixed and mobile wideband access, requiring services providers to publicly and reliably disclose the necessary information on the management procedures, results and commercial terms or practices they have in place so that users can make informed decisions concerning the use of these services. Keeping watch on an open Internet means adopting regulations that restrict procedures which companies might carry out to discriminate or block access to other agents in the digital ecosystem. The U.S. Federal Communications Commission took a position on this point in 2014 (vid. Federal Communications Commission 2014b).

3 The Value Chain and Business Models in the Digital Ecosystem

The digital ecosystem is a complex environment where agents with extremely different activities and roles interact. The Internet's arrival and development have led to new ways of establishing economic relationships on markets. The EED approach can be used to explain the dynamics and adaptation to the environment that the main agents participating and creating the ecosystem have undergone (Gómez-Uranga et al. 2014).

The digital ecosystem is distinctive for being a highly innovative and creative environment where changes are intense and evolution is very fast. If there is one aspect that accurately defines the scenario, it is constant change which is often disruptive and original. Disruptions in this scope enable continuous innovation and technology development.

The new environment that the digital ecosystem is evolving toward involves changes in conventional business models in many industries, but also changes in the roles that were traditionally assigned to market suppliers and users. Roles are sometimes transformed in the digital ecosystem, and this is especially obvious in the scope of content. This is one of the key aspects of the digital ecosystem, not insofar as the volume of business generated at the present time, but due to the high growth and large returns on investments it is showing. Information control is a powerful tool that the industry has been aware of since the Internet's origins. From initial market research to satisfaction surveys, marketing tools have evolved to obtain knowledge of the target users' profiles and even detailed information about them.

Hereafter, we review the Internet's classic value chain model, which was defined by Kearney (2010) at the time. In essence, the model is still valid to describe the main agents that participate in the system (vid. Fig. 1). However, the scope was more limited than the description of the ecosystem, as the participating

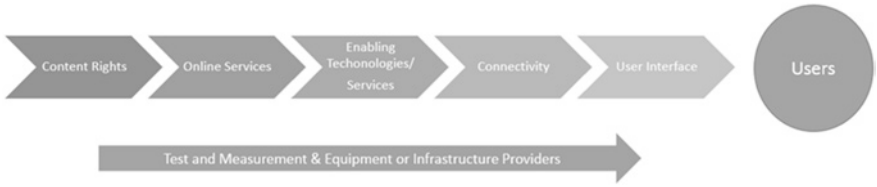

Fig. 1 The digital ecosystem's value chain. *Source* Own elaboration based on Kearney (2010)

firms have evolved and continue doing so due to the dynamics the digital ecosystem itself is subjected to. Some of the most widely known large multinational firms that have appeared around the Internet, Apple, Google, Facebook, Amazon or Microsoft, can be identified in various links of the value chain. The main agents by type of activity in the ecosystem could be classified in at least one of the following groups:

- *Content owners*. Creators and/or owners of the rights on content which is accessible on the web. They show a mixed profile, ranging from firms that make content generation their business model to individuals that share their experiences, work and creations on the network. The latter do not pursue only economic gain, as they may not receive financial rewards but may achieve social recognition as well as other objectives related to politics, morals, power, popularity, etc.
- *Online services providers*. These companies make all types of applications available to network users, enabling them use IP-based technology communication services over the network such as Voice (VoIP), email, messaging, data, videos. These services raise a challenge for conventional telecommunications operators, due to the technical improvements that have increased the quality of these services over the Internet. They enter into competition with their traditional businesses based on providing landlines and mobile telephony. However, there are also applications that support access to content, such as portals for news, public administration and procedures, leisure, browsers, games, music, shopping, different professional services such as financial, insurance, sales, and purchase platforms, etc. The agents acting within the Internet value chain in this segment usually focus their business model on advertising linked to the use of applications although there are also mixed models that combine free services with advertising and/or payment to access certain services.[2]
- *Technology-based companies and enabling services*. They provide technology support services and applications on the network, hosting web pages or content managers, for instance. They include billing and payment platforms, or advertising enabling platforms such as online agencies or service providers to third parties.

[2]Some of them are offered by companies with entertainment business models supplying video, music, game, etc. downloads. Search engines, which is the case of Google, were its main activity in the company's origins (i.e. its genomic instructions).

- *Telecommunications operators and network connectivity services providers*. They offer essential support to establish communication, the core network, providing traffic exchange services or high-capacity information transport services (i.e. highways), backhaul services, access to telecommunications infrastructures for both fixed and mobile networks.
- *User-network interface developers*. They enable contact between users and the network via physical devices such as smartphones, PCs tablets, wearables, as well as applications, software, etc.
- *Providers that offer the technical means and support to develop, deploy and maintain infrastructures*. They are manufacturers of equipment and materials suppliers, test and measurement, certification and homologation laboratories.

The highest growth in the digital ecosystem in the last decade (2005–2015), has taken place in the content segment. It showed the highest figures, registering rates of over 20 %, but lower investment returns than at other links of the chain. This is occurring in spite of the fact that it still only accounts for a small percentage of the ecosystem's total revenues in absolute terms. The next most profitable links in the value chain are online services, technology-enabling services, connectivity, user interface, and service providers with figures under 10 %. The most profitable in terms of returns on investments have been online services and user interface activities, with rates over 20 % in the last decade, followed by content, services providers, technology and firms enabling services and connectivity. Although the latter account for a significant percentage of the total revenues generated in the ecosystem, their business has been seriously damaged and the model is being transformed.

The United States leads growth in the ICT industry, as some of the biggest companies such as Apple, Google or Amazon are North American. Their position in the ecosystem has been strengthened in recent years and their leadership reinforced as a large part of consumers across the world have selected their products. The growing demand for devices such as smartphones and tablets has positioned two companies, the U.S. company Apple and the Korean Samsung as world leaders, followed by the Chinese Huawei and the Korean LG. Meanwhile, past European market leaders such as Nokia (which has now formed an alliance with Microsoft) have gradually lost their positions to the above firms. The case of other European companies that were industry leaders some decades ago was even more dramatic, as they actually disappeared from the ecosystem.

The connectivity segment is one of the most seriously affected by the changes taking place. It is also the most highly regulated due to the public nature of many communications services and the need to use public goods and resources from its beginnings. These agents' business model has clashed with that of the new actors. The unresolved dispute of net neutrality, in addition to others, is the subject of ongoing arguments between agents, with government and oversight agencies sometimes acting as judges and arbitrators as a last resort in conflicts created in the ecosystem.

3.1 Market Transformation. The "Information-Connection" Binomial

The Internet is a powerful tool for communication, opinions, information and interaction between users across the world. The digital ecosystem's development has and will continue to be a key driver in the overall process of globalisation. Globalisation of the economy is a complex process of interdependence between the different countries, boosted by increasingly easier communication and interaction, and international agreements to eradicate barriers to world trade. Commercial, financial transactions or exchange of any product or services can be carried out in the digital ecosystem because there are no borders. As production delocation is undergoing in terms of people, capital and technology, and all of these are also connected to the network, they too are undergoing delocalization.

The Internet has changed the way we understand commercial relationships. User connection capacity with increasingly user-friendly high-performance devices at reasonable prices available to a large sector of society has played a key role in this new model. Regardless of their role in the ecosystem, they can all access the web. There are no entry barriers other than those allowed by the infrastructures and connection devices in this environment free of conflict with the authorities. Governments can block or limit connection to the network from a particular physical location in a country, where the government controls connectivity or even imposes sanctions on users for certain activities in the digital ecosystem. However, they cannot eradicate the ecosystem.

The Internet, which emerged as a tool to solve a problem in the academic field, has become a complex all-encompassing system. Practically, all types of activities can be found on the network. Internet covers everything from the professional to personal scope of each user that connects, regardless of age and origin. The network is multicultural and diversity is a key part of the Internet, which offers content and services for all types of public. This global connection capacity, linked to the possibility of interaction in real time between network participants, is a disruptive combination if we take into account that its scope is also global. The only borders on the network are language and culture.

The Internet's peculiarities have solved some market failures while also creating new problems and challenges. Many of the information asymmetries existing on markets have only been partially solved by the digital ecosystem, where information appears on many webs, forums, recommendation services, etc. Interconnection platforms and online shops enable contact between suppliers and users requiring all types of solutions. However, information is not knowledge. Agents' roles may also be ambiguous; i.e. the same user may be a content generator that uploads to the network, while also demanding similar services from others.

The network's availability and ubiquity provides a new scenario where there are no timetables or barriers to business. Permanent interconnection is possible on the net, thus modifying conventional market rules. Its global nature clashes with each country or state's traditional model, which has specific legal systems (such as

tax regulations, intellectual property). This model has altered the different countries' taxation schemes on transactions. As a result, many economic sectors have benefited. Transport is a case in point. It has significantly improved with new telecommunications technology to manage logistics and transport fleet traffic, and in turn, fostering and promoting e-commerce.

The most relevant platforms at the present in the Internet ecosystem are mainly led by American and some Asian firms. Other developed regions such as Europe and the most advanced Asian nations, Japan for example, have not managed to capture a significant part of the value that the ecosystem has been creating with new business possibilities in information technologies, especially among services and applications providers.

Existing laws in each of the countries, at the national or regional level, such as the European Union, and their application to the new markets that have emerged and developed on the Internet have played a key role in spreading the success of some of today's leading global firms (see Chapter "4G Technology: The Role of Telecom Carriers"). This may also explain why the conditions in the environment have not fostered new alternative rival firms in the industry to compete with the leaders. The legal and regulatory differences, together with other cultural factors such as innovation support are important conditions in the environment when explaining the transformation of markets and their agents, as well as the evolution of the ecosystem. Easy access to capital markets to obtain the necessary funding, or even the intellectual property protection system, contribute to understanding some of the keys to the top firms' transformation and success in adapting to the environment.

3.2 New Applications and Services

From the economic point of view, the content industry is the key future segment in the digital ecosystem. This industry will have to undergo evolution until it finds the most suitable models to enable content creators to correctly position themselves in the ecosystem. In the current environment, it is the gatekeepers that occupy a privileged position, constantly exercising their power to foster or restrict access to content via online services and different interfaces and their own platforms. They act as intermediaries on a two-sided market between users and creators or owners of the content rights.

As mentioned, mobile applications are the new Internet ecosystem services showing the fastest growth. Mobile wideband traffic is reaching levels that are displacing fixed wideband connections. These services create revenues for applications developers and also from the sales generated on the network, in addition to the advertising they include or applications sold on the web. Online services providers are registering very high growth in comparison to the rest of the links in the Internet value chain, except for the content industry. Its main companies were showing higher than double-figure growth in 2014 (between 15–30 %).

This is also occurring with the returns on assets, which exceed 10 % in many companies, far above the connectivity-related activities in the value chain. Telecommunications operators usually have very low return rates, under 10 % in the most favourable cases (around 2–4 %) in 2014.

Estimates made by Vision Mobile and Developer Economy indicated that the activities created by the mobile applications market generated a total value of $60–70 billion on the global market. According to estimates made by the Boston Consulting Group (2014), in only five European countries, (Germany, France, Italy, Spain and the United Kingdom), the total revenues from Internet mobile applications, content and associated services reached €33.12 billion in 2013, which is 36 % of the total revenues of €92 billion. This figure takes into account the activities related to the rest of the links in the chain (access offered by mobile services operators and providers, revenues generated in enabling platforms devices and operating systems for mobiles and the operating costs related to maintenance and expansion of the network and infrastructures). The Boston Consulting Group estimated total revenues of €226 billion in 2017 for all the activities generated in the mobile ecosystem in the European countries mentioned (ibid). This means growth of 25 % in 2013–2017, considering a smartphone penetration rate of 64 % for adult users.

An enormous variety of mobile applications are available, from search engines, a basic tool and one of the most widely demanded in 2014–2015 by smartphone users that surfed the net with their device for music, video, leisure, games, trips, localisers, news portals, etc. Email, communications services such as WhatsApp or WeChat, and the applications classified as social networks (e.g. Facebook, Twitter, Instagram) were the most popular on the web in 2014. Many analysts agree that education, where there are already many applications, and the healthcare industry, which is expected to undergo sharp growth and development of new applications, are promising. The financial industry is also registering changes in the ecosystem, with a greater impact on an increasing number of national economies. Mobile applications to access banking services are widely used in many countries. These services evolve rapidly and offer more complete options, which is also the case of mobile payment systems with platforms and different devices or wearables. Many users shop on the web via their mobile devices (i.e. smartphones or tablets).

Most of the applications designed for mobiles can be easily downloaded via web browsers, from platforms or virtual shops for mobile applications such as Apple's App Store or Google Play, both of which are very popular. The number of available applications for Android operating system users alone was over 1.3 million apps in 2013. The Apple platform ranked second worldwide with 1.2 million (Federal Communications Commission 2014a). High-speed connectivity to the net may not be required for their use, depending on the application. However, they may also be operative without the need to connect once they have been installed in the user's terminal. It is increasingly common to find pre-installed applications in the operating systems when purchasing a terminal.

Another new development that appeared in the digital ecosystem is virtual currency (i.e. the bitcoin). It could mean a disruption in the macro economy and the

way we understand monetary policy. Electronic trading and currency and securities market platforms have been operating for years in the digital ecosystem. The first Electronic Communication Network (ECN) was created by the American National Association of Securities Dealers (NASDAQ) in 1971. The leading ECNs now trade billions of dollars in shares and currencies on a daily basis.

The applications related to multimedia content and social networks are a powerful combination. The new Cloud TV services with gatekeepers that can pre-empt the market and displace the TV industry to the network with the possibility of horizontal and vertical integrations with other agents, raise new challenges (vid. Noam 2014; Waterman et al. 2013). Multimedia applications for live video streaming such as Periscope or Meerkat are one of the latest tendencies in apps technology. They follow in the wake of other highly successful apps such as Instagram or Twitter where users share opinions and photographs.

The IoT has raised expectations concerning the scope of integration that new devices linked to everyday objects and items can reach, in addition to the connectivity and interaction challenges between devices. M2M communications have increased considerably in recent years, providing connectivity to different devices, sensors, etc. which are connected to the network and usually found in professional environments. However, M2M is showing a tendency to go beyond professional spheres and move into homes.

3.3 Relationships Between Agents. Interaction and Role Transformation

The evolution of business models, cash flows and user empowerment are transforming the way in which participants are organised in the environment. Globalisation is one of the key factors in analysis of the digital ecosystem. Disruptions are rapidly transferred across the world. The impact of changes and innovations in any activity is displaced throughout the ecosystem with results that are sometimes surprising. The scope and far-reaching influence of certain business groups in this environment give them an especially relevant role, not only in their primary field of activity but in the entire ecosystem. This, in turn, enables them to further strengthen their power if their long-term strategy is successful. The EED model makes it possible to analyse the case of some of these companies such as Google or Apple.

The so-called gatekeepers play an essential role in keeping the digital ecosystem running properly. The dynamics of the rest of the agents in the system and their evolution may be analysed under an epigenetic perspective. Companies that act as gatekeepers have become vital. Their actions filter access to other ecosystem activities, determining and even preventing the participation of other agents that are unable to overcome the access barriers if users choose said gatekeepers' applications and platforms.

The role of gatekeeper can be filled by large business groups that operate in the digital ecosystem. Google is, for instance, the case of a perfect platform. The fact that only a few platforms are competing for the lion's share is a factor that increases their power. The critical size reached by these firms, which is combined with the multiplier effect of network-based applications in which Metcalfe's Law can be applied, ultimately condition the dynamics generated in the digital ecosystem and its evolution. Multinationals such as Google, Amazon and Apple have become global agents with privileged positions in the ecosystem in just a few years. This arouses suspicion and creates alarm in the environment where other agents feel overwhelmed and threatened by the transformation in the ecosystem (see Chapter "The Digital Ecosystem: An "inherit" Disruption for Developers?" by Vega et al.).

Google is the world's leading web search engine. Its privileged position has placed certain regions on alert, such as the EU where Google searches accounted for 92.5 % of all search traffic at the beginning of 2015 (a market share which is even higher than its original market, the U.S.), in comparison to other competitors such as Bing 2.6 %, Yahoo 2.2 % or Yandex 1.3 %, while the rest of the platforms controlled 1.6 % of the market. The scenario has prompted EU institutions in charge of overseeing competition to accuse the company of abuse of market power in its web search business. However, it is not the only battle that the American giant is involved in and could be one of the reasons behind Google's new organisation structure and new name: Alphabet. Like other big leading Internet ecosystem companies, it has diversified considerably in recent years, from search and ad business to self-driving cars and life sciences research (see Chapter "Epigenetic Economics Dynamics in the Internet Ecosystem" by Zabala-Iturriagagoitia et al.).

An unfavourable political climate with legislative changes in many countries, above all in Europe, concerning data protection, guarantees for intellectual property and patents has led to disputes, many of which are pending resolution. The rest of the agents affected in these disputes, including the end users of applications, sometimes have conflicting views due to the very synergies and collaboration which are established between business groups in the ecosystem. It is remarkable that users' views are often closer to private companies' positions than their democratically elected governments'.

In 2015, Amazon was the world's largest e-commerce company. As per cloud services, Amazon led with nearly 28 % of this market at the end of 2014, which was only a decade after it launched its cloud computing business service. It is followed by other Internet giants such as Microsoft with 10 % at the end of 2014; IBM, Google and Salesforce, according to information provided by Synergy Research Group. Cloud services are growing very quickly, yielding over double-figure returns in some cases. In 2014, this return was 51 % higher for Amazon than the previous year.

From the legislative and legal perspective, there is no global judicial framework that establishes common rules or a shared law. In practice, this avoids carrying out systematic preventive control of the network. Legal and political systems vary according to the country and we may find very different decisions depending on the country where judgement is handed down. Certain activities persecuted by law

in some countries are not in others. Agents such as Google or Apple are expanding toward new businesses in the global ecosystem, which, in some cases, are under the authority of the communications services that the operators provide in each country. This has caused alarm, not only between these giants with feet of clay but also in government security agencies which have been allied with operators and companies responsible for providing network connectivity (see Chapter "4G Technology: The Role of Telecom Carriers").

Technology developments such as new protocols are sometimes released by those firms. Some may improve user navigation or automatically encrypt the user information transferred when they access certain nets and platforms or afford the possibility of routing heavy traffic flows to private proxies. All this raises new challenges for intelligence and government services that will be forced to negotiate on a scenario where big companies that have the control may not be under the jurisdiction of the country where the conflict originates.

4 Internet Governance

On a complex open scenario like the Internet, where multiple agents are constantly participating and interacting, the issue of international governance calls for large amounts of creativity and innovation. Internet is a space open to diversity and its governance should follow suit, based on inclusive participation, preserving, boosting and developing cultural diversity. The model of an open, distributed, self-run Internet has led to a working system which is unusual in other scopes. It is distinctive for multi-stakeholder participation as opposed to the multilaterality-based mechanisms that have been in place for decades in telecommunications, such as the case of the International Telecommunications Union (ITU).

Multilateral cooperation principles are based on the participation of all the agents (government, the private sector, civil society, and the technical community) in equal conditions. Participation is fostered and procedures that guarantee equal opportunities to collaborate and contribute to the decision-making processes are adopted. Transparency is a basic rule in all the processes, which are duly made known, public and open. Responsibility is another key point and involves implementation of accountability mechanisms to verify the results obtained. The approach is always based on consensus and must reflect the different points of view held by the entire community. This is an extremely ambitious cooperation mechanism but proves difficult to translate to reality which is riddled with interests, double talk, disputes over representativeness and legitimacy in decision-making. In actual practice, all of the above mean that this model does not function effectively, although it is an interesting experiment which, nevertheless, could solve many of the conflicts found in the ecosystem.

The support that many governments have provided to develop the current Internet cannot be denied. From the origins of the Internet, the U.S. government has played a crucial role, enabling its creation and evolution to the present

moment of transition. The role of governments is pushed into the background in the multi-stakeholder cooperation model as it facilitates deployment of telecommunications infrastructures that make it possible to create an optimal environment for access to the ecosystem. It envisages regulatory frameworks to achieve this but avoiding a proactive protectionist role that could limit innovation. Another of the tasks that falls under governments' responsibility is developing a legislative framework in their respective countries that strengthens the idea that the Internet is not an area outside the law where anything is allowed. This requires that the legislative framework evolve at the same pace as the ecosystem, which, as experience has shown in the last decades, is difficult to achieve. The conflicts that arise on the network often do not have the proper legal framework needed to resolve them in a systematised manner.

Human rights, freedom of expression and dissemination of information on the Internet or protection from cyber terrorism are other extremely important topics where governments must play a role and which have been debated in international Internet governance forums in recent years. Note that all these dimensions are included as the analysis of the consequences (in terms of innovation) as a result of epigenetic factors in the EED approach (see Chapter "Introducing an Epigenetic Approach for the Study of Internet Industry Groups").

Cooperation between governments, industry and society may lead to public policies that address the true needs of the digital ecosystem more directly. There is no clear group of leading agents in a multi-stakeholder environment. Governments, which are accustomed to being the leader, face a new framework, Internet governance, in which they participate on equal footing with the rest of the agents. This is a very different scenario from their participation in multilateral forums. Many find this contradictory, as they consider themselves the legitimate representatives of the citizens who elected them, at least in democratic nations.

It is hoped that governments will support the multi-stakeholder governance model and pass national laws that include the measures needed to safeguard the Internet and its freedoms, in search of the complex balance between the different parties' interests, which are often difficult to reconcile. The Internet Governance Forum (IGF) is the main international forum, and was created in the spirit of a multi-stakeholder approach, fostering internationalisation of Internet governance and cooperation. The first official IGF event was held in Athens in 2006. Since then, yearly meetings are held in which thousands of people representing all the stakeholders debate Internet governance. Another more recent forum is NetMundial, first held in Brazil in 2014. At this event, the community defined a series of Internet governance principles and began a new push for governance channelled through the yearly IGF held shortly afterward. One of the essential Internet governance principles, agreed by the different interest groups, looked to strengthen the Internet's basic values, advocating its recognition as a global resource that should be managed in the public interest. The focus was on achieving regulation for the Internet that would guarantee citizens the same rights in the online world as in the real world, in agreement with the Universal Declaration of Human Rights and the human rights obligations established in international legislation. The rights

recognised included freedom of expression, association, privacy, accessibility, information and access to said information, to development of countries by promoting innovation, creativity, innovation and cooperation between stakeholders.

4.1 Regulation of the Digital Ecosystem

Regulation of the net is an extremely complex task that goes beyond the virtual borders of each country's legal framework. Guaranteeing security and continuity of the original network design requires international cooperation between all countries. In future, the digital ecosystem should preserve and guarantee the original principles of freedom, openness and neutrality.

The convergence of conventional telecommunications with the computer industry created a fruitful combination that triggered the creation and later development of the digital ecosystem. Both industries had very different starting points. The traditional telecommunications industry has been regulated under the control of each country's telecommunications operators from its very origins. In many cases, they were directly supervised by government. However, the computer industry's origins had an open, global, more competitive and innovative approach and were not subject to public service obligations, use of public resources and goods and costly infrastructure deployment. Both industries have competed in the digital ecosystem although a new optimal regulatory and legislative framework to manage the new ecosystem has not been found. This has created regulatory asymmetry which has become even more obvious as the system has expanded and new business models and groups have appeared. Nevertheless, regulation of communications infrastructures has continued to evolve and has become, in some cases, excessively complex and unsuitable for this particular stage of the network's evolution.

The debate on regulatory asymmetries in the digital ecosystem and their solution have been demanded by operators for some time now. Other debates related to competing business models have arisen around this unsolved conflict. One such debate is network neutrality and the regulation of big Internet groups' businesses, for instance Google or Apple. Many telecommunications operators are incumbent in one country or several, but not global, as opposed to firms in other businesses which create value on the Internet. They are calling for a regulatory framework similar to that of their new competitors, the online services and enabling providers, applications and services platforms. Ultimately, they are demanding non-intrusive regulation or even better, one that allows agents to regulate themselves.

4.2 Network Security and Control

In non-democratic systems, governments are often tempted to control the Internet, taking "information is power" as their motto. However, they end up clashing with

the network design. Censorship on the Internet is difficult to eradicate; some governments distrust citizens' freedom of expression and their self-organisation abilities. This could pose a threat to existing power models. It is possible to force disconnection from the network but not to eradicate the Internet. It is also feasible to build a new network with a new made-to-order ecosystem, which is specific to a certain country or geographic region, similar to many of the islands that exist in professional fields on the net. However, it would be very different. Interconnection with the global network is what users are demanding and is what makes the Internet ecosystem so unique.

As Castells (2003) pointed out, as the use of the Internet has spread, information and social behaviour toward the Internet have become more important. Control over the Internet, the battle for freedom on the network has shifted from being the exclusive concern of the old elite and has become widespread. Access to the network is protected and guaranteed in democratic countries. This is based on freedom of expression, citizens' rights over public resources and goods, etc. as established in countries' constitutions and legislative and judicial systems. The debate on whether access to the Internet should be considered a universal human right, or the Internet as a global public good, raises divergent opinions on the scope of the digital ecosystem. Some people consider the Internet a technological tool to exercise fundamental rights. In this sense, the European Union pointed out at the start of 2015 that the use of the Internet was an inalienable civil right whose application national authorities could contribute to within their competences frameworks (Vid. Official Diary of the European Union 21.1.2015).

There is deep contradiction between the freedom provided by the digital ecosystem and the control and vigilance on citizens' lives that technology also allows. Users' propensity to lose control of the network in benefit of private firms or security agencies and governments elected in democratic processes is a tendency that cannot be reversed. Users lose their privacy on the network on a daily voluntary basis each time they accept the security and data protection disclaimers required by most of the applications they use. Connection and constant interaction on the network, combined with the possibility of being constantly geolocated on mobile networks offer many advantages and are creating new interaction models and added services. However, this carries high costs as regards privacy which, however, many users are not capable of assessing proportionately.

In spite of the different countries' approaches to the digital ecosystem, the economic and geostrategic role of this new ecosystem is so vast that, in actual practice, none can fail to enter and take part in its evolution. The rift existing between countries concerning the global Internet governance model was made evident in 2012 when numerous countries decided not to ratify the regulations on international telecommunications, which was put to the vote following the World International Telecommunications Conference organised by ITU in Dubai in 2012. Later events followed, such as U.S. Intelligence agent E. Snowden's disclosure in 2013 of some of the ecosystem's weak points concerning privacy, security and abuse of power on the Internet by some governments, particularly the U.S.

The events prompted response from many emerging nations and other countries such as Russia and China which had not been aligned with the U.S. government's position for some time and questioned the role of the U.S. as the safe haven guaranteeing freedom of expression on the Internet. They also criticised the Internet technical model of governance, and the critical resources control, which had until that time been under the responsibility of a group of U.S.-based private institutions supervised by the U.S. Department of Commerce.

Critical Internet resources include technical standards on protocols, procedures and services, the infrastructures needed for the net to work, root servers, assignment of domain names, addresses, IP or protocol administration. All of these resources are managed from private organisations: Internet Corporation for Assigned Names and Numbers (ICANN), Internet Assigned Numbers Authority (IANA) and the Root Server System Advisory Committee (RSSAC), (these two latter bodies are under the ICANN, although they operate autonomously), VeriSign, the Internet Engineering Task Force (IETF) and the World Wide Web Consortium (W3C).

Root servers are located across the world; only 3 of the 13 active servers in 2015 were outside the U.S. The primary root server that keeps a copy of all the Top Level Domains file of the other 12, is also based in the U.S. Management of these resources which are critical to the ecosystem's operation is decentralised and the different stakeholders are represented in the ICANN governing body. Although this model has functioned to date, it is inconvenient for many governments and agents, which are calling for greater independence and decentralisation. Governments are represented in ICANN through the Government Advisory Committee (GAC). This participation has always been considered limited and in recent years, a greater imbalance of powers between countries has been perceived.

Against such a background, reorganisation of the control of critical Internet resources became a topic of debate in 2014. Revision of the assignment of top-level domains was accepted by the U.S. government, shifting from the unilateral assignation model that had been used through ICANN and IANA until that time to a new collaboration model. The U.S. accepted the criticism expressed by numerous stakeholders and some allies at different forums and international meetings on Internet governance.

These conflicts and other new ones caused within the ecosystem entail significant changes in the environment and may put an end to the model that we know, obliging companies to adapt as shown in the EED model and taking the ecosystem to a new stage. The risk of fragmenting the ecosystem into different blocks can only be avoided by promoting transparency in Internet management and policy. This requires technologically solid architecture and infrastructures that give confidence to users and security to governments, protecting and improving the resilience and the security of the Internet. The virtues of the Internet ecosystem can be preserved and further advancement can be achieved through respect and promotion of cultural diversity and the safeguarding of human rights.

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