From Mathematical Theory of Communization to Network Society: a Social Transformation

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Abstract
An increasing pace of innovation in telecommunications, information technology has facilitated our society's transition into what is called the *Information Age*. This work is intended to offer a means of understanding current directions in digital innovation.
In 1948, the general theory for electronic communications (Shannon:1948), contributed to a substantial reorganization of our society; some fifty years later, Castells attempts to grasp the relationships between emerging technical, economic, political and cultural trends and helps us understand the processes of change triggered by the convergence of information and communication technologies (ICTs).
In this work, starting from the interdisciplinary literature, the main theoretical and practical contributions leading to technological convergence are investigated in order to open a window on the contemporary landscape in semantic web, algorithmic reasoning, and responsible research.
The resulting framework, although due to the dynamism of the phenomena under consideration, is not meant to be an exhaustive analysis of the relationship between digital tools and society, it rigorously summarizes many of the major technical and social issues open today and, in view of the future expansion of the ICT ecosystem, underscores the urgent need for conscious citizen participation in the information society.

Key words: information age; network; algorithmic reasoning; communication; digital transition.

INTRODUCTION

The massive production, manipulation and distribution of information is the defining characteristic of our age. By 2022, more than 90 percent of the world's population potentially has access to the global interconnection network, and we are witnessing an increasing demand for digital services. The expansion of *Information and Communication Technology* (ICT) has enabled the progressive integration of physical and digital space and placed the human experience in interaction with increasingly technologically advanced environments. In parallel, it is of paramount importance that new knowledge and awareness be developed so as to effectively benefit from technological progress; the possibilities of access to tools, as well as the environments and cognitions within which such access is characterized, are particularly relevant factors in this regard. This paper proposes a reading of modern orientations on the subject of digital transformation that follows a dual axis, the chronological one, relating to the evolution of information and communication technologies, and the thematic one, pertaining to the main sociological reflections that provide a basis for

reading the contemporary socio-technological paradigm. Through the theoretical contributions of Shannon (1948) with Information Theory, and those the mathematician Turing (1948), the first part of this work provides the conceptual foundations for understanding the nature of information and digital convergence. The expansion of telecommunications networks and developments in algorithmic techniques and in electronics and components mark profound repercussions on the ability of groups to communicate and constitute their world of meaning. This observation is important for:
The first one is the issue of algorithms as constraints. Social action insofar as it takes form in both -physical space and digital space is constrained to both spaces, that is, it must abide by both the rules of physical space and the rules of digital space. In physical space, the rules are dictated by physics; in social space, the rules are dictated by algorithms, which in any case are the result of the synthesis between technical norms and programmer's choices: in practice they are partially social constructs embedded in technical objects.
The second - central - issue is that of data as all-pervasive. If algorithms underlie technologies whether artifacts or platforms, it means that data are everywhere. In this sense, data are both technical products and social products just as technologies are both technical products and social products. In practice, data are nothing but media necessary for the implementation of the processes of digital technologies but at the same time a foundational part of the contemporary social ontology. Said very schematically: data are part of the current social organization as well as the concepts of identity, action, institution, and collectivity.
The implication of this is clear: if educating about technology is about platforms,
to educate about data is to educate about the ability to read the world around us with an awareness of the role played by algorithms (Bennato, 2020). Media education paved the way for us to media literacy by insisting that media are not reflections of reality but their interpretation (Buckingham, 2006; Masterman, 1997), now the time has come for data literacy, because data are not neutral, but are the result of technologies produced specifically within a process of social construction.

Information flows expand horizontally, over vast distances, from the many to the many, constrained only by access to tools. Unprecedented technological conditions lay the foundation for a new organization at the global level, the *reticular* one (Castells: 2002), where more complex social institutions are enabled by the pervasive, nonlinear interchange of information. The more recent sociological literature has begun to introduce different designations that seek to focus attention on the centrality that technology has assumed in recent years: network society, connective society, platfom society, digital society (Bennato, 2018; Castells, 2002; van Dijk, 2002; Granieri, 2006; Rainie & Wellman, 2012). Each definition has its own specifics and key concepts that declinate in some detail the socio-technical characteristics of the contemporary social structure (Bennato: 2020).

The digital revolution expands the means and cognition available to individuals; although today's technological and algorithmic tools are the product of human creation and therefore subject to human choices, they incur circumstances whereby their governance may not be without problems. Building on the famous statement of Kranzberg *Technology is neighter good or bad; nor is it neutral* (in Patrignani and Whitehouse: 2018), in light of growing slices of our everyday lives that rely on a small number of companies in the high-tech industry, it is appropriate to dwell on the opportunities and risks that are opening up at the dawn of the new digital horizon. The second part of this paper outlines some of the main issues on the current debate on algorithmic decision-making, with a focus on the personalization of online content and guidelines to promote responsible research and innovation in digital development and culture. The introduction of new conditions for the enjoyment of rights and services, from basic to more complex ones related to the status of citizens, now requires knowing how to work with information technologies, without being exclusively affected by them.

INFORMATION AS UNCERTAINTY REDUCTION AND DIGITAL ENCODING.

Although the term information recurs frequently, it does not find a shared formal definition. *Proteus of semantics* (Giglietto, 2006) finds its way into both mathematical formalizations, historically concerning quantitative aspects of reality, and sociological ones, concerning aspects of meaning. Adriaans (2020) outlines three conceptual classifications for a term that is certainly multifaceted in nature: (i) information as knowledge, therefore susceptible to the contexts and cognitions of individuals; (ii) information of a theoretical-mathematical nature, related to the laws of logic and those of probability; and (iii) information as compression within an optimal code for effective transmission. The possible intersections among the various conceptualizations have given rise to numerous research works and still constitute one of the most flourishing fields of interdisciplinary study. The following are the main theorizations leading to the digital revolution and the *information society* as we know it today.

What hath God wrought, is the first message to travel on Morse's telegraph lines from Washington to Baltimore; this is 1844 and the invention of electric telegraphy allows information to travel at speeds faster than human travel. It is not voice or text, however; letters are encoded through an alphabet of lines, dots and a few other symbols, transmitted as an electrical signal along a wire connecting the two stations. Since the invention of movable type printing, the difference in the frequency with which each letter occurs within a given language constitutes a known fact so Alfred Vail, in Morse code, assigns a smaller number of symbols to letters that occur more often (e.g., E), conversely, a longer average code to letters that occur infrequently (e.g., Q). Reducing the average number of symbols to represent information makes communication efficient, helping to reduce the probability of error in message transmission and transcription.

In fact, any form of communication makes use of symbols to represent information, and generally a message is more informative the more it succeeds in reducing the uncertainty of the interlocutor. An early theorization of the relationship between information and uncertainty goes back to Hume (in Adriaans, 2020), while major contributions to the study of the quantitative aspects of information are due to Vinton Hartley, Shannon and Warren Weaver in the middle of the last century. In the early twentieth century, the invention of the triode (or thermionic valve) enabled the amplification of the electrical signal and gave impetus to communications over long distances. Historian of science Gleick (2011) provides an accurate reconstruction of the growing volume of communications affecting the United States in the 1940s: more than one hundred and twenty-five million calls pass daily through the Bell Laboratories infrastructure; the census counts thousands of radio programs and dozens of televisions; however, these are rather crude measurements: what is it that is accurately measured in the Bell Laboratories infrastructure? Through what unit of measurement?

> *Not conversations, surely; nor words, nor certainly characters. Perhaps it was just electricity. [...] Everyone understood that electricity served as a surrogate for sound, the sound of the human voice, waves in the air entering the telephone mouthpiece and converted into electrical waveforms. This conversion was the essence of the telephone's advance over the telegraph, the predecessor technology, already seeming so quaint. Telegraphy relied on a different sort of conversion: a code of dots and dashes, not based on sounds at all but on the written alphabet, which was, after all, a code in its turn. (Gleick, 2011)*

Among the best-known engravings of the Mathematical Theory of Communication, and one that best exemplifies its nature:

> *The fundamental problem of communication is that of reproducing at one point either exactly or approximately a message selected at another point. Frequently the messages have meaning; that is they refer to or are correlated according to some system*

with certain physical or conceptual entities. These semantic aspects of communication are irrelevant to the engineering problem. The significant aspect is that the actual message is one selected from a set of possible messages. (Shannon, 1948)

Beginning with the published works of Harry Nyquist and R. V. Hartley, Shannon first introduced the idea of communication as a flow of binary digits (Giglietto, 2006), and what might at first seem to be a lack of interest in the physical and semantic aspects of the message turns out instead to be one of the greatest insights of the 20th century.

A progenitor of *Information Theory,* Shannon's writings introduce important innovations: the first is to isolate information from noise (the message from the background), thus allowing it to be quantified and made measurable. The word *bit* (contraction of *binary digit*) refers to the smallest unit of information obtainable (0 or 1) when only one of two alternatives is possible: « Bit refers to a unit of information that quantifies the uncertainty of two equiprobable choices » (Lombardi, Hollic and Vanni: 2015). From that point on, the bit joins the inch, pound, penny, gallon and minute as the fundamental determinant unit of a specific quantity, writes Gleick (2011). The second innovation is to use the laws of probability to decree the degree of predictability/uncertainty that characterizes the informational source. Each source can generate in a given time, one among the possible messages included in its repertoire, each of which has a certain probability of occurrence (Tse, 2020): « If the number of messages in the set is finite, [...]then it can be regarded as a measure of the information produced when one message is chosen from the set ». (Giglietto, 2006). Quantification of the information content of the message is achieved by resorting to the concept of *entropy*, this quantity indicates the minimum number of symbols required to encode the amount of information associated with the occurrence of an event*:* «Entropy (HS) as the average number of bits necessary to encode a letter of the source using an ideal code» (Lombardi, 2015). Entropy is considered maximum if all source events are equiprobable and minimum when one of the events is certain (Giglietto, 2006), as entropy decreases, the uncertainty associated with an information event decreases. Shannon succeeds in providing an effective model for both measuring information, through the bit, and an effective methodology for its encoding (through the source entropy), furthermore, after introducing the concept of channel capacity, he asserts how effective transmission in the face of noise, is possible if the entropy measurement is kept below that capacity.

The informational source presented here identifies, by logical extension, any modern electronic, magnetic and optical storage medium that encodes information in a digital format. Numerical encoding over time has established its superiority over analog encoding due to its greater efficiency, reliability and cost-effectiveness in terms of information storage and transmission.

The convergence of communication and information technologies (ICTs) constitutes one of the most remarkable phenomena affecting the second half of the last century from a social perspective. The spread of telecommunication networks with ever-increasing bandwidth, the advent of the Internet, developments in information technology, and the steady advancement in electronics are determining factors in what has been called *Digital Convergence* or even the *Third Industrial Revolution*. Thanks to technological convergence, today most of us have the ability to access a vast amount of digitized media content by relying on a single tool. However, the rise of complex technologies, which in a matter of a few decades go from being something the preserve of a specific elite, to commonly used tools (i.e., *General Purpose Technology*), means that today's society often finds itself in the uncomfortable position whereby it sees itself as completely dependent on a technological system, which on the one hand has disruptive features, on the other, is poorly, if not completely understood (Naughton, 2016).

The mathematical sciences, in the early twentieth century, contributed greatly to developments in mechanical computation. In 1937, the British scientist Turing, in his article *On Computable Numbers, with an application to the Entsheidungsproblem,* addresses the *decision problem*, presented a few years earlier by mathematician Hilbert. Turing aims to determine, if there is one, an effective method that can determine for each possible mathematical statement whether it is decidable or undecidable, true or false. At the time, in most cases, *calculators* were men who performed calculations at a tireless pace: «a mathematical assistant who calculated by rote, in accordance with some effective method suppied by an overseer prior to the calculation. [...] A human operator working in a disciplined but unintelligent manner » (Coperland, 2004). The machine conceived by Turing (UTM) is intended to implement any computational process involving a finite number of operations, the model provides: (i) a memory (*store*), a potentially infinite tape that serves as a medium for input, intermediate processing and output; divided into cells, each of which contains a single symbol included in a finite set (*0, 1, blank*); (ii) an *executive unit (executive unit*), a head that reads the symbols on the tape and the state of the machine, consequently performing one of the following operations: *erase, write, shift* or *halt;* (iii) an instruction (*control*) that guides each operation of the machine; goes Turing in fact, the idea of controlling the operation of a mechanical computer through the manipulation of symbols.

> *In Turing 1937 a certain type of discrete machine was described [...] These machines will here be called Logical Computing Machine. They are chiefly of interest when we wish to consider what a machine could in principle be designed to do when we are willing to allow it both unlimited time and unlimited storage capacity (Turing, 1948)*

Turing's Universal Machine performs a series of elementary operations that still embody the principles and limitations underlying the operation of modern computers. « A function is said to be computable if some Turing the machine will take in arguments (input) of the function and after carrying out a finite number of basic operations, produce the corresponding value (output) » (Coperland, 2004)

Computable (or recursive) is a problem for which it is possible to find an algorithm that computes it, i.e., an *effective method*, consisting of a finite number of instructions, unambiguous and capable of presenting a solution for all problems of the same class. Proving that a problem is computable, through a *mechanical procedure*, remains the theoretical foundation underlying modern programs that can be executed by a digital computer.

> *It is possible to design a universal machine which is a LCM [...] We do not need to have an infinity of different machines doing different jobs. A single one will suffice. The engineering problem of producing various machines for various jobs is replaced by the office work of programming the universal machine to do these jobs. (Turing, 1948)*

Recent languages arise to work on the network, develop predictive algorithms and implement methods that teach software to program itself and learn autonomously based on experience. Formal languages, and the relevance they assume in today's times in the initial programming of *intelligent systems*, are the subject of reflection.

THE SOCIETY OF NETWORKS

By the beginning of the new millennium, the *Information Society* is widely used in social science fields of study to refer to the technical, economic, spatial and cultural reorganization of society. The Information Age designates a historical epoch in which information and the technologies that enable it to be transmitted and processed rapidly and massively, generating a constant flow of new knowledge, become structuring elements of society; in contrast to the industrial society, in which steam and fossil fuels were its defining elements.

In the wake of what was proposed in *Theories of the Information Society* (Webster, 2006), five aspects should be considered to delineate the paradigm emerging in the second half of the last century: the technological one, «The information society is one in which information is the defining feature, unlike the industrial society where steam power and fossil fuels were distinguishing elements» (Scott, 2014).

Aspects of space and time in the social world escape contiguity, resulting profoundly influenced by the expansion of electronic communication networks, which break down traditional physical barriers, and enable encounters between different people and places by fostering the spread of shared and hybridized values, symbols, beliefs and practices: « individuals and groups is no longer tied to particular times and places, and processes increasingly happened in a nonlinear asynchronous fashion » (systemsinnovation.network, 2019). The most extensive and accurate contribution in terms of a systematic study of the characteristics of the information society, outside of specific particularisms, is that of Castells, who in his trilogy *The Rise of the Network Society, The Information Age: Economy, Society and Culture* (1996- 1998) provides an empirical framework that connects economic, political and social configuration. In sociological analysis, cultures and collective identities crystallize over time, in specific territories, through symbolic communication and through processes structured by historically determined relations of production, experience and power (Castells, 2002). The central assumption of Castells' theory is that the Information Age announces a new organization of society, put in place since the development of global interconnection networks, where the governance of *flows* holds decisive function, becoming a basic source of productivity and power. The exchange of information, at its fundamental core as communication, plays a decisive role for each human group, as it is closely related to survival and renewal capabilities. The expression *Network Society* is used by Castells to designate the social structure that characterizes the Information Age, where processes of interaction are linked to unprecedented technological conditions and the expansion, on a global scale, of electronic interconnection networks:

> *In a networked society communications exchange becomes pervasive. It comes to flow in multiple directions, between all points, continuously. This pervasive exchange of information comes to create a new form of organizational structure what we call a network, with organizations and individuals then becoming based around and defined by connectivity and access* (systemsinnovation.network, 2019).

The *flows* transiting within networks constitute the sap of the new era; a reticular model, where the dominant functions and processes of production, experience and power would predominantly curb according to a decentralized logic, when compared to the hierarchical and centralized logic of the not too distant past. The result is an organism characterized by the *pre-eminence of social morphology over social action* (Castells, 2002) where the power of flows *asserts its priority over the flows of power* (Ibid.) and where technological access is configured as an essential requirement to be an integral part of contemporaneity.

The network is a figurative system consisting of numerous nodes, each node proves functional, but not all nodes hold equal importance: the presence or absence within the network and the dynamics of each network vis-à-vis the others, represent critical sources of domination and change in society (Castells, 2002). The new geography of global space is reconceptualized through the expression *space of flows* where: «With information flows becoming central to the organization of today's society, disparate and far flung places can become integrated into international networks that link up their most dynamic sectors» (Castells, 1996).

The new social morphology embodies a highly dynamic system, which fits well, the logics of modern capitalism able to identify: «The action of knowledge upon knowledge itself as the main source of productivity (Castells, 1996) and it heralds a new economy as well as a new society» (Webster, 2006)

In this context, different levels of adaptability to change are crucial factors in determining new forms of social stratification at the spatial and individual levels. Spatially bound networks exist alongside new identities and new ways of living that are shaped in the global space of flows. The assumption at the core of the theorization is based on the idea that the evolution of the social organism is not determined by technological tools but enabled by them; society shapes technology according to the values, needs and interests of those who use it, while technological tools set the parameters of what is achievable.

Today while the digital revolution may appear, partially, behind us, the impacts it entails are, conversely, still largely ahead of us.

THE SEMANTIC WEB

The development of World Wide Web services, supported by the spread of broadband networks and gradually more sophisticated tools and devices, materialize to a great extent the logic of public access to the Internet and the sources of knowledge it can offer. At the same time, the libertarian ethos that characterizes the early stages of the network's spread among the population means that it has long eluded stringent regulatory policies. The rise of Big Tech within the framework of the New Economy, and the enormous ideological relevance of these, now becomes the subject of recent testimonies and perspectives on the intersection of human will and algorithmic reasoning, moving from the characteristics of the semantic web to the responsible research and development orientations promoted by European institutions on digital technologies.

The Web service, in its earliest years, consists of a simple worldwide repository of electronic documents, stored on servers, and distributed through the Internet; it is the *Read Only Web*, consisting of static, reference-only pages, without any possibility of customization, modification or interaction with the content. The main vector behind the overcoming of the limitations of Web 1.0 coincides with the need, on the part of major market players, to transform the medium into a space that facilitated money exchanges and with that of exploring the possibilities of electronic commerce (Balbi, 2014).

> *In order to make transactions possible, a whole range of problems had to be solved. For example, ways had to be found to allow interactivity between browsers and servers; to facilitate personalization of web content; and to overcome the problem that the http protocol was insecure (in that communications between browser and server could be intercepted and monitored by third parties).* (Naughton, 2016)

The ability to easily enjoy content on the Web directly affects its accessibility by people; age, technical and device-relationship skills (Pearson & Pearson, 2008), and motivational factors, often play a key role in determining subjects' relationship with the computer medium. The mature and interactive phase of the Web, Web 2.0 and 3.0, also redefined *Semantic Web,* is rethought to facilitate communication between human and machine according to the principles of *Web usability*.

> *One way to enable machine-to-machine exchange and automated processing is to provide the information in such a way that computers can understand it. This is precisely the objective of the Semantic Web - to make possible the processing of Web information by computers. The Semantic Web is not a separate Web but an extension of the current one, in which information is given well-defined meaning, better enabling computers and people to work in cooperation. (Berners-Lee, Hendler et al. 2001)*

The virtual space that the entire globe now shares seems almost to realize the visionary idea of a new civilization of the mind, announced by J. P. Barlow in the *Declaration of Independence of Cyberspace*; user generated content emerges and the first examples of *collective intelligence* sprout, from Wikileaks' revolutionary intent to place the decision-making processes of organizations under a transparent dome, to the libertarian movements of the Arab Spring, to the collective mobilization of thousands of citizens that the network is able to gather in the squares around the globe. Information and communication technologies in these years embody the hopes of an unstoppable democratizing power; these not only spread new tools, but profoundly change the communication dynamics themselves because of the combination of unique features that Internet technology provides. Interaction takes place at different levels without limitations related to space, time, or centralized authority (Fawkes & Gregory, 2000), introducing, alongside the communicative dynamics of one to one and one to many, that of many to many.

The perspective that sees the Web as a possibility for social emancipation and that takes cue from the participatory and democratic nature of the Web (Bentivegna & Boccia Altieri, 2019), is countered by the debate between the *information rich* and the *information poor*, ultimately substantiating the *Knowledge Gap* hypothesis whereby greater dissemination of information (in this context fostered by ICT technologies), would not coincide in a mirror-image manner with a more informed and knowledgeable group at a uniform level, but that individuals' starting social, economic and cognitive resources concur to determine the possibilities of retrieving, contextualizing, evaluating and deepening the information available.

TECH HEGEMONIES IN DIGITIZED SPACE

In the *information society,* the high-tech industry stands alongside energy giants and large media conglomerates. The economic, political, and ideological power that major companies in the IT landscape hold today stems from their exceptional mastery of the Web ecosystem and algorithmic tools. Much of the current debate about *Big Tech* emerge as a result of observations regarding the social spillovers of such power and the consequent need to identify new *governance* mechanisms (Birch and Bronson 2022). Apple, Alphabe, Amazon, Meta, Microsoft, Tesla, to name a few, are among the most visible and influential companies in the world, according to Bloomberg's Global Technology Tracker.

The pandemic has also been a driving force behind the digitization process (McKinsey & Company, 2020), which has affected countless sectors from the private sector, relating to the cultivation of one's personal and family sphere, to the public sector, as well as education, work and business, enshrining society's ultimate dependence on telecommunications platforms, devices, and networks. According to estimates in the Global Digital Report 2022, the amount of time people spend online is steadily increasing; appropriate awareness and management of the processes that take place in the virtual ether represent challenges of paramount importance on an individual and collective level. Although on a daily basis many of us enjoy free access to a wide range of digital content and services, most may possess little understanding of the amount, nature and application of data, and information of a personal nature left, more or less consciously, in the hands of web applications and platforms, so that the relative ease of use is often not commensurate with the appreciation of the implications.

The governments of many states, likewise, have long been unprepared regarding effective knowledge of the dynamics of how new digital media work. Only in recent periods has there been a greater awareness of the need to consolidate different policies of action and shared practices of empowerment, even and especially in the supranational dimension. The concentration of digital power[1] risks confining social and political dialogue in the hands of a limited number of actors who have, in fact, the ability to select and filter information, redefining collective agenticity. «Wonderful formula: a continuous power of finally negligible cost! When Bentham thinks he has found it, he thinks it is the egg of Columbus in the order of politics, a formula exactly opposite to that of monarchical power.» (Foucault, 2009), in the primordial attempt to solve a problem of control, digital networks introduce a new one (Giglietto, 2006). Information and communication technologies, because of their profound

[1] *Digital Power Concentration*, Worl Economic Forum, 2021

implications on the organization of society, give rise to an alternative field of surveillance studies to the tradition, called *New Surveillance*, where control is carried out in environments dotted with technological artifacts and intelligent sensors in perpetual communication.

The new surveillance tends to be more intensive, is extensive, extends the senses, is based on aggregates and big data, has lower visibility, involves involuntary (often categorical) compliance of which the subject may be unaware, tends to decrease cost, and reach remote locations (Marx, 2015)

Torpey (2020), identifies a specific reason why social platforms, in particular, are believed to be part of an attention economy; he argues that user data ends up being sold to advertisers who would target their ads to those deemed most likely to show interest in certain news, content, particular products or services:

[....] that is, user data is analyzed with the aim of understanding what a given individual tends to engage with, and the results of that analysis are deployed to keep the user constantly coming back for more content that further confirms that user's preferences (Torpey, 2020).

The constant recurrence in the eyes of users, who are often unaware of personalization, of what is familiar and what has been previously appreciated, risks creating a closed system *Filter Bubble*, within which most attention remains confined, which fosters a reflection of beliefs and attitudes, *Echo Chamber*, that can reinforce individuals' beliefs and inhibit, to some extent, confrontation with alternative positions.

Awareness building about algorithmic mediation represents a crucial node because it evinces obvious semblance in support of the debate on the value of data, along with a document containing policy lines and a novel collection of dendrograms and illustrations generated from the collected research data.

Of the existence of algorithms, users become aware mainly only in the presence of glitches, that is, in the case of unexpected and out-of-ordinary malfunctions or responses by the system, which make the presence of automated recommendations be perceived and visualized fully (Indiano, 2022).

The possibilities an algorithm is able to give and take away define the medium and its ability to act in the society, thus its responsibilities to society and those who use it. Alongside the powerful rhetoric that often accompanies the debate on the impacts of algorithmic decisions, with particular reference to filtering and recommender systems, and a body of literature with mixed results in the face of a phenomenon with complex and varied facets, we highlight, at the end of this section, four issues that according to Moller and Hellberger (2018) would require more attention in order to investigate the effects of the transition from mass to narrowly personalized communication and its repercussions on the value of diversity and the public sphere:

1. *To Wich Degree* algorithmic recommendation can lead to increased polarization of the society ?
2. *How* algorithmic news recommendation can lead to a fragmentation of the public sphere ?
3. *When* algorithmic news filtering leads to new divides in the society
4. *In Wich Cases* algorithmic recommendations can be a means to establish and consolidate economic market power, and create new dependencies

Within a little less than three decades, access to the Internet is increasing in terms of thousands: by 2022, more than 90 percent of the world's population potentially has access to the global interconnection network (ITU, 2021), and this remains the most suitable means of fostering innovation and creating wealth (Van Schewick, 2012). Geographical contexts, the possibilities of access to tools and the cognitions within which such access is characterized, turn out to be particularly relevant factors in order to actually benefit, materially and morally, from technological advancement.

DIGITAL INEQUALITIES

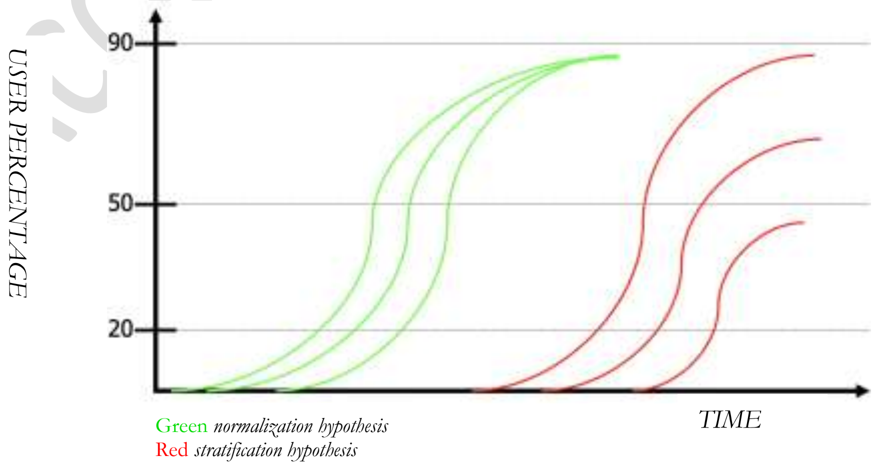
The globally connected network represents the latest in a long line of media that has allegedly accentuated social inequalities, altering pre-existing balances and enabling early adopters to interact with more people and more resources (Di Maggio, Hargittai, Celeste & Shafer, 2001). In an 'era in which an active role, of individuals and organizations, in the ability to access, use and implement Information and Communication Technologies is a critical factor in generating wealth, power and knowledge (Castells, 1998), disparate forms of inequality manifest themselves under different levels and scales of analysis. We will place here, for the sake of practicality, digital inequality on a *continuum* (Scarcelli and Riva, 2016) that moves from one pole of total lack of network access to another of ineffective management and use of digital resources. The digital divide, identifies multiple phenomena:

> *One, for example, is unequal Internet access and usage. A second is unequal ability to make use of the Internet, due not only to unequal access but also to other factors, such as education, language, content, etc. While the second definition is preferable to the first, it is still somewhat vague: make use of the Internet toward what ends? I prefer a wider definition: the digital divide refers to social stratification due to unequal ability to access, adapt, and create knowledge via use of information and communication technologies (ICT)* (2012).

Over time, differing availabilities in access and capabilities to manage digital resources underlie two different views that attempt to provide an interpretation of the phenomenon.

Both postulates start from a curve (in this case, the *Rogers Curve*) capable of describing the diffusion of innovations within society, the normalization hypothesis takes into account the passage of time as the only variable, so differences in the adoption and use of new technologies would tend to diminish until they reach a saturation point that corresponds with a nearly homogeneous diffusion of digital technologies in the population (Fig. 1). The stratification hypothesis, on the other hand, also takes into account economic and cultural factors, which point back to differential moments in the adoption of innovations (Fig. 1), so that differences in access and utilization opportunities would be grafted onto prior inequalities according to a cumulative dynamic that generates stratification.

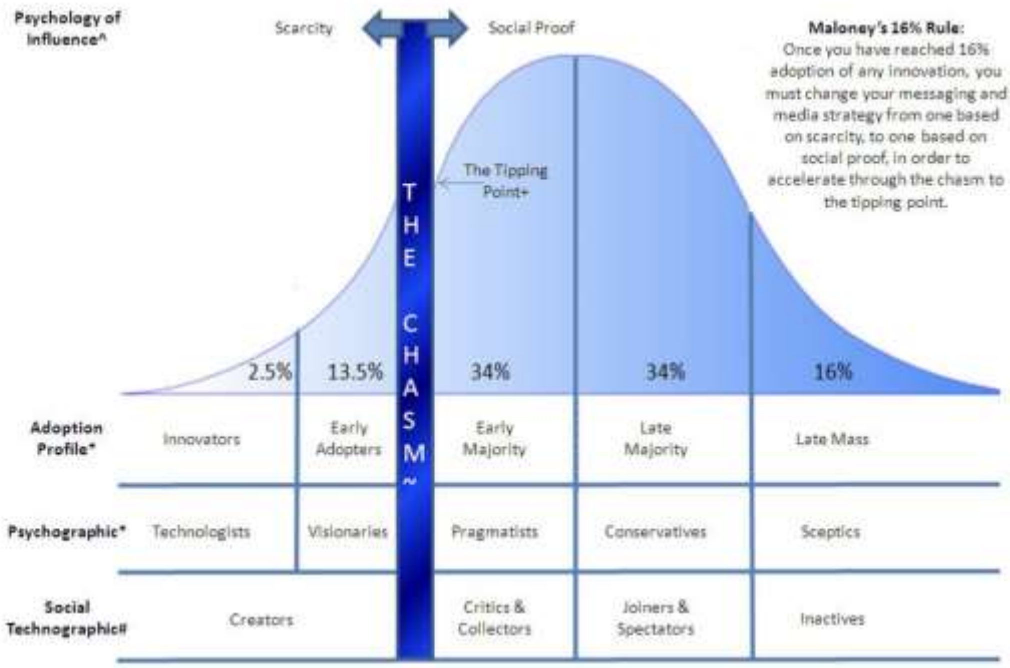
Figure 1: *Normalization and Stratification Assumptions.*



Source: author elaboration

Analyzing the spread of the Internet from the number of people using the network, (Bentivegna (2019, pp 227-228) here is an exemplification according to which both trends would be discernible if one compares the data from the European continent, Central Asia and North America, which would lend themselves to a normalization dynamic, with those for Central and Southern Africa, the Middle East and Latin America, which would instead show more obvious stratification dynamics (Fig. 2).

Figure 2: Accelerating Diffusion of Innovation



Sourse: Cialdini 2021

In nations or localized areas that cannot rely on a robust ICT ecosystem or adequate emancipatory policies to support specific segments of the population, the rapid digitization of living environments, education pathways, and work could lead to exacerbating pre-existing imbalances. First, in terms of countries' economic resilience, slowing down post-pandemic recovery; then, in terms of social equity, as ineffective management of ICT resources:

i. increases structural disparities related to schooling (e.g. The Economist Intelligence Unit Report: Connecting learners: Narrowing the Educational Divide, 2021, estimates the relationship between improvement [+10%] in school network in the countries considered, accompanied by an individual advantage expressed in quality of schooling [Learning-adjusted years of schooling, +0.6%] and a collective advantage expressed in GDP per capita [+1.1%][2]);
ii. affects access to job opportunities at a time when most jobs expand the range of IT skills required, effectively widening the gap between intellectual and manual occupations: Individuals differ more and more in their digital autonomy and opportunities to earn a livelihood in the digital markets of tomorrow (Ibidem).
iii. undermines the adequate acquisition of digital skills themselves by citizens, which are essential to confronting a fluid space with globalized dimensions: the appetite for capabilities predicated upon using multiple technologies working in concert, including

[2] https://www.weforum.org/reports/

artificial intelligence (AI), Internet of Things (IoT)/Internet of Robotic Things-enabled devices, edge computing, blockchain and 5G, is only growing (Ibidem).

iv. lastly, the increasing complexity achieved by information systems, juxtaposed with a serious gap in the digital skills of individuals, risks the emergence of a new and substantial *digital underclass,* even in those contexts characterized by traditionally strong economies.

CONCLUSIONS

In each era, social patterns have largely been defined by the way people communicate and form bonds with each other.

Castells' (2002) perspective is taken, whereby the convergence of social evolution and information technologies creates a new material basis for the conduct of activities throughout the social structure, shaping a *reticular society* with global dimensions, characterized by the pre-eminence of information flows over traditional power flows.

In today's society, access to technological *know-how*, which underpins productivity and competitiveness, is amplified by the cumulative feedback provided by the computational power achieved and the increasing use of artificial intelligence techniques. The emergence of monopolies in computing that provide much of the underlying infrastructure for the Internet ecosystem are investigated in relation to the growing concern concerning their economic, political and ideological role.

It emerges that technological readiness cannot proceed on its own, driven solely by market principles, thus the number of those who believe that human and environmental impacts should be better explored grows. At the same time, on the opposite side, framing the concept of citizens' digital competence in static terms, as far as the governance of different *devices is* concerned, would be limiting, suggesting the need for approaches that foster situated and conscious knowledge in the population in view of the future digital horizon.

Technological endowment, as well as the very uses of the Internet, today show important links with social affiliations, this suggests cautious innovation policies and above all capable of accompanying the formation of the citizen, especially among the most marginalized segments of the population, on pain of the progressive expansion of the distance separating those who benefit from the services and opportunities offered by the digital transition and those who suffer its effects. Today, as we live the story of change in the main processes and organizational forms introduced by the new technological paradigm, we also live the evolution of the social and regulatory model; given the current and future expansion of the ICT ecosystem, dialogue and shared consciousness about its powerful transformative nature will be vital for the integrity of the collective sphere.

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