Available online at www.worldscientificnews.com

World Scientific News

An International Scientific Journal

WSN 134(2) (2019) 118-147 EISSN 2392-2192

Forth Industrial Revolution (4 IR): Digital Disruption of Cyber – Physical Systems

Joanna Kasza

Institute of Culture, Jagiellonian University, Cracow, Poland

E-mail address: joanna.kasza@o2.pl

ABSTRACT

Article focus of the disruptive character of technological innovations brought by Fourth Industrial Revolution (4IR), with its unprecedented scale and scope, and exponential speed of incoming innovations, described from the point view of 'unintended consequences' (cross cutting impact of disruptive technologies across many sectors and aspects of human life). With integration of technology innovations emerging in number of fields including advanced robotics, pervasive computing, artificial intelligence, nano- and bio- technologies, additive and smart manufacturing, Forth Industrial Revolution introduce new ways in which technology becomes embedded not only within the society, economy and culture, but also within human body and mind (described by integration of technologies, collectively referred to as cyber-physical systems). At the forefront of digital transformation, based on cyber physical systems, stands Industry 4.0, referring to recent technological advances, where internet and supporting technologies (embedded systems) are serving as framework to integrate physical objects, human actors, intelligent machines, production lines and processes across organizational boundaries to form new kind of intelligent, networked value chain, called smart factory. Article presents broader context of 'disruptive changes (innovations)' accompanying 4IR, that embrace both economical perspective of 'broader restructuring' of modern economy and society (described in second part of the article as transition from second to third and forth industrial revolution), and technological perspective of computer and informational science with advances in pervasive computing, algorithms and artificial intelligence (described in third part of article with different stages of web development : web 1.0, web 2.0, web 3.0, web 4.0). What's more important, article presents hardly ever described in literature, psychological and philosophical perspective, more or less subtle reconfiguration made under the influence of these technologies, determining physical (body), psychological (mind) and philosophical aspect of human existence (the very idea of what it means to be the human), fully depicted in the

(Received 20 July 2019; Accepted 14 August 2019; Date of Publication 15 August 2019)

conclusion of the article. The core element (novelty) is the attempt to bring full understanding and acknowledgment of disruptive innovations', that "change not only of the what and the how things are done, but also the who we are", moving beyond economical or technological perspective, to embrace also psychological and philosophical one.

***Keywords*:** Forth Industrial Revolution (4IR), cyber-physical systems, digital disruption (disruptive innovations), Industry 4.0, Smart Manufacturing, SMAC (social, mobile, analytics and cloud), pervasive computing, artificial intelligence (AI), Internet of Things (IOT), Industrial Internet of Things (IIOT), M2M (machine to machine), M2H (machine to human), H2M (human to machine) communication, semantic web, symbiotic and ubiquitous web, infosphere, philosophy of information

1. INTRODUCTION - FORTH INDUSTRIAL REVOLUTION (4IR)

When talking about **Fourth Industrial Revolution** (**4IR**) we stand on the brink of yet another technological revolution, that within its almost unprecedented scale and scope, as well as almost exponential pace of emerging '*disruptive changes' (innovations*),[1] will fundamentally change the way we live, work and relate to one another- "changing not only of the what and the how things are done, but also the who we are" [Schwab 2016]. The core of this radical change is not only about the disruptive character of technological innovations brought by Fourth Industrial Revolution (with the speed of innovation in terms of both, its development and diffusion faster than ever before and the returns to scale unprecedented, due to marginal costs that tends towards zero), but rather systemic change across many sectors and aspects of human life, with the cross-cutting impacts of emerging technologies (the effect of synergy and convergence difficult to predict), even more important than the disruptive capabilities they represent.[2] Bringing forth disruptive changes (innovations) brought by new digital technologies, to describe both Third and Forth Industrial Revolution, we refer to the interrelated processes of '*unintended consequences'* as a result of progressive complexity and interdependence of the contemporary world we live in.[3]

---

[1] The term (theory) of disruptive innovation, invented by Clayton Christensen (along with Joseph Bower) in 1995 and called one of the most influential business idea of XXI century, is often 'widely misunderstood' and commonly applied to business that is not 'genuinely disruptive'. Not all innovations are disruptive, even if they are revolutionary, as disruptive innovations create not only new market and value network, but eventually tend to disrupt an existing market and value network, resulting in displacement of established market leading firms, products or alliances. As such, the discernment here is between the incremental innovations, that don't have the world changing consequences, but are critical competitive advantage on the global market, and the disruptive innovations, that do have potential of world changing consequences.

[2] According to Schwab, the speed (velocity) of 4IR is exponential rather than linear, when compared to Second Industrial Revolution, still unfolding in some parts of the world (with nearly 1,3 billion people: 17 % of the world population living without the electricity), this is also true for Third Industrial Revolution (with more than half of world's population, almost 4 billion people with no access to Internet). This also refers to returns of the scale, - comparing Detroit from 1990, major centre of traditional industries with three biggest companies having market capitalization of $36 billion, revenues of $250 billion, and 1.2 million employees to - Silicon Valley in 2014, with market capitalization of three major companies of $1.09 trillion, revenues of $247 billions, but with 10 times fewer employees (137,000) [Schwab 2016]

[3] The term of 'unintended consequences' introduced in social science by Thomas Merton [1936] is hardly brought to discuss the results (consequences) of (disruptive) innovations, it looks like researchers consider mainly an innovation's intended desirable consequences. In the research field of innovations the study of consequences is

This applies in particular to the concept of radical technological breakthrough or disruptive innovations, which J. Schumpeter [1934] wrote about that they have the power of '*creative destruction'*, destabilizing the economical and social operational modes, strategies, or institutions ("perennial gale of creative destruction from the inside constantly destroying the old and creating the new"). [4] According to Toffler [1984] accelerative curve of knowledge-acquisition, fuelled by new technologies, impacts ever increasing pressure of rapid changes, bringing forth '*future shock'* along growing sense of uncertainty and impermanence, reflected in a way we relate to people, things, values and ideas. When imposing such an increasing pace of overlapping, rapid changes on growing complexity and interdependence of the contemporary world (dynamic and turbulent global environment), we come across the area of 'perfect storm': convergence of intersecting waves of change and innovation, creating turbulent conditions with a high level of instability and unpredictability. Depicted character of disruptive changes (innovations) can generally be related to three main megatrends of informational revolution, fully discussed by Wierzbicki (2000),[5] technical megatrend of digital integration (technological convergence), socio-economical megatrend of digital integration (interconnected conditions based on complex requirements of network connections) and last but not least the cultural and cognitive megatrend (based on digital culture and communication, bringing forth the change of the way how we perceive ourselves and the world we live in).

While second industrial revolution focused mainly on the automation of mass production based on electric power, gas and oil, creating industrial economy based on production of mostly industrial, tangible goods, third information-communication revolution, described also in terms of digital revolution, brought forth the transition from analogue, electronic and mechanical to digital, network technology along with post-industrial, digital economy based on the production of cognitive, mostly intangible goods. To compare, Forth Industrial Revolution is characterized mainly by further integration (fusion) of technologies, collectively referred to as cyber-physical systems, representing new ways in which technology becomes embedded not only within the society, economy and culture, but also within human body and mind (described and driven largely on the convergence of physical, digital, and biological innovations). While Second and Third Revolution brought mostly disruptive changes within economic, social and cultural (collective) spheres -described in terms of structural changes within institutions (operational modes) along with dynamics of the relation to values and ideas (current form description: modes

mainly conducted within the diffusion of innovation stream, based on the concept of diffusion [Rogers 1976, 1983], defined as " the process by which an innovation is communicated through certain channels over time among the members of a social system". Diffusion theory applies taxonomy consisting of three dichotomies of consequences of innovation: desirable vs. undesirable; direct vs. indirect, and anticipated vs. unanticipated, defining it from the perspective of the members of the system, i.e. both change agents and adopters (while Schumpeter describes it mainly from the innovator's perspective)

[4] The theme of disruptive innovation or 'creative destruction' as well as their impact on economy described by J.A. Schumptete r [1934, 1939] - "a perennial gale of creative destruction" as an immanent trait of capitalism-presents itself differently within contemporary post-modern world in refers to the original conception, underlying mainly the disruptive results (on-going innovations in technology) and discontinuous, yet systemic character of the process (innovation systems), based on the networks and open innovations (cooperation and exchange) , [more E. G. Carayannis, J.E. Spillan, Ch. Ziemnowicz 2007 ; Wierzbicki 2000].

[5] Introduced concept of megatrend(s) is defined slightly different than the original definition of J. Naisbit [1982], referring to the megatrends as new directions - according to Wierzbicki [2015] this third (intellectual and/or cultural) megatrend brings the greatest challenge(s) of conceptual revolution- the process of destruction of old episteme, resulted in a divergent development of three differing epistemai (technical sciences: more pragmatic then paradigmatic, natural 'hard' sciences more paradigmatic (Khun 1962) and 'soft' social sciences & humanities)

of knowledge) and people (personal interactions and lifestyles), Fourth Industrial Revolution brings more personal (individual) changes affecting directly our body and mind, determining both physical, psychological and philosophical aspect of human existence (the very idea of what it means to be a human). Changing not only what we do but who we are, it will invoke change in our identity (psyche) and all issues related with that: our notion of time and space, [6] relation and perception of physical world (often mediated via digital technology), our way of living: time we devote to work and leisure, our sense of privacy, notion of ownership, our consumption patterns, the way we develop our careers, cultivate our skills and meet people or nurture our relations.

With Forth Industrial Revolution as a leading theme of 2016 World Economic Forum, Klaus Schwab [2016] the executive chairman of the World Economic Forum, who introduced this term on the public forum, associated it mostly with the ‘second machine age’, referring to famous book of E. Brynjolfsson and A.McAfee [2014] in terms of the effects of digitization and artificial intelligence on global economy along with a broader role for advances in nano- and bio- technologies. It’s the fusion of these technologies and their interaction across physical, biological and digital domains that make Forth Industrial Revolution fundamentally different from the previous ones, with advanced robotics and autonomous vehicles accessing information remotely via cloud to disrupt old manufacturing and transport paradigm; artificial intelligence augmenting processes in every industry and institution, revolutionizing the way in which the individual and institutions engage and collaborate; 3D printing creating physical objects from digital drawing with the use of new smart materials (lighter, stronger, recyclable and adaptative) and nano- and bio- technologies redefining the boundaries between digital, physical and biological. Bringing forth integration of technology innovations emerging in number of fields including robotics, quantum computing, artificial intelligence, 5G wireless technologies, additive manufacturing (3D printing), autonomous cars, nano- and bio- technology, Internet of Things, it almost force us to “win the race between the growing power of the technology, and the growing wisdom with which we manage it” [Tegmark 2017].[7]

Toffler underlines, that the acceleration of change(s) in our time is, itself, an elemental force, that has personal and psychological (individual) as well as sociological, economical and cultural (collective) consequences, leading to ‘future shock’: shattering stress and disorientation induced upon individuals by subjecting them to too much (too rapid) changes in too short time,

[6] According to Castells [2000] all major social changes are ultimately characterized by a transformation of space and time in the human experience. Development of digital communication networks radically transformed the spatiality of social interaction by introducing the phenomena of simultaneity at any chosen time frame in social practices, regardless of the location of the actors engaged in the communication process. Thus moving the whole civilisation from the previous ‘space of places’, where physical space became significant barrier limiting development, mainly because the access to goods and services or information and knowledge was limited in time and space (in large part distributed in local communities, and accumulated in the urban space) to the current ‘space of flows’, in which the physical space is partly replaced, partly extended by space of communication (global network of communication), where the access to goods and services as well as knowledge and information is almost immediate and available for all ‘through streams and flow nodes’.

[7] In his book *Life 3.0: being human in the age of artificial intelligence* [2017] Max Tegmark focuses strongly on the phenomena of artificial intelligence and its impact upon all spheres of human life, using the web metaphor for different stages of human life since its inception: with life 1.0 referring to its biological origins, life 2.0 referring to cultural developments in humanity, and life 3.0 referring to technological age of development. With description of current stages of AI development like Deep Mind or Open AI we follow range of possible futures, that feature convergence of humans and intelligent machines, in both positive (Friendly AI) and negative (AI Apocalypse) scenarios.

or massive adaptation breakdowns on the side of the collective. As such, concept of future shock, and the theory of adaptation that derives from it, strongly suggests balance, not merely between rates of change within different spheres or sectors, but rather between the pace of environmental change and the limited pace of human response (potential). To fully understand these phenomena of 'disruptive changes', usually described by reference to new paradigm change, we need to underline, that they have been defined by many scientific disciplines, each of which within the context of its semantic field describing it in its own way (resulting different explanatory models built around different theoretical concepts, together with accompanying different methodology). Looking from the historical perspective the 'totality of change' has been depicted by XXth century discourses in terms of "end-ism" to call Francis Fukuyama *The end of the history* [1992] or Immanuel Wallerstein *The end of the world as we know it* [1999]. With XXIst century discourses we find rather descriptions referring to the dynamics of changes, using the concept of 'disruptive innovations' or Schumpeter's 'creative destruction' to define almost exponential acceleration ('acceleration of the acceleration') to evoke Alvin Toffler *Future Shock* [1984] or Manuel Castells opus magnum *The information Age* [2000].

What's more important, described phenomena are usually depicted from technological (informational or new media sciences) as well as economical or sociological perspective in terms of 'broader restructuring' of modern economy, society and culture, replacing existing structures with the flow (instant, interactive access of information, knowledge, culture as well as capital, goods, services), hierarchical (knowledge and institutions) with horizontal (information and networks) [Stehr 1994; Castells 2000; Bard and Soderquist 2002; Rifkin 2001]. [8] Both the flows and the traffic they carry are largely outside traditional modes and regulation, being merely the diverse expressions of the process(es) of structural (functional), cultural (value and meaning) and institutional 'disruptive change'- endless expansion of reconfiguration (specific ways in which they are being assembled, disassembled and re-assembled) within so called 'liquid modernity' [Bauman 2000; Rheingold 2000; Dawson, Foster 1998; Thirft 2005]. But they hardly ever describe psychological and philosophical perspective of these 'disruptive changes', needed to be depicted and fully acknowledged, more or less subtle reconfiguration of our psychological space (identity) made under the influence of these technologies, determining physical (body), psychological (mind) and philosophical aspect of human existence (the very idea of what it means to be the human).

To conclude our reflections upon 'unintended consequences' of digital disruption (innovations) to characterise Fourth Industrial Revolution (4IR), we need to underline that the concept of 4IR introduced by Klaus Schwab at World Economic Forum (2016) is not well embedded in the body of disciplinary research, when compare to study of (technological) innovation systems embedded mostly in (evolutionary) economics [Hekkert, Suurs, Negro,

---

[8] Above mention scientific discoursed refer mainly to the transition from second to third industrial revolution, describing all the phenomena connected with emergence of new digital technologies, impacting (transforming) simultaneously all sphere of our lives (economic social, political and cultural). Until now we have been mostly benefiting from the emergence of these technologies as a customers (on the demand side of the economy) enjoying from the access to the technology. The next phase, described as 4IR which brings further integration of the technologies, referred to as cyber-physical systems, will predominantly focus on the supply side of the economy with massive structural improvements in efficiency and productivity (automation of manufacturing and management), where the machines will be increasingly competing with the humans on labour market, causing structural unemployment and rapid price deflation in the costs of the global trade.

Kuhlman, Smits 2007].[9] For that reason, introduced concept of Fourth Industrial Revolution can be read rather as ideological or political statement, introduced by the representatives of World Economic Forum, which in itself "provides the platform for thousand leading companies to shape better future ... striving to model world-class corporate governance, where values are as important as rules".

World Economic Forum created Centre for the Fourth Industrial Revolution „global hub of expertise, knowledge-sharing and collaboration, based in San Francisco (milieu of Silicon Valley) to develop policy frameworks and advance collaborations, that accelerate the benefits of science and technology" (described as Network for Global Technology Governance). As such, it seems to presents the perspective (and interests) of 'thousand leading companies' (usually high tech giants located In Silicon Valley), the supply side of the economy, hardly any taking into account the perspective and the interests of the recipients (the demand side of the economy with growing digital inequalities and big data analysis (governance)). Presented by World Economic Forum 4IR discourse, although underlying strongly the disruptive character of incoming changes, inadvertently forgets to mention the 'unintended consequences' of digital disruption (disruptive innovations brought by 4IR), not only positive (intended) but also negative (unintended) consequences (like digital divide or structural unemployment), that put humans in rather precarious position(s).

Its more than understandable, that with dynamics of changes progressing so fast, that whole industries, sectors, companies and social practices are changing before our very eyes, there is a constant and increasing demand for explanations and solutions, coming from the entrepreneurs (private sector), policy makers (public sector), institutions as well as broader public (society). As such, the approach presented by World Economic Forum is much more aligned with the future studies (foresight), considered as subdiscipline of social studies, with the example of technological life cycle analysis (trend analysis and forecasting used in future studies), presented in a form of *Gartner Hype Cycle for Emerging Technologies* [2018]. [10]

It provides us with a road map, graphical depiction of the common patterns arising within new emerging technologies, tracking down maturity of the technology(ies) and its future

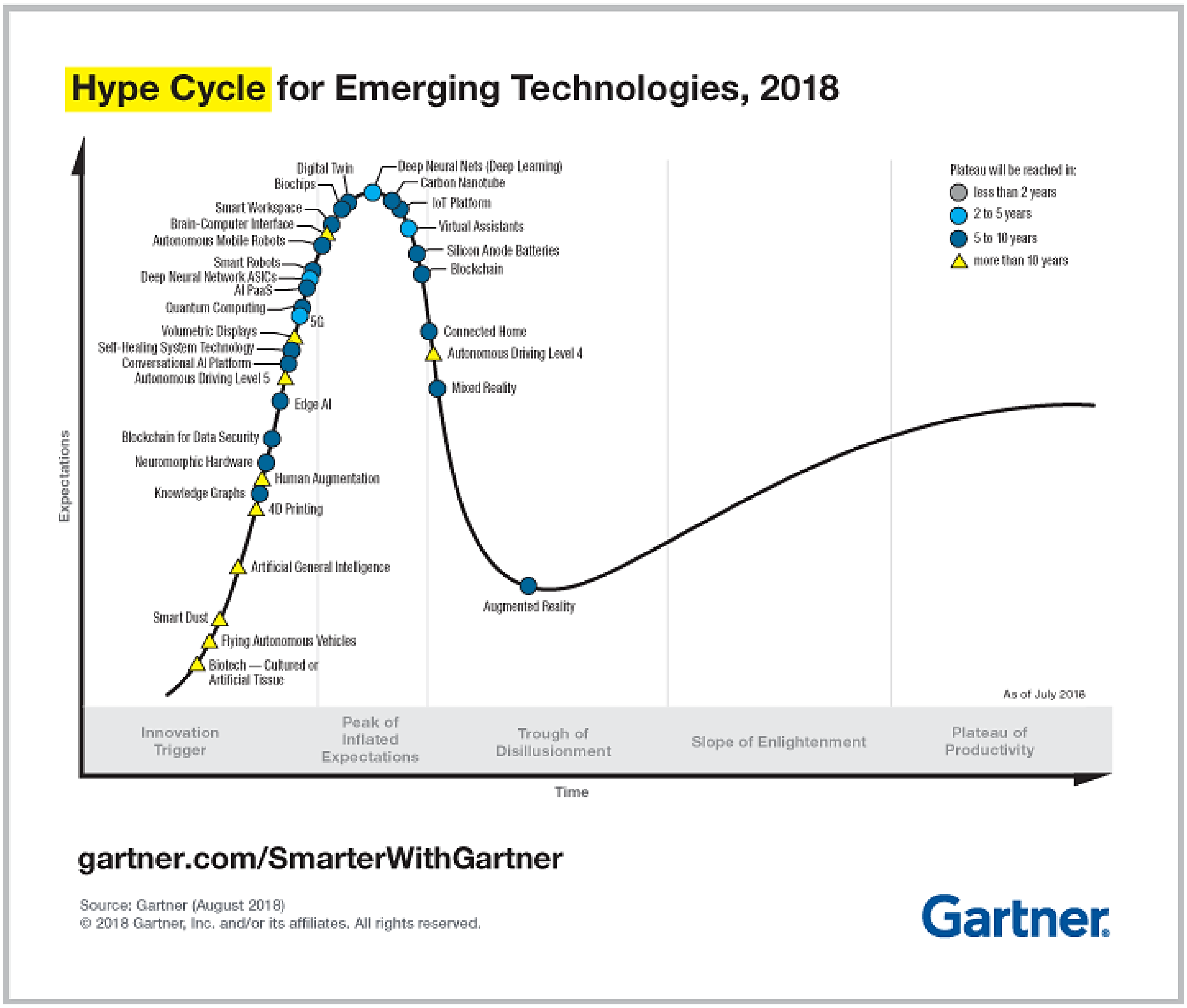
---

[9] Over the last decades, institutional theories combined with evolutionary theories have led to the concept of Innovation System (IS) a heuristic attempt, developed to analyse all societal subsystems, actors, and institutions contributing in one way or the other, directly or indirectly, intentionally or not, to the emergence or production of innovation. Applying the systemic aspect of the systems of innovation approach in order to understand technological change has large implications, explaining why technological change is often a very slow process and why it is so difficult to influence. After all, the rate and direction of technological change is not so much determined by the simple competition between different technologies, but predominantly by the competition between various existing innovation systems, both fully developed and emerging ones. The inertia of technology-innovation system combinations is quite large, which can lead to a lock-in that results in relatively rigid technological trajectories. [Kemp 1994 ; Hekkert at al 2007]

[10] Future studies – interdisciplinary field aggregating and analyzing trends to study possible, probable and preferable future along with the worldviews (paradigm) that underlined them. In terms of technique, futures studies concentrate mostly on extrapolating present technological, economic and social trends, or on attempting to predict future trends. Over time, the discipline has come to put more and more focus on the examination of social systems and uncertainties to the end of articulating scenarios. What's interesting in USA future studies as a discipline emerges from the successful application of the tools and perspective of systemic analysis, focusing on applied projects quantitative tools, while in Europe they focus rather on analysis of long-range future of the humanity with symbols and semantics constituting that future. The field currently faces the great challenge of creating a coherent conceptual framework, featuring widely accepted and consistent concepts and theoretical paradigms linked to quantitative and qualitative methods, exemplars of those research methods, and guidelines for their ethical and appropriate application within society [Masini 1993; Dator 2002; Sohail 2007]

potential, depicted by five phases of Hype Cycle: Technology Trigger, Peak of Inflated Expectations, Rough of Disillusionment, Slope of Enlightenment and Plateau of Productivity. It's a useful depiction to understand both the scope and scale of disruptive character of technology innovations emerging within Forth Industrial Revolution, including Quantum Computing, Deep Learning, Machine Learning, 4D Printing, 5G Technology, Virtual Assistance, Brain Computer Interface, General Artificial Intelligence, Internet of Things (IoT), Industrial Internet of Things IIoT, Smart Buildings, Smart Cities, Smart Grid (IoT Energy Management), Autonomous Transportation Systems (Picture no. 1).

From presented graphic it's easy to understand unrealistic expectations and disillusionments of 'virtual reality' technologies in the 1990 and early 2000s as a result of middle phases of the life cycle, encountered before this technology can be fully integrated (embedded) within the society.



Picture 1. Gartner Hype Cycle for Emerging Technologies [2018]

2. TRANSITION: FROM SECOND- TO THIRD- AND FORTH INDUSTRIAL REVOLUTION (FROM THE POINT VIEW OF THE ECONOMY)

In literature**, transition from second to third industrial revolution refers mainly to the *classical paradigm (concept) of industrial labour***, emphasising the transition from the traditional fordist to post-fordist modalities of labour as a result of fundamental, structural transformation within the economy, described previously by D. Ricardo or J. M. Keynes in the context of industrial capitalism, or more recently by D. Bell (1973) in terms of post-industrial society, J. Rifkin (2011) third wave of industrial revolution (cognitive capitalism: Vercellone 2007; Pasquinelli 2009; Boutang 2012; Peters 2011 or informational capitalism: Hardt and Negri 2000, Castells 2000, Fuchs 2010). From the point view of the economy, its defined by *transition from the industrial economy* (production of material, tangible goods) based on the economy of scale (mass production, mass consumption; manufacturer's market) *into the post-industrial economy* (defined in terms of informational or digital economy and knowledge-based economy), personalized production and consumption (castomerization) based on the production of mostly cognitive, intangible goods (information, knowledge, culture: symbolic goods). We could also described it in terms of paradigm shift, referred by M. Castells [2000] as information society, associated primarily with, moving for the first time, beyond the physical limitations of time and space - transition from "space of places" to "space of flows", in which physical space is partly replaced, partly extended by space of communication: symbolic and virtual. That simply means, that development of digital technologies radically transformed the spatiality of social interaction by introducing the phenomena of simultaneity or any chosen time frame in social practices, regardless of the location of the actors engaged in the process. Thus moving the whole civilisation from the previous 'space of places', where physical space become significant barrier limiting development, mainly because access to goods and services, and information or knowledge was limited in time and space (in large part distributed in local communities and accumulated in urban space) to current 'space of flows', where within global network of communication, access to goods and services or information and knowledge is almost immediate (instant, interactive and synchronic), taking place in 'timeless time' in 'virtual space through streams and flow nodes'. [11]

From the point view of classical paradigm, *fordist modalities of labour associated with the industrial economy*, moulded in 20 of XX century, refer to production of homogeneous industrial (material) goods, based on the economy of scale (mass production and mass consumption as an accumulation regime; manufacturer's market) or "particular configuration of technical and social division of labour involved in making long runs of standardized goods" (Jessop 1992).[12] Fordist's mass production, based on the rigid technology of the assembly

---

[11] This new form of spatiality, defined by M. Castells as the space of flows: material support of simultaneous social practices communicated at a distance, embrace both the transmission and processing of flows of information or culture (symbolic goods) as well as the connectivity of activities located in the local nodes of global communication networks. As such the key feature of the networked connection is the relation, or rather increasing tension, between the local and the global (glocal) : micro-network of the high-level decision-making process, based on the face-to-face relations (space of places) linked to a macro-network of decision implementation, based on global digital communication networks (space of flows) - Castells [2010]

[12] When describing fordism and post-fordism concept (along with it's terminology) from the point view of political economy, in order to avoid the popularised (vulgarised) version, one should distinguish four levels on which it has been analysed within the literature : the labour process, the regime accumulation, it's modes of regulation and societalization (more : Jessob 1992, 1995). At the same time, it's worth noted, that fordism when talking about the

production line and standardised 'taylorist' work routines, brings the phenomenon of mass worker on one hand, with homogeneous mass consumption (homogenisation of the working class) on the other, to provide a market for mass commodities. Classical fordist model of labour, symbolized by a qualified industrial worker (usually male), was based on stable employment model on the basis of permanent employment contract (for an indefinite duration), mainly because companies then operated in a stable, durable and sustainable environment. In fordist model of labour, employee (worker) perceived his environment, in which he functioned, both in the social (male as a dominant figure on the labour market: the sole supporter of the family) and economic sphere (low level of unemployment, steady economic growth, low inflation) as stable, with the remuneration enough to ensure the stability not only to himself, but also to his family (accessing various entitlements or allowances in the field of social security as a derivative of employment). From that perspective, *post-fordist modalities of labour, associated with post-industrial economy,* have been shaped mostly by technological changes, mainly the development of ITC technologies and related economic, social and demographic changes, especially changes in the family structure and women entering the labour market. The primary determinant of this model is the transition from the dominance of the sphere of production (tangible, industrial goods) into sphere of services (mainly intangible) towards the symbolic goods (information, knowledge, culture), described often as a transition from industrial to post-industrial economy, where both production and consumption is personalized (castomerization and customization) and flexible, based on a wide range of niche products tailored to variables and specialized needs of narrow target audiences (segmented, niche production and consumption, consumer's market). [13] Along with the flexibility as a main characteristic of post-fordist modalities of labour (flexible production and appropriately flexible workforce) comes the unstable employment model - the transition from classical, stable mode of employment (for an indefinite duration on full-time basis) to unstable, flexible mode of employment (fixed-term contract, or others form of contract under civil law i.e. the contract orders or managerial contract). Often referred in literature as so-called 'junk contracts', mainly because they not only offer unstable employment model, but also do not include any social or security benefits (bringing increasing flexibility of employment on one hand, with lack of stability -erosion of the traditional employment relations- on the other, with part of the risk of employment projected from the employer to the employee).

Coming to **the transition from the third to fourth industrial revolution we require emergence of new paradigm (concept) of digital labour (*immaterial labour 2.0*)** as a result of fundamental change within technology, using web metaphor (referring to civilization 2.0,

labour process, was actually quite limited in diffusion and never fully realized even in Ford's own plants in North America, not to mention those in Europe. As such only a small part of manufacturing output has been produced in fordist conditions along with a small proportion of labour force employed in fordist modalities of work, mainly because every economy develops its own technically optimal labour process to match its pattern of industrial specialization and development stage [Kasza 2018].

[13] When talking about post-fordism and its new modes of regulation, its concept derives entirely from the promise of overcoming the limits of fordism - technical limits defined by reduced possibility of raising productivity through economies of scale, de-skilling workers and intensifying labour, - social limits defined by growing pressure on profitability, managerial prerogative and public finances imposed by the growing demands of the mass worker ; - economic limits defined by falling rate of profit as a results of organic composition of capital, rising wages in the face of declining productivity growth, or the limited market for homogeneous consumer goods as incomes rise [Kasza 2018].

economy 2.0 or society 2.0),[14] to indicate the world after information and communications revolution (McAfee 2006; Tapscott 2008; Cote, Pybus 2007; Cook 2008).Third Industrial Revolution underlines the progressive process of digitalisation of economic, social and cultural sphere as a result of fundamental (disruptive) changes within technology itself (digital revolution), imposing constant transition ('in between') two different environments simultaneously: the physical environment, embedded in real space and time continuum, and digital environment, embedded in virtual time and space (timeless time and space of flows Castells 2000). The new paradigm of network society (or informational society) introduces quite new categories for the analysis of labour relations 'in between' : human-tool-object (described in research trend STS science-technology studies, exploring the relations between science-technology-society), underlined in the theory of actor-network ATN (Latour 2005, 2010),[15] as well as new science of networks (Barabási 2002 studies of social networks, multi-agent system analysis, including research on algorithms and artificial intelligence or technology cooperation networks ; Reingholt 2000). This new paradigm, focuses mainly on the dynamics of the relations 'in between' objects, ideas, processes as well as actors, or rather actants (expanding the definition of human actors with the categories of nonhuman: tools, technologies or objects), both in the context of the individual and the collective. This new description of relations, based on new concepts: translation, transformation, or binding, launch new areas of study (tension) in between: the real, physical and symbolic, digital (environment, organization or identity), as well as in between humans and non-humans: machines, new technologies (algorithms or artificial intelligence). In the context of digital economy, or using the Latour's terms techno-human collectives (networks), arises the dilemma of effective investment in network development: in whom to invest more: the employee (human) or technologies (machines). Within the context of increasing 'human gap', we could find more and more hybrid models or solutions, which attempt to combine subjectivity or agency of human (actors) and non humans (in a concept of co-agency), which applies not only to digital networks, but in general to cooperative networks in which human(s) participate alongside the inhuman(s), creating techno human collectives, where they form a symbiotic system engaged in the process of learning (Levy and Murnane 2004; Hirschhorn 1986; Rotman 2013).

Fourth Industrial Revolution brings forth further integration (convergence or fusion) of technologies, collectively referred to as cyber-physical systems, to become fully embedded within the societies, economy, politics and humans, thus blurring the boundaries 'in between' physical, digital, and biological spheres [IEEE 2008, Lee 2008]. With new disruptive innovations rapidly emerging, to start with the internet, social networks, mobile platforms,

[14] O'Reilly [2007] uses this term 2.0 to describe second generation networked services, giving the example of Google as a leading Web 2.0 entity with the efficacy of its search engine largely depending upon the collective activity of its users. We could say, that web 2.0 happens when the accretion of cultural knowledge, or the 'general intellect' - in networked relations - becomes the primary dynamic of the internet. Another example of Web 2.0 would be wikis (open user-generated content sites like Wikipedia) and folksonomy (user defined categories or 'taxonomy from below' with practices commonly known as 'tagging' as a central feature on social networks like Flickr or de.licio.us).

[15] Actor–network theory (ANT) is both theoretical and methodological approach to social theory describing social and natural worlds exists in terms of constantly shifting networks of relationship (constructivist approach based on 'material-semiotic' method reflecting maps of relations, that are simultaneously material (between things) and semiotic (between concepts). As such nothing exists outside those relations, all the factors involved in a social situation are on the same level, thus, objects, ideas, processes are seen as just as important in creating social situations as humans, bringing new definition of actants (expanding the existing definition of human actor(s) with nonhuman categories of: tools, technologies or objects) [Latour 2005]

advanced analytics, big data, cloud computing and the artificial intelligence- the increasing convergence of *social media, mobile devices, analytics, and cloud computing* (SMAC) combined creates new technology system (environment), that supports disruptive and sustaining innovations [Cornelius 2013].[16] Thanks to the Internet, sensors and embedded systems, completely new environment is opening up for convergence of physical, mechanical, mental and digital work with the latest phase of so called 'pervasive computing', based on progressive integration of Information Technology (IT) and Operational Technology (OT). This is the convergence of two historically independent, economical developments: advanced of *Information Technology* (Business Process Automation and Office Automation) with predictive data analytics, smartphones and traditional administrative automation, and *Operational Technology* (Industrial Process Automation& Factory Automation) industrial machinery and automation designed and developed since the start of the industrial revolution [Sogeti 2014]. This integration results in further industrial development on the basis of end to-end automation, with triple paradigm : *machine-to-machine communication (M2M)* not only between machines in factories but also between all conceivable devices and systems (reduction of human work with increase in efficiency and security), *predictive maintenance* of machines and appliances on the basis of direct status reports with possible upgrades and remote repairs (extra reliability and quality upgrade, speed to numerous appliances and adjusts in response to routine maintenance schedules) and *improved human to machine interaction (H2M*) mostly via consumers' products usage (sharing user data with appliances to create new value and shape or improve service quality).

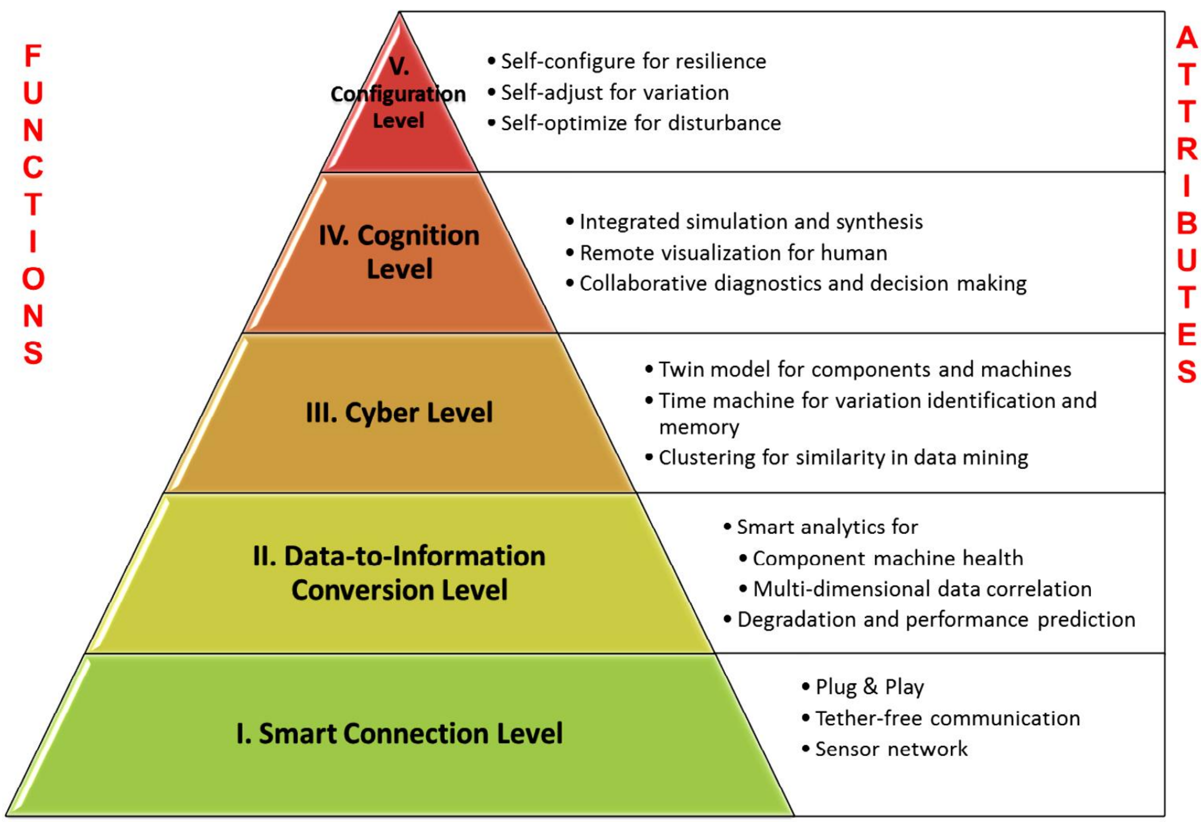
At the forefront of described digital transformation, based on cyber physical systems, is the *Industry 4.0,* [17] referring to recent technological advances, where the internet and supporting technologies (embedded systems) are serving as framework to integrate physical objects, human actors, intelligent machines, production lines and processes across organizational boundaries to form new kind of intelligent, networked and agile value chain, called *smart factory* [Schumacher, Erolb, Sihna 2016]. According to Helmuth Ludwig, CEO of North American industrial branch of Siemens, "this is nothing less than a paradigm shift in industry: the real manufacturing world is converging with the digital manufacturing world to enable

---

[16] SMAC (social, mobile, analytics and cloud) is the new concept, in management studies, based on the convergence of four technologies (social media. mobile devices, analytics and cloud computing) that creates the ecosystem supporting disruptive and sustaining innovation(s). While each of the four technologies can affect business individually, their convergence is proving to be a disruptive force that is transforming industries and creating entirely new business models, enabler for the next generation of technological trends. That's not the only term describing this phenomenon, Aberdeen Group, came up with the term "SoMoClo" (social media, mobile technology and cloud computing), Gartner described it as the "nexus of forces," consisting of social media, mobile technology, cloud computing and information, International Data Corporation (IDC) as "the third platform." a combination of "technology enablers that allow businesses to accelerate their digital transformation" [Cornelius 2013]

[17] The term of industry 4.0 originated from German Goverment project promoting strategic approach to digitalization of manufacturing, and has been presented to public forum for the first time at Hanower Fair in 2011 - Working Group on Industry 4.0 headed by Siegfried Dais (Robert Bosch GmbH) and Henning Kagermann (German Academy of Science and Engineering) presented set of Industry 4.0 implementation recommendations to German federal government in 2012, with the outlined characteristics of : required automation technology improved by the introduction of methods of self-optimization ; self-diagnosis, cognition and intelligent support of workers in their increasingly complex work ; and self-configuration strong customization of products under the conditions of highly flexible (mass-) production [more : see *Re-Imagining Work: White Paper Work 4.0* Federal Ministry of Labour and Social Affairs of Germany 2015]

organizations to digitally plan and project the entire lifecycle of products and production facilities". In essence industry 4.0 describes trend towards automation and data exchange in manufacturing technologies and processes embedded in ICT technologies like cyber-physical systems (CPS), cloud computing, cognitive computing, big data analytics, artificial intelligence (AI), Industrial Internet of Things (IIOT), based on three principles : - interconnectivity and information transparency (allowing to collect immense amounts of data from all points in the manufacturing process, aiding functionality and key areas for innovation and improvement), - technical assistance (of CPS both physical, performing tasks unpleasant for humans, and analytic, aggregating immense amount of data to made human better decisions) and - decentralise decisions (CPS autonomous decisions). Described process need to take place both on horizontal level (across all participants in whole value chain) as well as on the vertical one (across all layers of automation), where integrated and networked factories, machines and products will act in intelligent and party autonomous ways, that requires minimum (manual and cognitive) intervention from human side [Monostori 2014].[18]



Picture 2. 5C architecture for implementation of Cyber-Physical System [Lee, Baghieri, Kao 2014].

[18] Lee, Bagheri, Kao [2015] propose 5 level architecture of CPS structure as a model for industry 4.0 (picture no.2) providing step-by-step guideline for developing and deploying CPS for manufacturing application : 1. Smart connection level, 2. Data-to-information conversion level, 3. Cyber level, 4. Cognition level, 5. Configuration level, all based on two main functional components: - advanced connectivity that ensures real-time data acquisition from the physical world and information feedback from the cyber space; and - intelligent data management, analytics and computational capability that constructs the cyber space.

Comprehensive description of Industry 4.0, defined by Boston Consulting Group, underlies nine aspects embedded within the concept: big data and analytics, autonomous robotics, cloud computing, simulations, additive manufacturing, horizontal and vertical integration, augmented reality, Internet of things and cyber security [Erboz 2017; Rüßmann 2015]. The end result of this process is described in terms of *Smart manufacturing* or *Cloud Based Manufacturing*, and (*Industrial) Internet of Things* (IIoT), where everything will eventually be connected to everything else, from design to maintenance, upgrade and reuse, producers, service providers and customers, the real manufacturing world and digital world of connectivity and cognitive thinking, humans and the machines (Picture no. 2).

From this perspective physical world is becoming a type of information system with sensors and actuators embedded in physical objects and linked through wireless network via IP (internet protocol) along with digital network system, based on algorithms and artificial intelligence, that in itself is an information system, thus making possible integration (fusion) of physical and digital environments (systems translatable to each other as information systems). Its accompanied by biological components (living beings), that can be embedded within these informational system through bio- and nano- technologies (directly affecting human body and mind to determine physical, psychological and philosophical aspect of human existence) or/and wearable devices with embedded sensors and actuators (with human experience mediated through digital devices). That's why, as said before, with 4IR comes fusion (blurring the boundaries between) physical, biological and digital with no real difference between physical (objects or materials), digital systems (algorithms, artificial intelligence) and biological beings (with humans and animals inextricably linked or embedded into these information systems in the nearest future), becoming part of these information systems, describe by Luciano Floridi in terms of 'infosphere' [2014]. [19]

3. 4IR: DIGITAL DISRUPTION OF CYBER PHYSICAL SYSTEMS - FROM THE POINT VIEW OF INFORMATIONAL SCIENCE

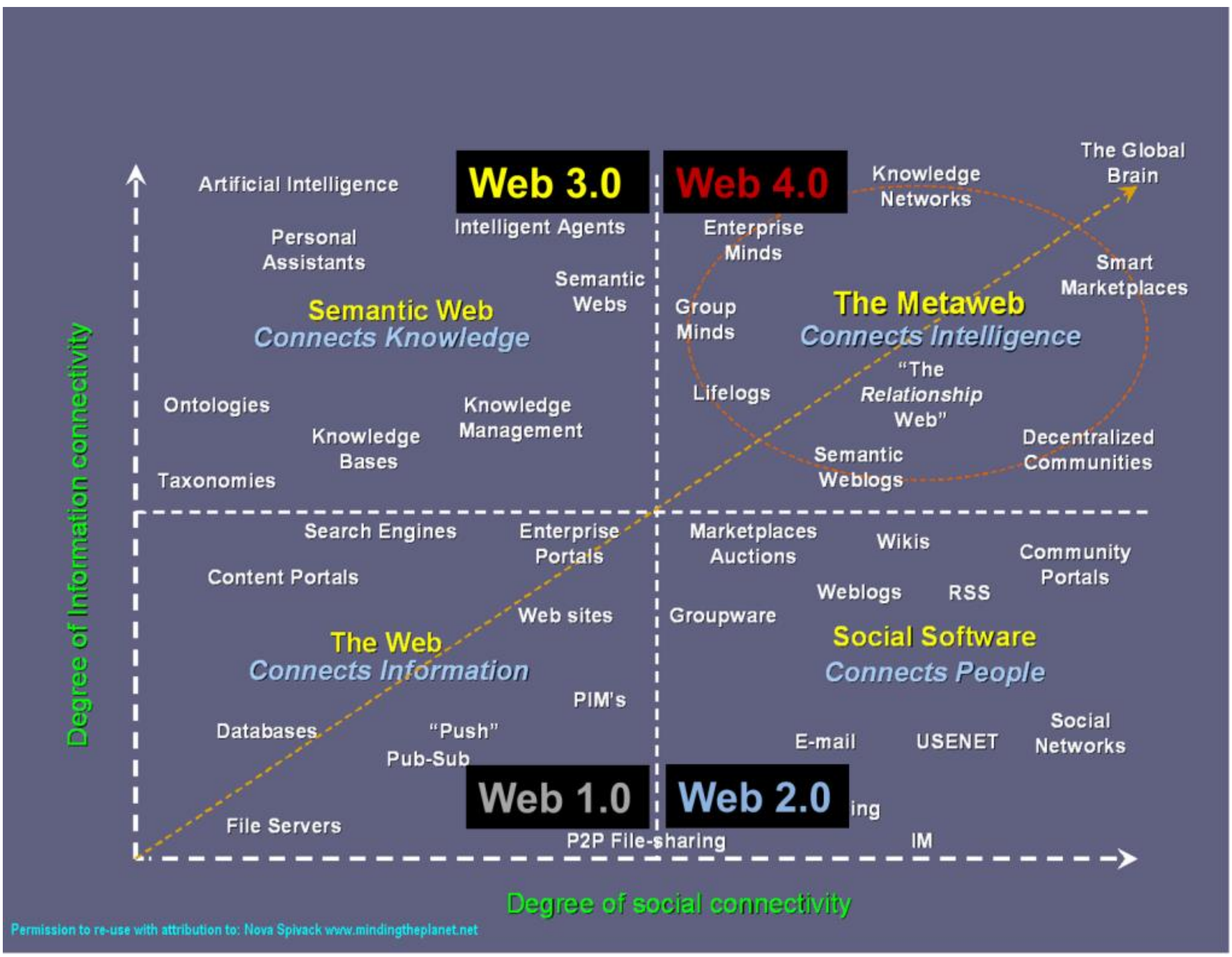
If we look at the ongoing Industrial Revolution from the perspective of development of cyber-physical systems, using web metaphor to describe the world after ICT revolution, four steps come into view: *web 1.0* (read only, company focus, connected information, home page), *web 2.0* (read-write, community focus, connected people, blogs and wikis), *web 3.0* (read-write-execute, individual focus, connects knowledge, live-streams, intelligent agents, semantic webs) *and web 4.0* (read-write-execute concurrency web, connects intelligence, symbiotic web: convergence of humans and the machines, knowledge networks).[20]

---

[19] Luciano Floridi in his book *The Fourth Industrial Revolution. How the infosphere is reshaping human reality* [2014] describes the whole pheneomena of Forth Industrial Revolution from the point view of philosophy of information (PI) and information ethics (IE), thus forming the epistemological base to re-think the increasingly technologized world we live in, that is turning into this 'new informationally' dense environment, defined in terms of 'infosphere', where we spend more time, interfacing and interacting with intelligent agents (algorithms, artificial intelligence). He denotes that this informational environment with all its processes, properties, interactions, and mutual relations is a main point of reference for knowledge-based economy, where information and data become essential driving force for the whole society.

[20] I focused mainly on the description of already existing semantic web 3.0 and incoming intelligent web 4.0, although in literature we can also encounter description of further stages of web, like sensory-emotive web 5.0 [Benito-Osorio al 2013; Parvathi, Mariselvi 2017]. Prediction (foresight studies) define web 5.0 in terms of

The current form internet Web 3.0, known as semantic web, provides a structure to data and link existing systems more efficiently for reuse across various applications to create context, that, in turn, gives meaning (using metadata, data in converted into meaningful information which can be located, evaluated and delivered by software agents). The next step Web 4.0, known as symbiotic and ubiquitous web (intelligent web) is based on symbiotic relations between humans and the machines, with the entire web being a single operating system interacting and communicating with users in a form of personal assistance. As we can see from the drawing below (Picture no. 3) continuous development of following stages of the web depends upon two factors : degree of information connectivity (technological side and digital disruption) and degree of social connectivity (social side and active involvement of the users)



Picture 3. Roadmap of Web development [Nova Speak mindingtheplanet.net)

---

emotional interactions between humans and machines, based on neuro- and nano- technology and weareble devices that will recognize our emotions in real time through changes in facial recognition and body response (more: mapping of human emotions www.wefeelfine.org), creating emotionally-resonant environment for users [Kambil 2008].

First generation of World Wide Web: web 1.0 - was officially created in 1989 with a proposal from Tim Berners-Lee, computer scientist working at the European Organization for Nuclear Research (CERN) as an open computer network for research exchange within CERN.[21] This new space of information, described in terms of *web 1.0* (*connects information*) was based on the static web sides (home pages) written in HTML code, functioning mainly as a one-way model of communication (*read only*) with asymmetrical relation between (active) sender (site owner) and (passive) recipient (site user), in form of interlinked, hypertext documents accessed through the web via hyperlinks with poor graphics and unintuitive interface of web browser(s). ***Second generation of web 2.0*** refers primarily to change in design and use of websites (*social aspect: connects people*), not so much with a breakthrough in technology (although new codes of XHTML and RSS has been introduced). Term 'web 2.0' was first used by Darcy DiNucci [1999] in the article '*Fragmented Future'* addressed to web designers, and later widely promoted by the Conference dedicated to Web 2.0, organised by O'Reilly Media and Media Live in 2003 (Tim O'Reilly and Dale Dougherty).[22] Important feature of Web 2.0 is defined by interactive, two-way communication (*read-write*), based on the "open exchange, sharing and use of information", with more symmetrical relations between the sender and the recipient, where sender (site owner) and recipient (site user) become both the creator and receiver of the content (with new terms appearing like 'user generated content' and 'wreader' as a word combination of writer-reader). Major role in creating web 2.0 played social networks along with social media, self publishing platforms (wordpress), blogs and wikis, tagging (folksonomies), video sharing, hosted services and web applications- both in the context of personalisation of content as well as active role of users (enabling increased participation), influencing the shape of future web development (*community focus).* It was mostly social and participatory nature of web 2.0 (social networks, community portals and collaborative knowledge), that made a difference with more flexible web design, creative reuse, and collaborative content creation and modification, bringing forth social networks like MySpace, Twitter, Facebook, media sharing such as YouTube, Slideshare or Flickr and collaborative knowledge through wikis: Wikipedia to support and gather collective intelligence of web users [Patel 2013]

[21] While working in CERN 1989, Tim Berners Lee made a proposal for information management system, linking hypertext idea with Transmission Control Protocol and domain name systems (developing three fundamental technologies of web: HTML, URI, HTTP) using similar ideas to those underlying the ENQUIRE system to create the World Wide Web, for which he designed and built first web browser (his software functioned also as an editor called WorldWide Web running on NeXTSEEP operating system and first Web Server CERN HTTPd (Hypertext Transfer Protocol demon) [Sindhu, Chezian 2016]. „Creating the web was really an act of desperation, because the situation without it was very difficult when working at CERN. Most of the technology involved in the web, like the hypertext, like the internet, multi-font text objects, had all been designed already. I just had to put them together. It was a step of generalising, going to a higher level of abstraction, thinking about all the documentation systems out there as being possibly part of a larger imaginary documentation system" [Berners Lee, Fischetti 1999]. Currently working in Massachusetts Institute of Technology (MIT), director of World Wide Web Consortium (W3C), Web Science Research Initiative (WSRI), founder and President of Open Data Institute.

[22] In his article 'What is Web 2.0 .Design Patterns and Business Models for the Next Generation of Software' Tim O'Reilly described the initial brainstorms session between O'Reilly and MediaLive, that brought into being the concept of 'web 2.0' - the article is still more than relevant to read as the term 'web 2.0' become so and commonly used, serving as a meme and buzzword with no real understanding of just what it means. The article defines broad delineation (differentiation) between the web 1.0 and web 2.0 that can be described as a transition: from publishing to participation, from directories (taxonomy) to tagging (folksonomy), from screen scrapping to web services, from domain name speculation to search engine optimalization, from personal websites to blogging, from page views to cost per click, from DoubleClick to AdSense [more O'Reilly 2007]

The **current form of third generation network: Web 3.0**, known as *semantic web*, provides a structure for more effective contextual search (*connects knowledge*) with the use of meta-data, which converts data into meaningful information, that can be located, evaluated and delivered by the software agents. Term Web 3.0 has been used for the first time by John Markoff New York Times journalist [2007] in the context of networks based on intelligent tools (intelligent agents) and mechanisms associated with artificial intelligence, allowing to obtain data in deliberate way in accordance with user's preferences.[23] However, the original vision of the Semantic Web belongs to Tim Berners Lee, introduced initially as 'web of data', that could be processed by the machines in the form in which you can link to its importance within the appropriate context of personal assistance.[24]

Important feature of Web 3.0 is immersion (integration) of data, based on the use of meta-data and new semantic technologies: RDF (Resource Description Framework), OWL (Ontology Web Language) and XML (Extensible Markup Language), facilitating effective, contextual search (personalized, taylor made search), content-aware and context-aware with next generation of browsing and searching capabilities (*read-write-execute*) [Patel 2013]. By appropriating new semantic technologies (semantics markup and web services) to structure data and link them for more effective search, integration and reuse across various applications (supporting computer to computer interactions), web 3.0 extends network of hyperlinked human-readable web pages (existing architecture of web 2.0) with machine-readable meta-data about pages and their mutual relations (architecture of web 3.0), based on their importance within appropriate context of personal assistance (enabling software agents to access web more intelligently and perform 'execution function' by automated information gathering and search in behalf of the users). Due to amount of data or information, growing at almost exponential pace, search of network resources becomes much more difficult, in this situation the key becomes the processes of selection and verification of data as well as the need for precise understanding of enquires systems, generated by the user (knowledge bases, ontologies, intelligent agents, personal assistance).

The next step in Web 4.0, known also as symbiotic and ubiquitous web, or intelligent web (*read-write-execute concurrency web*), is based on the symbiotic relations between humans and the machines, with the entire web being a single operating system interacting and

---

[23] In his article '*Entrepreneurs See a Web Guided by Common Sense*' (2006) Markoff introduces the idea of web 3.0 as the idea of semantic web, that adds meaning - citing Nova Spivak, the founder of a start-up firm whose technology detects relationships between nuggets of information by mining the World Wide Web- who „call it the World Wide Database", the transition from „Web of connected documents to a Web of connected data". He than compares the web 2.0 „which describes the ability to seamlessly connect applications (like geographic mapping) and services (like photo-sharing) over the Internet" with the future potential of web 3.0 „when machines will start to do seemingly intelligent things" by adding „ a layer of meaning on top of the existing Web that would make it less of a catalogue and more of a guide, and even provide the foundation for systems that can reason in a human fashion. That level of artificial intelligence, with machines doing the thinking instead of simply following commands, has eluded researchers for more than half a century" [more Markoff 2006]

[24] The concept of the semantic network model was formed in the early 1960s by researchers such as the cognitive scientist Allan M. Collins, linguist M. Ross Quillian and psychologist Elizabeth Loftus as a form to represent semantically structured knowledge. Referring to those concepts, when working upon the www standards, Berners-Lee has expressed his original vision of the semantic web "I have a dream for the Web [in which computers] become capable of analyzing all the data on the web - the content, links, and transactions between people and computers. A "Semantic Web", which makes this possible, has yet to emerge, but when it does, the day-to-day mechanisms of trade, bureaucracy and our daily lives will be handled by machines talking to machines. The "intelligent agents" people have touted for ages will finally materialize" [Hendler, Berners-Lee T. 2010].

communicating with users in a form of personal assistance, simulating the way we communicate with each other. Web 3.0 has already began the development of machine-readable content for Web 4.0. with smart appliances connected to the Internet able to perform tasks without human involvement, mostly with the use of sensors and radio frequency identification tags (RFID). It's described in literature in terms *Internet of Things* (IoT) and *Internet of Everything* (IoE), where not only people (web 2.0) or the machines (web 3.0) are connected, but also almost all objects and appliances with given an IP address (web 4.0), creating ubiquitous web of highly intelligent interactions in between the real and digital world in 'real time' [White 2015; Almeida 2017]. It's also described in terms of ubiquitous computing [25] and pervasive computing (ambient intelligence) [26] to denote 'computing that can be made anywhere anytime' through any device, any format, and any location (in refers to distributed computing, mobile networking, location computing, sensor networks, human-computer interaction, context-aware smart technologies, artificial intelligence) bringing forth issues like mobility, access control, privacy and trust, along with security.

Internet of Things is the network of physical devices, vehicles, appliances and other items embedded with electronics, software, sensors and connectivity, enabling all things to connect, collect and exchange data (knowledge networks, smart grid), thus creating the opportunity not only for more direct integration (connectivity) of physical world with digital world of computer based systems, but also more direct integration (convergence) of humans and the machines, blurring the boundaries between physical, digital and biological. New 'symbiotic environment of Internet of Things' will be created through more interactive data coming from embedded sensors and RFID tags connected to objects (not only movable devices and objects like autonomous cars but also immovable buildings, creating so called 'intelligent building' as an element of future smart homes, smart cities and smart grids) on one hand, and personal assistance coming from both intelligent agents and wearable devices with embedded sensors to recognize user's personal preferences (through all the data and information, digital tracks or digital personality, we create and leave in web) on the other.

The concept of Internet of Things is closely intertwined with 5G (Fifth Generation) technology and advances in AI (Artificial Intelligence),[27] large scale of networked multi-agents

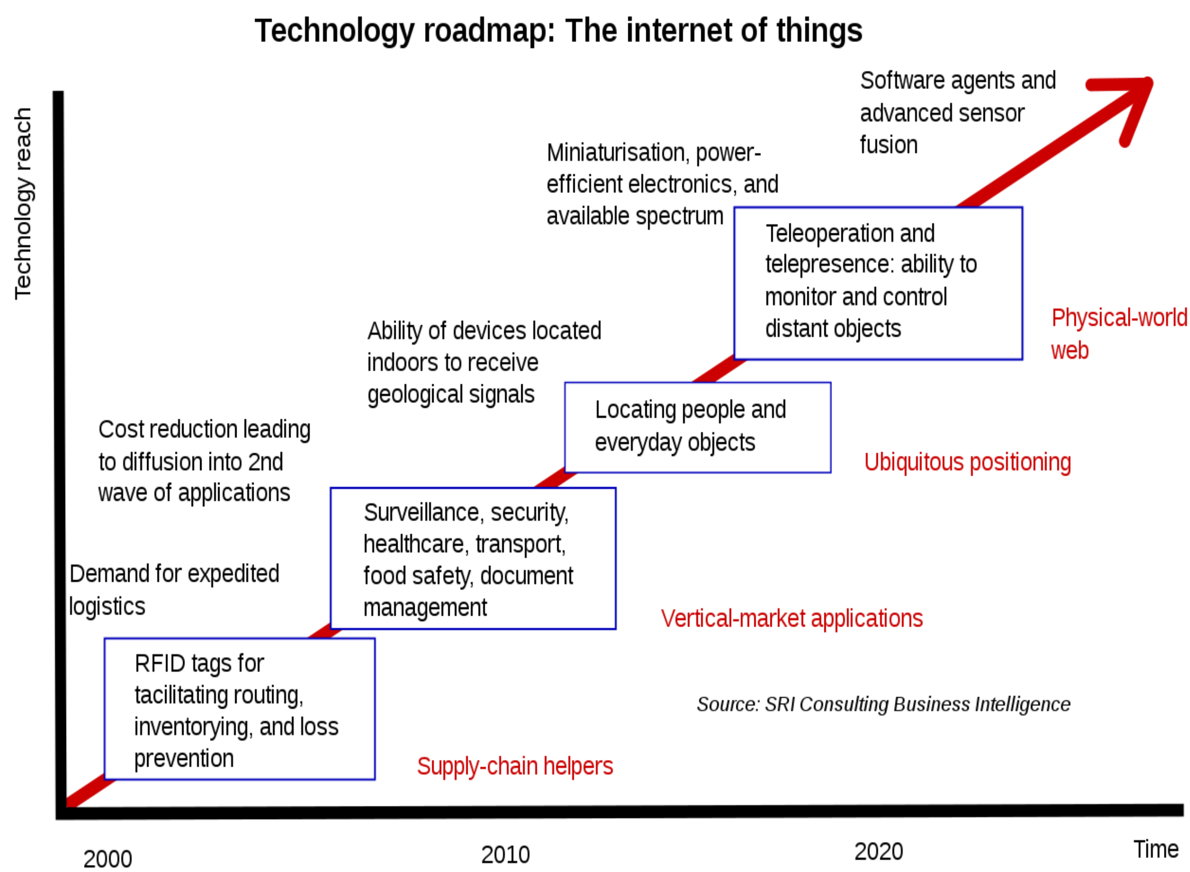
---

[25] Term 'ubiquitous computing', often used in software engineering and computer science, has been introduced by Mark Weiser, chief Technologist of Xerox Palo Alto Center (PARC) around 1988, depicted later in the research paper *The most profound technologies are those that disappear* (1991). In order to fully characterize 'ubiquitous computing' one need to introduce a taxonomy of properties, from which different kinds or flavors of ubiquitous systems and applications can be described (more: Weiser at all 1999; Shaheed at all 2015)

[26] Term 'ambient intelligence' refers to the concept of electronic environment, sensitive and responsive to the presence of people, where devices in concert to support people in their everyday life activities, tasks and rituals in natural way, using information and intelligence hidden in the network connecting these devices. The term has been originally developed by Eli Zelkha and his team at Palo Alto Ventures for time frame 2010–2020 (more: Zelkha and Epstein 1998) to describe computing that 'move from an explicit, instructional model to an implicit, anticipatory one' with context aware, personalized, adaptive and anticipatory machine intelligence (more Aart at al. 2006, 2009)

[27] 5G (Fifth Generation) Technology refer to the future generation Communication Technology, coming after 4G (high speed applications with mobile TV, 3D TV and videoconferencing and wearable devices) technology, based on LTE (Long Term Evolution) and LTE Advanced data capacity with data speed transmission up tp 100 megabits per second (Mbps), about ten times faster than the speeds offered by 3G, although initially specified up to 1 Gbps gigabits per second. With coming 5G Technology, based on the 5G NR (5G New Radio Frequency using milimetr waves shorter than microwaves) with speed data transmissions from 600 Mbps up to 2,5 Gbps (from 10 to 100 times faster than 4G), enabling devices and applications connected to Internet of Things to fully function in real time.

intelligent systems [Korhenon and Karhu 2011; Parvahti and Mariseli 2017; Almeida 2017], complex enough to handle all data transmission and data sharing between machines (M2M), having critical impact on the performance of whole system (with overwhelming volume of data being generated and stored by the connected machines to meet complex system structure and heterogeneity in hardware and software platforms, resulting in challenges for ubiquitous access and interoperable sharing of machine generated data) (Picture no. 4).



Picture 4. Technology RoadMap: IOT [SRI Consulting Business Intelligence]

4. CONCLUSION - 4IR: DIGITAL DISRUPTION OF CYBER PHYSICAL SYSTEMS FROM THE POINT VIEW OF PHILOSOPHY OF INFORMATION

To understand more the phenomena of cyber-physical systems, we can describe it from the point view of the relations 'in between' humans and their artefacts: tools, objects, technologies (described by science-technology STS studies, exploring the relations between science-technology-society) as constantly shifting networks of relations 'in between' objects, ideas, processes as well as actors, or rather actants (expanding the existing definition of human actor(s) with non-human categories of actants: tools, technologies or objects).[28] As such, the whole phenomena of cyber-physical systems can be described from the perspective of *machine to-machine* (M2M), *machine-to-human* (M2H), *human-to-machine* (H2M) and *human to human* (H2H) interactions, introducing the phenomena of relation between humans and non-humans (algorithms or artificial intelligence) as well as between physical and virtual: identity, organization, environment. Describing 4IR from the perspective of relations we should start from underlying the significant difference between machine to-machine M2M (at the core of cyber physical systems) and human-to-human H2H communication (at the core of human's identity, culture and the perception of the world) in data transmission pattern(s). This very difference allow to capture the impact of 4IR (digital disruption) upon the individual and the collective (change in the human perspective: how we perceive and relate to the world and each other), from both psychological and philosophical perspectives.

Until this time we have been describing the whole concept of 4IR mainly from technological, and economical perspective with the latest phase of 'pervasive computing', based on progressive integration of IT and OT with the internet as a core structure. It results in further industrial development on the basis of end to-end automation, based on the triple paradigm: *machine-to-machine communication (M2M)* not only between machines in factories but also between all conceivable devices and systems (reduction of human work with increase in efficiency and security based on the machine work), *predictive maintenance* of machines and appliances on the basis of direct status reports with possible upgrades and remote repairs, and *improved human to machine interaction (H2M*) via consumers' products usage (sharing user data with appliances to create new value and help improve service quality). Coming from this perspective *machine to machine interactions (M2M)* refer to digital interactions within and between the machines and systems operating within the framework of inter-algorithm communication, that form the base of digital network systems. With IOT this communication will also embrace physical objects and devices with the use of embedded electrics, sensors and meters along with wireless technology, software platforms, and network infrastructures, by means of which appliances and protocols can gather and distribute real time data (with billions of connections accessed at will).[29] In addition to the above, high-level data managing and processing methods such as semantic technique, cloud service, and data analysis technology should contribute to M2M interactions, with integration of data in both hardware and software infrastructure, along with potential use of the machine generated data, becoming major concerns within M2M operating base for future IOT systems. Within industrial framework we are talking than about progressive and extensive process of factory automation with limited human

---

[28] Analysis of the relation in between': human- tool- object (described in research trend STS science-technology studies, exploring the relations between science-technology-society), is clearly visible in the theory of actor-network ATN (Latour 2005, 2010) as well as in the new science of networks (Barabási 2002 studies of social networks, multi-agent system analysis, or Reingholt 2000 research on technology cooperation networks, including research on algorithms and artificial intelligence). It expands the existing definition of human actors with the categories of nonhuman (tools, technologies or objects) with the description of relations that are based on new concepts, like translation, transformation, or binding, to induce new areas of study in between: the real, physical and digital, virtual (environment, organization or identity), as well as in between humans and non-humans (intelligent agents: algorithms or artificial intelligence)

[29] To realize the potential of the Internet of (Every)Thing, anything must be able to communicate with anything - striving to reach that potential, we struggle with the current reality that there are more than a hundred communication protocols, so how this universal communication will happen is still unclear. Solutions are being built to tackle this problem, such as the "smart engine" (the intermediate unit, that mutually connects all communication protocols).

intervention as task are assigned more and more to the machines, appliances and systems. European Roadmap for Industrial Process Automation (2013) describe M2M interactions in context of H2MI (*Human-Machine Interfacing*) „Internet compatibility and open standards are expected to be key elements in the expansion of large-scale automation systems. Machine-to-machine communications (M2M) is a principle, key enabling technology for IoT and IIoT, that will form the cyber-physical systems (CPS) of tomorrow; these systems are predicted to enable new automation paradigms and improve plant operations in terms of increased Overall Equipment Effectiveness (OEE)."[30] There is no doubt that M2M communication, when compared to H2H traffic, are massively emerging and according to various estimation studies expected to deploy in three waves: from 'networked consumer electronics' through 'networked industries' and finally 'networked society' [Cisco 2014]. As we can see usually *machine to machine interactions (M2M)* are often described in context of *machine to human interactions* (M2H) or *human-machine interfacing* (HMI), where machine to human interactions are defined as *it-ready machines*: machines equipped with sensors measuring their functioning, to be later communicated in human language (acting as human-machine interface) to support the systems and factory automation, forming the basis of so called 'smart factory'. These M2H interaction will evolve along with Internet of Things, where digitally network of 'smart devices' will continually communicate with humans and themselves (in form of data transmission to personal appliances), in more and more 'intelligent and interconnected environment'.

Looking from much broader perspective, emergence of 4IR with its cyber-physical systems and IOT aims to enable the machine perception of the real world and seamless interactions with it, possible due to growing availability of smart objects, directly related to the physical world with communication and computation capabilities, to connect and interact with their surrounding environment.[31] Taking it from another perspective, the IoT is a platform that facilitates the virtualisation of real world objects with sensor (and actuator) middleware framework, offering sensor descriptions, sensor site data and measurement data services on the web or application level. To extend this to heterogeneous real world objects, data from the physical world needs to be interlinked to domain knowledge and existing data sources on the web, made available in homogeneous way to allow integration of the data from the wide variety of sources to provide formal, structured and machine-processible platform to heterogeneous data sources, as well as providing context to the data and to the objects themselves. [De at al 2010]. One way or the other it's design for further development of autonomous reasoning and decision making of the machines as intelligent agents (actants), thus creating this informationally dense, intelligent environment of interconnected (smart) objects, that pervasively, profoundly and relentlessly affects our sense of self and the world, changing the

---

[30] It's not surprising, that M2M is currently attracting interest from companies worldwide, becoming quite new business and, in addition to telecommunication companies, there are other players: 1. *suppliers of hardware and semi-conductors:* they supply the material that collects the data, such as sensors, smart meters, RFID tags, video cameras and smartcards ; 2. *communication service providers:* that take care of the transmission of data ;3. *M2M service providers:* vertical niche players that provide specific M2M analysis solutions to support decision-making; 4. *system integrators:* delivering the expertise to integrate systems and can add value by means of advanced analytics. [Cisco 2014]

[31] Initially, the IoT considered physical objects to be tagged with RFID transponders, but this has grown to encompass sensor networks and distributed smart objects collaborating via local networks or through the Internet. Initial efforts in this area resulted in ontologies for sensor descriptions as well as standardisation efforts towards semantic descriptions of sensor networks, needed to be linked to the measurements and domain knowledge and then to the observed IoT entity in the domain

way how we perceive and interact with each other, ourselves, and the world. We are yet to discover how billions of devices like smartphones, tablets, smart home appliances, small cellular base stations, edge routers, traffic control cabinets along the roadside, connected vehicles, smart meters and energy controllers in a smart power grid, smart building controllers, manufacturing control systems (just to name a few), can and will affect (disrupt) our perception of the self and the world, where everyday objects become interconnected and smart, inducing the change of the way we live, work and relate to each other and how we relate to (smart) objects and devices. However, before going further, we need to underline, that human understanding and usage of, and interaction and experience with 'smart things' and the systems they form, have not developed at the same pace, and this creates enormous challenges not only with societal, economic and political, but also with psychological and philosophical consequences.

Luciano Floridi in book *The Fourth Industrial Revolution. How the infosphere is reshaping human reality* [2014] describes it from the point view of *philosophy of information*, with the intent to identify and explain some of the deep technological forces behind 4IR, that results in profound transformations, both on the level of the collective (of economical, political, social and cultural spheres) as well as the level of the individual (psyche or identity). These disruptive transformations have caused huge conceptual deficit due to dissipation of the current cognitive paradigm, as the intellectual categories we used to describe or understand the existing reality have been coined in different circumstances, and therefore can hardly grasp what is new (coming in the future) by referring to the past.[32] Therefore we need philosophy to come onboard and ask all the rights questions about emerging technologies (along with preferences and intentions that lay behind), whether they will be used to empower humans or rather constrain their physical and conceptual spaces, quietly forcing them to adjust, because it's just the only possible way, and whether they help us to solve most of the pressing social economic and environmental problems or are they rather going to exacerbate them.

These are only few challenging question this revolution (4IR) is imposing on us, and the effective way to address both the opportunities and threats of these new emerging technologies is possible, only if we gain the deeper and more insightful undertaking (along with intellectual framework that can help us to sematisize its sense and meaning) of their impact on our current and foreseeable future. What's make the whole analysis more difficult, is that we use these new technologies as a tools of interacting with each other and the world (our experience of ourselves and the world is mediated via these technologies), as such, they have become anthropological, environmental, social and interpretative forces, creating and shaping our intellectual and physical realities, changing our self understanding and modifying how we relate to each other and the world [Floridi 2014].

---

[32] This syndrome of impermanence (inadequacy) applies not only to the existing models or strategies, or institutional arrangements, but also to their current description of knowledge. Alvin Toffler in his book Future shock (2007) talks about "breaking with the past", in which spatial and temporal restrictions has been aborted (disrupted), underlying the impermanence syndrome of existing models or strategies (modes of operations) as well as form descriptions (modes of knowledge). Thus there is the urgency for a new approach (paradigm shift) to understand economy, culture, and society in which we live 'here and now', characterized by almost instantaneous flow and exchange of information, capital, and cultural communication. Both the flows and the traffic they carry are largely outside traditional modes & regulation, all becoming diverse expressions of a process of multidimensional, structural and cultural (disruptive) change(s), overcoming traditional limitations of forms of organization to manage complexity beyond a certain size of the network [more: Kasza 2017a]

Reflecting about nature and impact of Forth Industrial Revolution (4IR), Floridi describes it in terms of 'infosphere' (in comparison to biosphere: limited sphere on our planet to support life), denoting informational environment with all its processes, properties, interactions, and mutual relations as point of reference (knowledge-based or informational economy, where information and data become essential driving force for the whole society). One of the most obvious ways in which these new emerging technologies transform world into infospehre is the transition from analogue to digital, where intrinsic nature of tools (software, algorithms, databases and protocols) are now the same as, and therefore fully compatible with, the intrinsic nature of their resources (raw data). This results is exponential growth of information and dense digital environment in which we spent more and more time, populated by intelligent agents (all equally informational : digits dealing effortlessly and seamlessly with digits with no informational friction). Impact of technology upon human and the society as a whole is explained in terms of its function: mediating 'in between' humans and the nature (so called 'in betweenness'), quantifying first order technology (in between human and nature: human-technology-nature), second order technology (in between human and other technologies: human-technology-technology, implying complex level of social order), and third order technology (in between technology-technology-technology), making revolutionary (exponential) leap as technology 'in betweenness' relate to the technology as user (with human user no longer needed nor necessary). Forth Industrial Revolution 4IR and Internet of Things IOT are perfect examples of such third order technology, that works with little or no human intervention (machine readable data, high frequency trading, smart environment), functioning at extreme speed with millions orders per second, adopting and adapting strategies in milliseconds. With third order technology(ies) becoming self-referential as technology interacts with another technology (and human neither invited nor involved as user or beneficiary), all of 'in betweenness' becomes internalised, and as a result invisible, beyond human's perception.[33] There is no fourth order of technology, it's the ultimate stage that becomes self-referential and self-reliable (of course the chain of technologies interacting with other technologies can be extended, but eventually they can all be reduced to series of triples). It's hard to imagine what can happen, when objects (technology) will regularly communicate with each other (technology as a user with technology as a prompter and technology as an intermediary) and what does it mean for humans and humanity, which brings forth transhumanism and singularity as other terms used to describe and make sense of this technological predicament [Savulescu, Bostrom 2009; Benedicter 2015].

Stating that, let us reflect further, how living in such environment (infosphere) impacts our sense of self (identity) and the way we perceive and relate to the world and ourselves. According to Floridi we become accustomed to this 'onlife experience', looking at it as a form of adaptation of human agents to digital environment (with internet as a digital environment, perceived as a form of freedom from constraints and freedom of pursuit, different from physical environment) as well as form of neo-colonialization of digital environment by human agents

[33] This process of technological internalization is bringing huge concerns about technologies controlling human lives (it's worth noted that with this internalization comes the new outside: new digital environment, describe here as infosphere). With interfaces becoming less and less visible, comes blurring the boundaries between physical and analogue, offline (here) and virtual and digital, online (there), although with much of the advantage to 'there' than 'here' and anthropomorphization of objects and technologies (with almost limitless, omnipotent gods like computational power comes mythical or magical thinking about its power and further dependence upon the technology)

(although it may be the other way round, where conquered infosphere captivates its conqueror). With interfaces (in between) becoming less and less visible, comes blurring the boundaries between physical (analogue, offline and here) and digital (virtual, online and there), although with much of the advantage of the pervasive digital (pervasive computing, ambient intelligence), spilling over the physical (human experience and the physical world). We can also analyze it from more collective perspective -the transition from pre-history to history and hyperhistory as described by Floridi - to define the impact of technology upon human culture, based on human to human communication, making all the difference between who we were, who we are and who we become (along with possible pace of social development). [34] From this perspective human societies stretch across three ages as ways of living: prehistory based on the oral culture and agriculture first order technology, history with mostly written culture and second order technology (engine based, mechanical power), and hyperhistory with digital (multimedia) culture and third order technologies (digital, based on computational power), with technology becoming increasingly autonomous while society becoming more dependent upon.

The need of stay connected is a human nature, so we appropriate ourselves more and more to this new interconnected environment (infosphere), transitioning from connectivity limited mostly to local (and physical) environment to global digital environment of super-fast connectivity, changing our communications patterns along with the way we live, work and relate to one another, that is more and more mediated via (depended upon) the technology, through fast data transfers and exchange of information. We are already living 'onlife in infosphere', that is becoming increasingly pervasive, and more synchronized, delocalized and correlated, bringing forth progressive process of informationalization and digitalization of almost all spheres of our lives on one hand, with growing dependence and anthropomorphization of both objects and technologies (due to the process of increasing internalization of technology and its almost limitless computational power). The result is the profound change of our perception of ourselves and the world, from modern, historical and materialistic (in which physical processes and objects play dominant role, although they lost its uniqueness) to postmodern, hyperhistoric and informational (where processes and objects become more dephysicalized, intangible and virtual, able to multiply with no difference between the original and the copy). While "industrial revolution marked the passage from nominalist world of unique objects to platonic world of types of objects" with mass production of industrial goods, being perfectly reproducible as identical and therefore dispensable due to possibility of being replaced without any loss (and culture that expects strictly uniformity and 'universal' ideal standards, that don't touch upon 'unique' individual). Postindustrial (digital) revolution (with its next stage in form of 4IR and IOT) marks next transition from the world of physical objects and processes to digital world of virtualized objects and processes (personalised production of mostly digital goods and services on demand), that only further exacerbates this process. Digital 'proxy' culture not only de-physicalize but also de-indivdualize our sense of self, treating us mostly as type of consumer, type that work that kind

[34] Analyzing the historical impact of technology upon culture (cultural dimension of media evolution) as the first appeared the oral culture (the original communication based on the spoken word as the only medium of expression, and the transfer of knowledge and experience), dominated after a while by writing and written culture (based on the alphabet, thus replacing (separating) oral culture/ domination of sound by written culture/ domination of sign) and typographic culture (based on Gutenberg' printing), replaced then with audiovisual culture emerged along with mass media (radio, film, television). Next radical shift is the appearance of new multimedia digital culture, that integrates all separated modes of communication within one system [more : Kasza 2017a]

of job, buy that kind of products or reads that kind of information (meta-data or big data), that erode our sense of personal identity as we conceptualize ourselves as anonymous entities among billions of similar others online. It's followed by the profound change in economic and social patterns of perceiving (informational) goods and services, where physical ownership becomes transformed into non-physical disposable (usage or access), and free usage possible due to the advertisement (in more and more informationaly dense and de-centralised environment, it's your attention time and span that counts the most, mostly because of informational overload and overstimulation).[35] With this comes the 'digital divide', generating wide generational and geographic, socio- economic and cultural discrimination, that cuts across all societies and countries, between 'information rich insiders' and 'information poor outsiders' living within (without) infosphere [Sevron 2002].

References

[1] Aarts E., Harwig R. and Schuurman M. (2001), Ambient Intelligence, in: Denning P. (Ed): The Invisible Future. New York: McGraw Hill. pp. 235-50.

[2] Aarts E., Encarnação J. (2006) Into Ambient Intelligence, in: Aarts E., Encarnação J.(Eds) True Visions: The Emergence of Ambient Intelligence. Springer-Verlag. pp. 1-16.

[3] Aarts E. de Ruyter B. (2009). New research perspectives on Ambient Intelligence. *Journal of Ambient Intelligence and Smart Environments* 1(1). pp. 5-14.

[4] Aghaei S., Nematbakhsh M.A., Farsani H.K. (2012), Evolution of the World Wide Web: from web 1.0 to web 4.0. *International Journal of Web & Semantic Technology* Vol. 3, No. 1

[5] Allenby B., Sarewitz D. (2011), The techno-human condition, MIT Press, Cambrigde, London

[6] Almeida F. (2017) Concept and Dimensions of Web 4.0, *International Journal of Computers and Technology*, Volume 16 (7)

[7] Arthur B. (2011). The Second Economy, *McKinsee Quarterly* 4, pp. 91–99.

[8] Barabasi A.L. (2002) Linked. The New Science of Networks, Perseus Press, Cambrigde.

[9] Bard A., Soderqvist J. (2002) Netocracy - The New Power Elite and life after Capitalism, Reuters/Pearsall UK

[35] Progressive process of digitalization (and/or informationalization) connected with 3IR and 4IR is often defined from the point view of human perception as 'informational overload': too much of the information streaming down for us to process - the obvious response to that is to engage with more and more efficient technologies (AI) to process that much information (big data), but more efficient technologies can create only more data and information (thus exacerbating the whole problem). According to Floridi the real epistemological problem with 'big data" (overabundance of information) lays its 'small patterns', because of so many data available there is pressure upon new tech companies to 'spot where the small patterns with real value added', which is the problem of conceptual 'brain power' (quality) rather than computational power (quantity), being the driving force that lies behind the innovation [Floridi 2014]

[10] Baudrillard J. (1995), Simulacra and Simulation, Michigan Publishing, Universtity of Michigan Press

[11] Bauman Z. (2000) Liquid Modernity, Polity Press, Cambridge

[12] Bell D. (1973) The Coming of Post-Industrial Society: A Venture in Social Forecasting, Basic Books, New York

[13] Benedicter R. (2015) Essays in the philosophy of humanism, *Journal of the American Humanist Association and the Institute for Humanist Studies*, vol. 23.2-2015, pp. 133-159 Equinox, Bristol

[14] Benito-Osorio D., Peris-Ortiz, M., Armengot C. R., Colino A. (2013), Web 5.0 the future of emotional competences in higher education, *Global Business Perspectives*, p. 274-287

[15] Berners Lee T, Fischetti M. (1999) Weabing the Web, Harper, San Francisco

[16] Boutang Y. M. (2012), Cognitive Capitalism, Polity Press, Cambridge

[17] Brynjolfsson E., McAffee A. (2011) Race Against the Machine, How the Digital Revolution is Accelerating Innovation Driving Productivity, and Irreversibly Transforming Employment and the Economy, Digital Frontier Press, Lexington

[18] Brynjolfsson E., McAffee A. (2014) Second Machine Age. Work, Progress, and Prosperity in a Time of Brilliant Technologies, Norton and Company, New York London

[19] Castells M. (2000, 2010) The information Age: Economy, society and culture, Blackwell Publishing, Oxford

[20] Carayannis E.G., Spillan J.E., Ziemnowicz Ch. (2007). Introduction: why Jospeh Schumpeter's creative destruction? Because everything has changed in: Rediscovering Schumpeter, Creative Destruction Evolving into "mode3", Palgrave McMillan, Houndmills-Basingstoke

[21] Christensen M. C., Raynor M.E, McDonald R. (2015), What is disruptive innovation. *Harward Business Review*, p. 44-53

[22] Bower, J. L., and C. M. Christensen. Disruptive Technologies: Catching the Wave. *Harvard Business Review* 73, no. 1 (January–February 1995): 43–53.

[23] Cisco (2014) Cisco Visual Networking Index : Global Mobile Data Traffic Forecast Update, 2013 2018 p. 40, 2014

[24] Cornelius D. A. (2013), SMAC and transforming innovation presented at PMI® Global Congress 2013, PA: Project Management Institute

[25] Cote M., Pybus J. (2007), Learning to immaterial labour 2.0: MySpace and social networks, *Ephemera*, 7(1), pp. 88-106.

[26] Cook N. (2008), Enterprise 2.0: How Social Software Will Change the Future of Work, Gower Publishing, Hampshire

[27] Dator J. (2002) Advancing Futures, Praeger, Westport, Connecticut

[28] Dawson M., Foster J.B. (1998) Virtual Capitalism in: MCChesney R.W.,Wood E.M., Foster J.B. (Ed.) Capitalism and the Information Age. Political Economy of Global Communication, Monthly Review Press, NY

[29] De S., Elsaleh T., Barnaghi P., Meissner S. (2010) An Internet of Things platform for real-world and digital objects, Scapable Computing. *Practise and Experience* Volume 13, no. 1, pp. 45–57

[30] [30] Erboz G. (2017) How To Define Industry 4.0: Main Pillars Of Industry 4.0, , Conference Paper Conference: 7th International Conference on Management (ICoM 2017), At Nitra, Slovakia

[31] Floridi L. (2011) The Philosophy of Information, Oxford University Press, Oxford

[32] Floridi L. (2014) The Forth Industrial revolution. How the infosphere is reshaping human reality, Oxford University Press, Oxford

[33] Floridi L. (2011) Why information matters, Journal of technology and Society, The New Atalntis News, p. 7-16

[34] Fuchs C. (2009a), Information and communication technologies and society: A contribution to the critique of the political economy of the internet, *European Journal of Communication*, 24(69), pp. 69-87.

[35] Fuchs C. (2009b), Class, knowledge and new media, *Media, Culture & Society*, 32(1), pp. 141-150.

[36] Fuchs C. (2010), Labour in informational capitalism and on the internet, The Information Society, 26, pp. 179-196

[37] Fuchs C. Sevignani S. (2013), What is Digital Labour? What is Digital Work? What's their Difference? And why do these Questions Matter for Understanding Social Media?, tripleC - *Journal for a Global Sustainable Information Society* 11 (2), pp. 237-293

[38] Fukuyama F. (1992) The end of history and the last man, Free Press , New York

[39] Hardt M., Negri A. (2000), Empire, Cambridge MA, Harvard UP London

[40] Hardt M., Negri A. (2004), Multitude : war and democracy in the age of Empire, The Penguin Press, NY

[41] Hekkert M.P., Suurs R.A., Negro S.O., Kuhlmann S., Smits R.E.H.M. (2007), Functions of innovation systems: A new approach for analysing technological change, *Technological Forecasting & Social Change* 74, pp. 413-432

[42] Hendler J. Berners-Lee T. (2010) From the Semantic Web to social machines: A research challenge for AI on the World Wide Web, Artificial Intelligence, no. 174, pp. 156-161, Science Direct

[43] Hirschhorn L. (1986) Beyond Mechanization: Work and Technology in a Postindustrial Age, MIT Press, Cambridge

[44] Hollan J. Hutchins E., Kirch D. (2000) Distributed cognition : towards a new foundation of human-computer interaction research, *ACM Transactions on Human-Computer Interactions,* Vol 7 (2) pp. 174-196

[45] Sha L., Gopalakrishnan S., Liu X., Wang Q. IEEE International Conference on Sensor Networks, Ubiquitous, and Trustworthy Computing Cyber-Physical Systems: A New Frontier (2008),

[46] Jessop B (1992). Fordism and Postfordism: a Critical Refomulation, in : Pathways to Regionalism and Industrial Development, Editors: Allen J. Scott, Michael J. Storper, pp.43-65, Routledge

[47] Jessop B. (1995). The regulation approach, governance and post-Fordism: alternative perspectives on economic and political change?, *Economy and Society,* vol. 24 (3), p. 307-333

[48] Kambil A. (2008) What is your Web 5.0 Strategy?, *Journal of Business Strategy,* Volume 29, Issue 6.

[49] Kasza J. (2017a) Simulacra and Simulation: The Impact of ICT Upon “Radical Transformation” of Culture, *World Scientific News* 78, 288- 306

[50] Kasza J. (2017b) Post-modern identity :"in between" real and virtual (identity), World Scientific News 78, 41-57,

[51] Kasza J. (2018) Immaterial labour - impact of ICT upon new modalities of labour in digital economy, *World Scientific News* 104, 234-251

[52] Kemp R. (1994) Technology and the transition to environmental sustainability - the problem of technological regime shifts, Futures 26 (10), 1023-1046.

[53] Korhonen, J., Karhu, K. (2011) Explaining the Evolutionary Development of the Web. in Gummesson E., Mele C., Polese F. (Eds.), The 2011 Naples Forum on Service - Service Dominant logic, Network & Systems Theory and Service Science: integrating three perspectives for new service agenda, Capri, Italy

[54] Lacoff G., Johnson M (1980) , Metaphors We Live By, University of Chicago, Chicago

[55] Latour, B. (1996) Actor Network Theory. A Few Clarifications, *Soziale Welt* vol. 47, nr 4, pp. 369–381

[56] Latour B. (2005), Re-assembling the Social. An introduction to Actor-Network Theory, Oxford University Press

[57] Lee E. (2008) Cyber Physical Systems: Design Challenges, 11th IEEE Symposium on Object and Component-Oriented Real-Time Distributed Computing (ISORC), IEEE pp. 363-369

[58] Lee J., Bagheri B., Kao H.A. (2015), A Cyber-Physical Systems architecture for Industry 4.0-based manufacturing systems, *Manufacturing Letters* 3 (2015) 18–23

[59]] Levy F., Murnane R. (2004) The New Division of Labor: How Computers Are Creating the Next Job Market. Princeton University Press, Princeton, New York

[60] Markoff J. (2006) Entrepreneurs See a Web Guided by Common Sense, New York Times

[61] Masini E. (1993) Why Futures Studies?, Grey Seal Books, London

[62] McAfee A.P. (2006). Enterprise 2.0: The Dawn of Emergent Collaboration, *MIT Sloan Management Review*, vol. 47 (3), pp. 21-28.

[63] McKinsey Quarterly (2010): 'The Internet of Things', no.2 2010, McKinsey, New York

[64] Merton R.K. (1936). The Unanticipated Consequences of Purposive Social Action. *American Sociological Review,* vol. 1, no. 6, pp. 894-904.

[65] Merton, R.K (1968) Social Theory and Social Structure, Enlarged edn, Collier-Macmillan, London.

[66] Monostori L. (2014). Cyber-physical Production Systems: Roots, Expectations and R&D Challenges, *Procedia CIRP*, vol. 17, pp. 9–13

[67] Naisbitt J. (1982) Megatrends. The New Direction Transforming our Lives, Warner Books, NY

[68] O'Reilly T. (2007) What is Web 2.0: Design Patterns and Business Models for the Next Generation of Software, *Communications & Strategies*, No. 1, p. 17

[69] Pasquinelli M. (2009) Google's PageRank Algorithm: A Diagram of Cognitive Capitalism and the Rentier of the Common Intellect, in: Deep Search: The Politics of Search Beyond Google, Transaction Publishers, London

[70] Parvathi M., Mariselvi R. (2017) A bird's eye on the Evolution Web 1.0 to Web 5.0: Lib 1.0 to Lib 5.0, *International Journal of Advanced Research Trends in Engineering and Technology* , Vol. 4, Special Issue 4

[71] Patel K. (2013) Incremental Journey for World Wide Web: Introduced with web 1.0 to recent web 5.0 , *International Journal of Advanced Research in Computer Science and Software Engineering*, 3(10)

[72] Peters M. A. (2011) Cognitive Capitalism, Education and Digital Labour, Peter Lang, New York

[73] Postman N. (1992) Technopoly. The surrender of culture to technology, Pantheon, New York

[74] Rheingold H. (2000) The Virtual Community, MIT Press, Cambrigde, Massachussets, London

[75] Rifkin J. (1996) The end of work : the decline of the global labour force and the dawn of post-market era, G. P. Putnam's Sons, New York

[76] Rifkin J. (2001) The Age of the Access, Penguin Books, London

[77] Rifkin J. (2011) The Third Industrial Revolution: How Lateral Power Is Transforming Energy, the Economy and the World, Palgrave Macmillan, New York

[78] Rheingold H. (2000) The Virtual Community, MIT Press, Cambrigde, Massachussets, London

[79] Rogers E. (1976). New Product Adoption and Diffusion, *Journal of Consumer Research,* vol. 2, no. 4, pp. 290-301.

[80] Rogers E. (1983), Diffusion of Innovations, The Free Press, New York.

[81] Robertson R. (1992) Globalisation : The Social Theory and Global Culture, Sage, London

[82] Rotman D. (2013) How Technology is Destroying Jobs , MIT Technology Review, June 20013

[83] Rüßmann et al (2015) Industry 4.0: The future of productivity and growth in manufacturing industries. Boston Consulting Group (BCG), pp.1-14.

[84] Savulescu J., Bostrom N. (2009), Human Enhancement, Oxford University Press, Oxford

[85] Schumacher A., Erolb S., Sihn W (2016) A maturity model for assessing Industry 4.0 readiness and maturity of manufacturing enterprises , *Procedia CIRP* 52 (2016) 161-16

[86] Schumpeter J. A. (2006) [1939]. Business cycles: a theoretical, historical, and statistical analysis of the capitalist process, Mansfield Centre, Martino Pub, Connecticut

[87] Schumpeter J.A. (1997) The theory of economic development: an inquiry into profits, capital, credit, interest, and the business cycle [1911, 1934], New Brunswick & London

[88] Schwab K. (2016) The Forth Industrial Revolution, World Economic Forum, Geneva

[89] Servon L. (2002) Bridging the Digital Divide: technology, Community and Public Policy, Blackwell, Oxford

[90] Shaheed S.M., Abbas J., Shabbir A., Khalid F. (2015) Solving the Challenges of Pervasive Computing, *Journal of Computer and Communications,* 3, 41-50.

[91] Sindhu R.A., Chezian R.M. (2016). The Movement of Web from Web 0.0 to Web 5.0: A Comparative Study, *International Journal of Multidisciplinary Research and Development*, Volume 3; Issue 3; pp. 176-179; (Special Issue)

[92] Sohail I. (2007). Questioning the Future: methods and tools for organizational and societal change, Tamkang University Press, Tamsui

[93] Stehr N. (1994) Knowlegde Societies, Sage Publications, London

[94] Thrift N. (2005) Knowing Capitalism, Sage Publishing, London New Delhi

[95] Tapscott D. (1998) Growing up digital. The Rise of the Net Generation, McGraw- Hill, London

[96] Tapscott D., Caston A. (1993), Paradigm Shift: The New Promise of Information Technology , McGraw Hill,

[97] Tapscott D., Williams A. (2008) Wikinomics: How mass collaboration changed everything, Portfolio, NY

[98] Tegmark M. (2017), Life 3.0: being human in the age of artificial intelligence, Penguin Random House, NY

[99] Toffler, A. (1970, 1984) Future Shock, Bantam Books, New York Toronto London Syndey Auckland

[100] Toffler, A., Toffler H. (1980). The Third Wave. William Morrow, New York

[101] Vercellone C. (2007). From formal subsumption to general intellect, *Historical Materialism*, 15, pp. 13-36.

[102] Wallerstein E. (1999) The end of the world as we know it, University of Minnesota Press, Minneapolis

[103] Weiser, M., Gold R., Brown J.S. (1999) Ubiquitous Computing, *IBM System Journals*, Vol. 38, no.4

[104] Wierzbicki A.P. (2000) Megatrends of Information Society and the Emergence of Knowledge Science, in: Proceedings of the Intern. Conference on Virtual Environments for Advanced Modelling, JAIST, Tatsumokuchi

[105] Wierzbicki A.P. (2015). Techne: Element of Recent History of Information Technologies with epistemological conculsions, Springer Int. Publishing, Switzerland

[106] White B. (2015) Discovering the Future of the Web, *Journal of Computing and Information Technology*, 23(1), 87-93.

[107] Zelkha E., Epstein B. (1998). From Devices to 'Ambient Intelligence': The Transformation of Consumer Electronics. Presentation at the Digital Living Room Conference, p. 16-19