Internet of Things – A New Epistemic Object

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ABSTRACT

Within the digitalization the Internet of Things (IoT) plays an important role. The research areas of the Internet of Things, highlighting its potentialities as well as its dark sides, are discussed. Here, IoT is seen as a new epistemic object with its own history, which is not fully documented yet. The concept of agency, design and material morality is discussed. The responsibility embedded in the design, according to an advisable collective decision making approach is investigated, where humans and non-humans, as key parts of the IoT, can make their own contributions.

Keywords
Internet of Things, IoT, Epistemic, Digitalization.

1. DIGITALIZATION: YESTERDAY, TODAY AND TOMORROW

We refer to a short historical summary of the development and the rise of the computational power, the interaction of humans with computers, the interaction between humans and computers, and how the business and the government adapted to these changes [1].

Here, four streams of development are the pillars of the exponential digitalization curve, depicted in Figure 1: Information Systems, E-Business Applications, Web 2.0 Revolution and Artificial Intelligence [1]. Even though they are gathered around single columns, they are not separated from each other. The technological advancement in each topic is still influential and progressive to each other. A fifth stream has a question mark instead of a title, because we do not know where all this fast technological development will lead us. The question mark opens up new questions, which we try to answer in a "common sense" approach.

Information Systems

In the middle of the 20th century began the rise of computers; first they were used widely in companies and later, through the evolution of the personal computer, also at home. From a corporate use perspective, it was all about accessing data, information, and knowledge collectively gathered in the computers. Originally, the discipline of the information systems developed gradually, by evolving programming, data warehousing, records management, process and workflow management, IT strategy and management, IT security, innovation and technology management, Internet and world wide

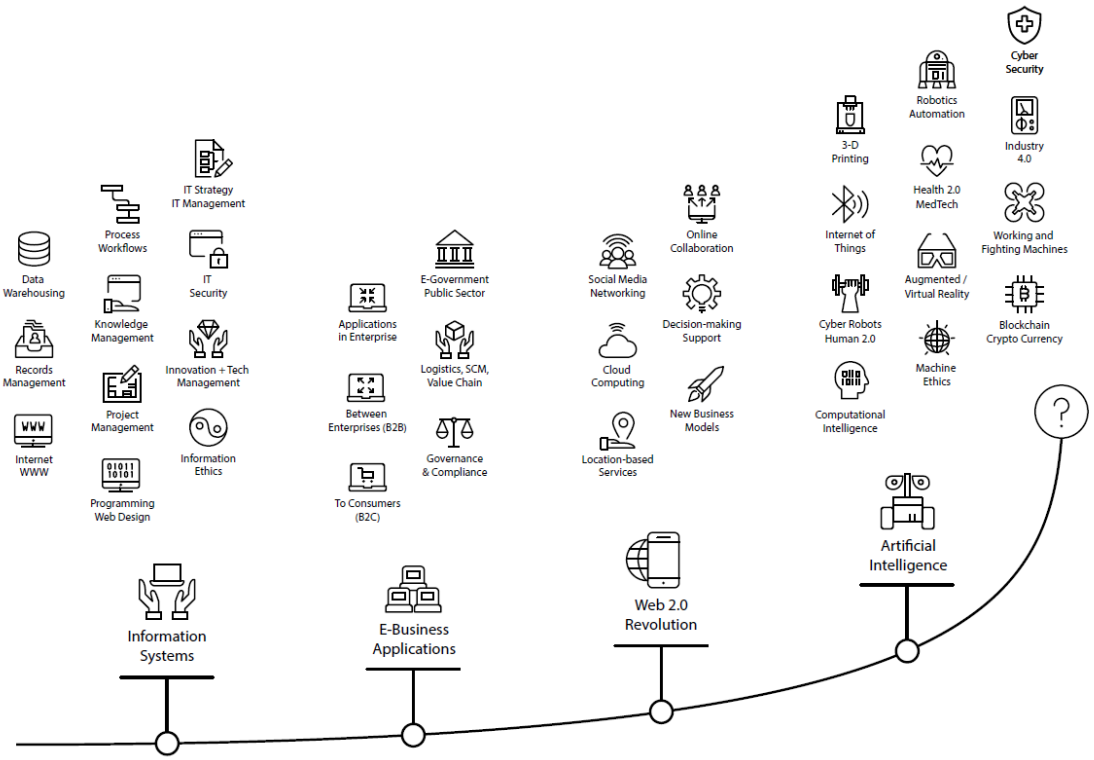

Figure 1 – Digitalization: yesterday, today and tomorrow

web, as well as user interface and web design. In parallel, the concept of knowledge management came into being, because companies wanted to have direct access to their experts' knowledge, through forms of sharable practices in data, reports, document records and so forth. Finally, the more computers there were on the grid, the more data and information were generated.

E-Business Applications
The business sector, as well as the government, developed their own special cases for the information systems. More and more companies were introducing applications in the areas of the e-business and its related species with the rise of collaborations with suppliers, customers, and other companies (B2B: business-to-business, B2C: business-to-consumers). Supply chain and logistics branches were managing the electronic data flow and creating a strong business value chain. In addition, the government identified the potentialities of the technology for elections, electronic tax declaration, and other types of civic participation (E-Government).

Web 2.0. Revolution
In the years at the beginning of the 21st century, the computing devices became smaller (e.g. smartphones). Widespread use and accumulation of user behaviour and data have made thrive the massive expansion of business opportunities based on data analytics and marketing. This catalysed new business models and big corporate structures in social media and e-business. Mobile and social media advertising reached its highest demands during the mid-10s and location-based services found more opportunities in the app stores. With the excessive connectivity speeds, cloud computing appeared as a solution to many boxed services, reduced the costs for production and created an on-demand application market.

Artificial Intelligence
Computational power exponentially increases while new challenges for new technologies to fulfil are introduced. Amongst many achievements within this dynamic and constantly changing panorama, the Internet of Things (IoT) has appeared to be a key concept forecasting to connect everything. From robotics to blockchain servers, from the sensors used in the health sector to surveillance devices in cyber security, every device will be linked to the network and theoretically, the network will know about every other device in the world connected to it. In this perspective, the IoT becomes a driving force for artificial intelligence to enable research to develop smarter interactions between humans and the digital world.

2. THE INTERNET OF THINGS AND ITS RESEARCH AREAS

In order to understand what is considered the *Internet of Things* (IoT), we revised some literature for a broader view of the IoT and to highlight the new research areas.

The term IoT was coined by Kevin Ashton, and he used it for the first time in 1999 during a presentation held at Procter and Gamble to represent the emerging internet based information service architecture thanks to sensors connected to the internet "*adding radiofrequency identification and other sensors to everyday objects*" [2]. However, Oliveira et al. [3] reminded us that the concept was developed years earlier, in the early 1980s, by a group of programmers at the Carnegie Melon University, who modified a Coca-Cola machine by linking it to the Internet to obtain information about the availability of the drink and about the time that the bottle spent inside the machine *"to ensure that the beverage was chilled and thus prevent them from making the trip in vain*."

Park et al. [4] define *cyber-physical systems* as a combination of four technologies: *automation of knowledge work, Internet of things, advanced robotics and autonomous/near autonomous vehicles*, and raised the IoT to a key technology, which will have an immense economics impact. For the US National Intelligence Council (NIC), the IoT is in the list of six *Disruptive Civil Technologies*. The NIC foresees that by 2025, Internet nodes may reside in everyday things – food packages, furniture, paper documents, and more.

IoT – One Paradigm with Many Visions
Mishra et al. [5] summarized the IoT as *one paradigm with many visions*, in reviewing publications between 2000 and 2016. The authors defined four major IoT application domains: *industry, healthcare, smart environment* and the *personal and social domain*. With optimism, they state that "*digital industries contribute about 20 percent of the GDP, while the rest 80 percent comes mainly from physical industries, i.e. agriculture, construction, manufacturing, energy, transportation, and healthcare. Therefore, IoT aims to transform the way in which physical industries do business by connecting them to the computerized world*." [5]. They proposed *a five-cluster classification of the IoT research themes*, based on data clustering. Such a clustering is important, since it enables researchers not only to acknowledge the diversity of research in the field, but also highlights those areas where it is needed to do more research. In order to find out the area of the research focus of each cluster, they examined the leading articles, finding out that the research belonging to the *first cluster* is mostly theoretical and conceptual. Researchers in this cluster review the literature and outline current and future challenges [6] [7]. The aim of the *second cluster* is to develop more established concepts and theories and implement them in different fields, including the IoT in smart cities and hospitals. Authors in the *third cluster* are mainly interested in the IoT in logistics and supply chain [8] [9]. Researchers in the *fourth cluster* concentrate their research on the designing and the planning of the IoT and those in the *fifth cluster* are devoted to study the security and privacy aspects of IoT.

Based on this summary, Mishra et al. [5] ask the IoT researchers the following four questions:

- *"What are the drivers and barriers of IoT implementation and adoption?"*
- *"How can we explain IoT implementation and adoption using alternative organizational theories?"*
- *"How can we measure the impacts of IoT on organizational and supply chain performance?"*
- *"Can we propose a holistic model that explains the acceptance of IoT applications?"*

For the authors, the literature surrounding the IoT is still underdeveloped, even if the IoT as a research topic has attracted significant attentions from both academia and industry. However, the majority of the literature comes mainly from a technology perspective. Research activities related to the adoption and applications of the IoT in business, for instance, in particular within a human-centred context [10], smart cities, hospitals, and supply chains and new business models [11], are still underdeveloped.

In this line of reasoning, Oliveira et al. [3] asked the question: "*What is relevant to research in IoT*?". They offered the following thirteen possible research areas:

1) The *IoT European Research Cluster* has the aim of defining a common vision of the IoT technology and addressing European research challenges.

2) *Innovation Ecosystems*: The focus is designing actions to develop innovation ecosystems by stimulating start-ups, encouraging the use of open IoT platforms, enabling Large Scale Pilots, and linking large and small companies through open innovation.
3) *IoT Standardization*: As an important step for developing strategies and using cases aiming for a) the consolidation of architectural frameworks, reference architectures, and architectural styles in the IoT space, b) interoperability and c) personal data and personal data protection to the various categories of stakeholders in the IoT space.
4) *IoT Policy* is making recommendations to address existing and potential barriers that prevent or hamper the take-up of the IoT in the context of the Digital Single Market.
5) *Smart Living Environment for Ageing Well*: This area refers to developing smart homes and smart living environments that can support vulnerable people, such as elderly or disabled people, also leading to reduced costs for care systems and promoting a better quality of life for vulnerable categories of citizens.
6) *Smart Farming and Food Security*, where IoT scenarios/use cases can monitor and control plants and animal products life cycles.
7) *Wearables*: IoT can promote solutions that integrate key technologies (e.g. Nano electronics, organic electronics, sensing, actuating, communication, low power computing, visualization and embedded software) into intelligent systems to bring new functionalities into clothes, other fabrics, patches, watches and other body-mounted devices, working on healthcare, well-being, safety, security and infotainment applications.
8) *Smart Cities:* The IoT can promote solutions to enhance performance, safety and wellbeing, to reduce costs and resource consumption, and to engage more effectively and actively with its citizens.
9) *Smart Mobility* refers to IoT solutions that enable increased multi-modal mobility, more efficient traffic management, a dynamic road infrastructure, usage based insurance and improved policy making through the analysis of road usage data provided by smart vehicles including autonomous and connected cars.
10) *Smart Water Management* focuses on improving water management efficiency by monitoring and controlling surface water retention, flooding, etc.
11) *Smart Manufacturing*: Here the IoT solutions can bring together information, technology and human ingenuity to achieve a rapid revolution in the development and application of manufacturing intelligence to every aspect of business.
12) *Smart Energy* refers to IoT solutions deployed by various companies along the value chain (i.e. IoT technology providers, energy companies) to allow the performance optimization of their energy asset portfolios.
13) *Smart Building and Architecture*, through which the IoT technologies and solutions deployed in buildings and districts of buildings can improve life of the occupant by addressing and optimizing elements such as comfort, light, temperature, air quality, water, nourishment, fitness, and energy usage.

Oliveira et al. [3] state that the topic of *interoperability* is one of the most important in the IoT, because "things" need protocols to communicate with other "things", and to accomplish this, there is a need for an *IoT Architecture*. In this IoT ecosystem, there is the need for providing services (*Software Services for IoT).* These services are delivered by *IoT Applications* that will be executed on *Hardware devices* in a secure way (topics such as *security, privacy and trust technologies*), and should return value (*economic*). These issues are very relevant to research, especially in the actual state of the IoT. Regarding the topics of *societal responsibility* and g*overnance (legal aspects),* IoT has not yet reached the state of maturity necessary to be considered.

According to Whitmore, Agarwal and Xu [12], the IoT represents an evolution of the use of existing technologies, as well as the interconnection of networks of these devices, across the Internet. These devices include servers, desktops, laptops, tablets and smartphones. What the IoT offers is to connect the technology to everyday devices and make them online, even if they were not initially designed with this ability in mind. The other major change promised by the IoT, is the integration of networks that contain these devices, making each device directly accessible through the Internet. More generally, the IoT holds as one of its key promises the creating of a global network supporting ubiquitous computing and *context-awareness* as key requirements of *ambient intelligence*.

Whitmore, Agarwal and Xu [12] reviewed 127 articles, taking into account the following categories: *technology* (hardware, software, and architecture), *applications* (smart infrastructures, healthcare, supply chains and logistics, social applications), *challenges* (security, privacy, legal and accountability, general), *business models* and *future direction*. The analysis of the literature revealed that the research on the IoT is largely focused on technology. Once the technology matures, the IoT research will need to broaden into the fields of management, operations, law, economics and sociology, among others.

In addition, the IoT is not well represented in the management literature. The coverage of IoT driven business models is also scarce and little work has been done on issues related to the legal and governance frameworks that will regulate the IoT. These findings lead to a set of questions that need to be answered through future research, like for example:

- *What are the appropriate theories of the IoT for management and operations?*
- *How does the IoT fit into the "Big Data" movement?*
- *How will information systems working with IoT data overcome the inherent complexity and data volume in order to provide useful decision support?*
- *What are the unaddressed applications areas of the IoT (for example, military)?*
- *What are the IoT business models that will drive global business and commerce?*

Ortiz, Hussein and Park [13] offered a new perspective in clustering topics of the IoT together with the social networks (SNs). This combination enables the connection of people to the ubiquitous computing universe. In this framework, the information coming from the environment is provided by the IoT. On the other hand, SNs are the glue to allow human-to-device interactions. The authors define this new scenario as the *Social Internet of Things (SIoT)*. Although there have been early stage studies in social-driven IoT, they use one or some properties of SIoT to improve a number of specific performance variables. The IoT follows two interaction paradigms:

1) *Human-to-human*
2) *Thing-to-thing*

And then humans utilize data from things as an old-fashioned client-server interaction model. This scenario implies that the IoT

does not adopt a true connection between humans and things for real ubiquitous computing. To integrate computing into our future daily life, we need to improve the connectivity of all the relationships between users and things. The future-driven SIoT needs to consider three perspectives:

1) *Interactivity Perspective* in conjoining *human-to-thing* interactions to achieve the SIoT. This type of communication opens the door to another level of pervasiveness in IoT environments, where *networking* and *communication* issues must be tackled.
2) *Collaboration Perspective*: The SIoT ultimately allows humans and things to act as producers or consumers, and this leads to *increasing collaboration* among all the entities.
3) *Handled-Data Perspective*, considering the kind and the mass of data acquisition and the handling techniques needed to be considered in pervasive environments. Here, the data acquisition techniques can be divided into two categories:
    a. *Proactive data acquisition*, using crawling techniques, learning algorithms, or various data analysis algorithms.
    b. *Reactive data acquisition*, which usually operates in real-time using data mining and query techniques.

According to Ortiz, Hussein and Park [13] in order to make the SIoT paradigm real there are still twelve challenges that must be faced. These are:

- Interoperability, Data Management, and Signal Processing
- Discovery and Search Engines
- Energy Management
- Security, Privacy, and Trust
- Self-Operation, Management, and Organization
- Heterogeneity of the devices
- Interactions and Interfaces
- Service Management
- Application Development
- New Business Models and Stakeholders
- Fault Tolerance
- Semantics and Context Management

Kim et al. [14] did a semantic analysis examining the frequency and the semantic networks of the terms related to the IoT, figuring out how society adopts or rejects a specific technology (here IoT). The study used *time* as one of the specific elements of the diffusion of the innovations theory of Rogers [15]. Time affects the adoption of an innovation, and this choice helped to answer the following research questions:

- *What are the implications of the diffusion of the IoT according to the journal articles on the IoT technology*?
- *How do the words used most frequently in the abstracts differ between the data set of 2007–2012 and that of 2013–2015?*
- *How do the semantic networks of the words in the abstracts differ between the data set of 2007–2012 and that of 2013–2015?*

The research revealed that among five innovation-decision processes (that are *knowledge, persuasion, decision, implementation, and confirmation)*, many social sectors have reached the implementation stage.

Moreover, concepts like mobile payment, digital economy, 3D printing and cloud computing are starting to recur. Mobile payment and digital economy are concepts recurring in the financial areas, where the first innovators are appearing. 3D printing, cloud computing and smart city are concepts that early adopters in the electric power industry and in the urban planning areas are using. In addition, the energy industry is one of the early adopters of the IoT. A smart grid is an electrical grid, which enables the increase of the effectiveness of energy use and the decrease of the greenhouse gas emission. The common enabling technologies are *RFID (radio frequency identification), sensor networks, and cloud computing*. Sensor networking technologies such as wireless sensor networks are also the core technological element of IoT. The cloud-computing technology, which enables the processing of big data, is one of the important supportive technologies of the IoT.

Meanwhile, also the concept of *security* is a potential concern of embracing the IoT technology. As Rogers [15] warns, the diffusion of innovative technology can be delayed if it conflicts with the existing social values or social norms. In this case, the issue of information security remains as a social concern, which is combined with the issues of *privacy* [16]. A new perspective towards the IoT is the understanding of its phenomena called, *the dark side* [17]. The authors addressed the issue under the concept of *integrity challenge*. If from our homes the Internet allows us to reach out to the world, so is the world able to reach our homes. Such an *integrity* problem poses a major challenge and needs further exploration. The authors highlighted that this issue represents a gap in the literature. The IoT has received much attention recently, but its dark side and its effects have received very little attention. An inevitable consequence is the diminishing of trust. Malicious intentions and practices can spread and grow exponentially [18].

De Cremer et al. [17] identified two key reasons that may result in a dark-side behaviour. Firstly, *a lack of a strategic focus of the IoT and a lack of understanding of the integrity challenge* may lead to malicious actions that can exploit customers. Second, *at the tactical level, when firms use intrusive technology, poor application of IoT systems may result in inappropriate abuse of customers, because the IoT technology can equip them with powerful resources to do this*. Reports suggest that systems in the IoT industry are insecure. When the IoT connects all the dots, combining personal details and behaviour with excessive monitoring, it may also lead to the integrity risk of what will happen with all the personal data, especially if the data is not securely implemented.

In their search for reasons that may lead to the failure of IoT implementation, De Cremer et al. [17] focused on issues:

1) At *the tactical level*, including quality of data, project management skills and technological skills.
2) At *the strategic level*, such as IoT implementation, IoT capability and IoT networks.

The lack of a clear definition of the IoT has affected its implementation negatively. The authors summarized that the severe lack of strategic focus in organizations are caused by:

1) Research that does not take a broader strategic focus
2) Absence of a strategic orientation of the IoT from senior management
3) Operationalization of the IoT that continues to reflect a tactical, as opposed to a strategic, character.

With the power that comes with the IoT in terms of data-driven knowledge, the potential for exploitation of customers is clearly present. The authors identified that the dark side of the IoT occurs in two ways: When firms mistake the IoT with excessive data collection, leading to customer exploitation, but also when firms are maliciously motivated to take advantage of the customers for their own profit. IoT providers, policy makers, consumers and researchers should be engaged in finding ways to avoid dark-side behaviour and in spending time, energy and resources to understand the nature of the *integrity challenge*.

In order to avoid these dark practices, the authors were inspired by the Payne and Frow paradigm [19], which considered how a holistic approach to the IoT processes can help guide organizations away from the dark side. A holistic IoT strategy can be developed through the management of the cross-functional processes of:

- Strategy development
- Value creation
- Multi-channel integration and customer experience
- Information management
- Performance assessment

De Cremer et al. [17] consider that the types of the IoT dark-side behaviour can be managed through a fairer and holistic approach to the IoT. To ensure lasting trust in the data collection process and in the monitoring technology used, it is crucial for businesses to manage *the fairness of how the data are collected and by which means*. The authors define it as *the management of the IoT's fairness*. On the one hand, without fairness, exploitation, manipulation, deception and distrust may become common practices. However, with greater fairness over time, increased trust can be developed and a more effective and long-term view of the IoT will be realized. Research on the dark side of the IoT has been given little attention so far and needs to be put as a priority in the research agenda.

Ng and Wakenshaw [20] are convinced that the IoT opens up new perspectives in the marketing framework. They presented four conceptualizations of the IoT, developed from four theoretical constructs:

1) *Density of information resources* [21]
2) *Digital materiality and its seven properties*:
    a) Sensibility: the ability of a digitalized artefact to have sense and respond to changes in its environment
    b) Addressability
    c) Traceability, so that it can be identified and located in real time
    d) Associability with other objects to enable inferences about future states and conditions
    e) Communicability: the ability of a digitalized artefact to send and receive digitalized messages
    f) Programmability: the ability to accept new sets of instructions and to modify its behaviour
    g) Memorability: the ability to store information and historical logs of its state and interactions [22]
3) *Assemblage and service systems* through decomposing and recomposing-reconfiguring [23] [24]
4) *Modularity and transaction network*

A future of the IoT will see the combinations of these competences as a way to ameliorate services in context and on demand [25]. Ostrom et al. [26] highlighted the need to research into building adaptive and flexible service systems to respond to dynamic environments. Collecting and integrating the consumer data from these environments will produce a so-called *personalized data density* [27]. Ng and Wakenshaw [20] suggest that an era of the IoT would extend physical goods into dynamic service platforms with meaningful implications of the *IoT on Marketing Research*. In the era of the IoT, a marketing focus is needed, because not all IoT technology has already been adopted by the users. The authors suggest that the IoT is an important step change for research in marketing, but one that poses a challenge concerning the research at the interfaces between *marketing and at least one other discipline*. This would require academics to embark on interdisciplinary research.

When everyday objects can be augmented with tags and intelligent sensors, real-time data flow can be automatically produced. Such objects would also be able to generate regular updates and send out large quantities of data about their state and the environment within which they operate. An era of the IoT could provide visibility of experimental and consumer contexts that have not been possible before. This visibility into day-to-day contexts would influence the following three areas of marketing research, generating a massive amount of data:

1) *Consumer experience,*
2) *Dispositions and situations,*
3) *Behaviours and decisions*

This implies that real-time consumer generated data from objects will be dominating the IoT, leading to the ability to create real-time on-demand responsive service from data.

The authors argue that the transformation of data into information, both for the firm and the consumer is a critical research issue. What needs to be taken into account is the use of the data and its transformation into information, which need to be integrated with other datasets, and made usable by firms and consumers. This means *data being a service*.

IoT will transform the firm's business model and will need to incorporate:

- Value creation (the more visible experience of customers)
- Value proposition (the reconfigurable offering)
- Value 'capture' or creating worth for exchanges (the economic model – with shifting boundaries).

The authors suggest that a step change for *research in marketing* is a real priority. They advance that human needs have not really changed. Only the way we—as humans—fulfil our needs is changing. In an increasingly time-poorer society, an innovation that gives us more time, makes things efficient, and improves coordination and a sense of fulfilling will win. For the authors, the full potential of an IoT era has not yet materialized. The current state is a collection of fragmented networks of things. Marketing has an opportunity to actively participate in this new space, to both reflect and shape the challenges within its research and practices. Research in marketing will lead the transformation of the new markets, shaping them through *Marketing Management* and the trained generations of marketing professionals who can transform markets and bring innovation to households, improving the lives of individuals and society.

3. THE INTERNET OF THINGS: A NEW EPISTEMIC OBJECT

In this short review of the literature, we learnt that there are still many layers of the IoT, which need research to be understood. The IoT seems to mean something for everyone who deals with it. The IoT does not have a fixed identity. It is a *new epistemic object*, or *an object of enquiry* [28] [29] [30]. From an anthropological perspective, things and artefacts have *agency* [31] and agency is embedded in things and in artefacts. Sociality establishes relationships with artefacts and objects and this *objectualization* implies that "*objects displace human beings as relationship partners and embedding environments, or that they increasingly mediate human relationship, making the latter dependent on the former*." [29]. The difference between *the epistemic object* and *the technical object* lies in its functional qualities. For Knorr-Cetina [29] in our knowledge society, the construction of an *epistemic object* is becoming crucial, because it is not a thing with fixed qualities but it has open-ended projections, it is oriented towards somethings that does not exist yet or that we do not know for sure. This new object can be regarded as a central source of innovation and re-orientation in social practices. This framework can help us define the IoT from another point of view.

Knowledge processes are dependent on objects of knowledge. In fact, the rise of modern science has been reinforced by object-relations, because it is linked by these object-relations. "*In an post-social knowledge society, … we need to trace the ways in which knowledge has become constitutive of social relations … knowledge cultures centrally turn around object worlds to which experts and scientists are originated … these object worlds need to be included in an expanded conception of sociality and social relations.*" [29]. In order to explain the *objectual relationship* and the so-called *object centred sociality*, objects of knowledge are the goal of the experts' work. The quality of this experts-objects relationship is defined by Knorr-Cetina [29] with: "*the notion of a lack, and a corresponding structure of wanting, a continually renewed interest in knowing that appears to be never fulfilled by final knowledge … wants are always directed at an empirical object mediated by representations – through signifiers, which identify the object and render it significant. But these representations never quite catch up with the object, they always in some aspects fail (misrepresent) the thing they articulate. They thereby reiterate the lack rather than eliminate it … in that sense one could say that objects of knowledge structure desire, or provide for the continuation of the structure of wanting*".

According to the knowledge historian Rheinberger [28], *an epistemic thing-object* embodies what one does not know yet, with its own experimental systems and practices. These objects of knowledge are open, complex and they generate questions, which involve processes and projections. The more we observe and explore them, the more their complexity increases. "*… objects of knowledge are more like open drawers filled with folders extending indefinitely into the depths of dark closet. … Since objects of knowledge are always on the process of being materially defined, they continually acquire new properties and change the ones they have… objects of knowledge can never be fully attained, that they are, if you wish, never quite themselves*." [29].

For Rheinberger [28], artefacts and objects have two distinct roles in human activity: they can be *objects* or *means* (like for example, technologies). For the technologies, they have a black boxed nature, constituting a tacit dimension of activity. To better understand this tacit dimension, the routines and the habits attached to these activities must be made into objects of enquiry, and therefore into an epistemic object. Rheinberger suggests *the bricolage approach* [32], because the bricolage in science "*includes improvising, imagining, playing and searching for new, unexpected cultural resources … as a model of the solution to the basic tension between the necessary reproductive routinisation and the transformative tendencies inherent in human practices.*" The solution should be in the development of new tools and organizational forms that make *reflection on practices* a part of an activity. Forms of reflection can be built within the production of services or between R&D, design activities and actual production as a new practice.

Also for Miettinen and Virkkunen [30], an *epistemic thing-object* is an insightful mean to analyse practices and critical aspects of such practices, in order to produce new ways of acting, especially within the organizational routine for understanding organizational change. We need to study the significance of these artefacts (the IoT) in practice. Social sciences and psychology suggest that action and cognition are objectified into artefacts and they influence our actions [33] [34] [35] [36] [37].

The human form of sociality is objectified in the use of shared artefacts. Therefore, "*a more elaborated theory of the role of artefacts in human activity is necessary in order to understand the underlying dynamics of organizational continuity and change*." [30]. One of the prevailing ways of understanding the technological determinism and the social construction in and through technology studies is *the actor network theory* (ANT). This theory states that sociotechnical systems are developed through negotiations between people, institutions and organizations, but also in collaboration with artefacts - therefore machines. Machines - the nonhumans - are also part of these negotiations and have an active role. Actor network theorists argue that the material world pushes back on people, because of its physical structure and design. Latour, as one of the leading thinkers in ANT theory states that "*we have been able to delegate to nonhumans not only force as we have known it for centuries, but also values, duties, and ethics*." … and consciousness as well, which is rooted in the interaction between humans and nonhumans, the world of the objectified cultural artefacts [35].

Latour [35] [36] explores how artefacts can be designed to both replace human action and shape humans' actions. He argues that we cannot understand how societies work without an understanding of how technologies shape our everyday lives. Latour's study of the relationship between producers, machines, and users demonstrates how certain values and political goals can be achieved through the construction and employment of technologies.

4. DESIGNING AND MATERIALIZING COLLECTIVE MORALITY AND COLLECTIVE RESPONSIBILITY

An interesting point of view is the one developed by the philosopher Verbeek [38] [39]. He uses the concepts of *materializing morality* and *designing morality of the technology artefacts*, providing a new sensibility also towards the object of our analysis, the IoT, as a new epistemic object within the moral dimension of the technology. He uses the concept of *script*, indicating the prescribing role of technologies in human actions. When technology plays a role in the humans' actions, it should give answers to the ethical question *How to act?* This question implies that engineers and designers are doing 'ethics with other means': *they materialize morality*. Technology is not neutral, because it contributes to the actions we decide to take. Technology has an influence on ethical theory and on the ethics of design. The concept of *script* is similar to the *technology mediation* also for designing ethics. The aim of the *script* is to influence human actions by raising moral questions through:

1) "Anticipation by imagination" in the form of a "mediation analysis"
2) Augmented version of constructive technology assessment

The *script* reminds one that there is always a social impact embedded in the technology-in-design, because technology profoundly influences our behaviour and our experiences. There is an ethic within the engineering design of the technology, because technology has a functionality.

According to Akrich [40] and Latour [35] [41], *scripts* are the products of "inscriptions" of the designers, because they should *anticipate the context* of how users will use the technological artefacts they are designing and creating [42]. They are building "*prescriptions for use into the materiality of the product*" [38]. According to Latour [35] [41], this *inscription process* promotes a *delegation*, meaning that designers delegate the responsibilities to the artefacts. As Verbeek summarizes well, *scripts* transcend functionality "*they form a surplus to it, which occurs once the technology is functioning. … For this reason, the script concept lays bare ethical questions regarding technology design that transcend the common sense idea that technologies only need to be morally evaluated in terms of the goals for which they are designed or of the quality of their functioning. The script approach opens up a new way to morally assess technologies with respect to the role they play in their use contexts. In doing so, it also reveals a specific responsibility of the designer, who can be seen as the 'inscriber' of scripts.*" [38]. Verbeek investigates how the concept of *mediation* can be beneficial for designing ethics, answering normative questions during the design process, such as *How to act*? It is a *technological mediation*, which creates a specific responsibility - with a moral and ethical stance - for designers and engineers.

A possibility for designers and engineers is that they could build into the technological artefact the specific desired forms of mediation, which is not an easy task, considered that they should anticipate the future mediating role of the technologies they are designing. Technologies do not have a fixed identity, but they will be defined in the context of the uses. Verbeek reminds one that technologies can be used in unforeseen ways and therefore they mediate human actions, promoting "*an unforeseen influence on human actions."*[38]. Designers are charged by the responsibility to anticipate this *mediated role of technology*. They are *materializing morality*, coping with unpredictability and uncertainty. A solution might be to engage designers and stakeholders in a democratically organized debate promoted by a democratic decision-making.

So, the question that arises is *do technological artefacts have material morality*? An original answer would be the one that Latour expressed [35] towards the speed bump in the road with the inscription "*slow down before reaching me*". The sign embeds morality, because as an artefact it reminds us to slow down and thus avoid an accident. Many actions and interpretations are co-created by the technology we use. They possess an intentionality and a degree of freedom [39].

Technology has a mediation role between humans and reality, because it encourages artefacts to form *intentions*. It shapes how we humans act and experience things. Technology is therefore an active mediator. This mediation, as Verbeek underlines, has two directions: one pragmatic, because it deals with actions and one hermeneutic, because it concerns interpretation (see also [43]). Artefacts are active, because they help us take decisions. They do not have the intention to do something deliberately, but they help us direct our thoughts and actions. They possess *a specific form of intentionality*, which is different from human intentionality. Only within the relations between human beings and reality can artefacts play their 'intended' mediating roles. Therefore, subjects who act or make decisions about actions are never purely human, but rather *a complex blend of humanity and technology*. Decisions are co-shaped by technological artefacts. At the same time, the technologies involved do not *determine* human decisions here. Moral decision-making is a joint effort of human beings and technological artefacts. There is no such thing as 'technological intentionality', because intentionality is always a *hybrid affair*, with intentionality distributed over the human and the nonhuman components in the human-technology-world relationships. This intentionality comes in associations between humans and nonhumans. For this reason, it could be defined as *hybrid intentionality or distributed intentionality*. [39].

To understand the moral relevance of technological artefacts, Latour offers this example: the debate between the National Rifle Association in the USA and its opponents [44]. In this debate, the American opponents of guns in the USA use the slogan "*Guns Kill People*", while the NRA replies with the slogan "*Guns don't kill people; people kill people*". The two positions are both right. If someone is shot, nobody would ever think that the gun is responsible for the shooting. This example illustrates that when a person is shot, *agency* should not be located in either the gun or the person shooting, but *in the assembly of both*. Therefore, we need to develop a new perspective: artefacts can 'have' intentionality and freedom, just as it is also assumed in humans [39].

Technologies can be used in unforeseen ways, and therefore are able to play unforeseen mediating roles. Unexpected forms of mediation can arise when technologies are used in the way their designers intended. A good example is the revolving door, which keeps out both cold air, but also the wheelchair users. Designers play an influential role in designing forms of mediation. Also the users, with their interpretations and their forms of appropriation, have a part to play, as well as the technologies. Together they give rise to unintended and unanticipated forms of mediation. The relations between technologies, designers, and users in the mediation of actions and interpretations are complicated. In all human actions and their moral decisions, there are three forms of agency at work:

1) *Agency of the human being performing the action or making the moral decision, in interaction with the technology*
2) *Agency of the designer who, either implicitly or explicitly, gives a specific shape to the artefact used and helps to shape the mediating role of the artefact*
3) *Agency of the artefact mediating human actions and decisions, sometimes in unforeseen ways.*

Taking responsibility for the technological mediation means entering into an interaction with the agency of future users and the artefact-in-design. The fundamental unpredictability of the mediating role of the technology that follows from this does not imply that designers are by definition unequipped to deal with it. To manage the unpredictability and complexity of technological mediation, it is important to seek links between the design context and the future use context [39].

Verbeek [39] invites us to reflect about two ways to take mediation analyses into the ethics of technology and design, as shown in Fig. 2. One way is to develop moral assessments of technologies in their mediating roles in human practices and experiences, through an *action-ethical approach*. The focus is the analysis of the *practices* that are introduced by the mediating technologies, and their implications for the kind of life we are living and the ways we are acting in this world. The second way

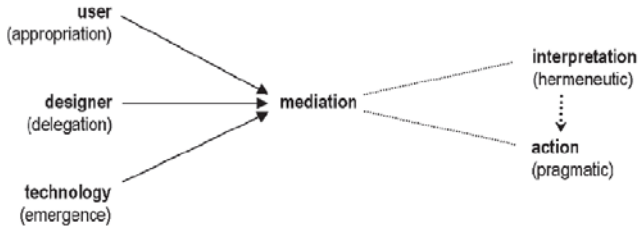

Figure 2 – Origins of technological mediations, by Verbeek

to augment the ethics of technology with the approach of technological mediation is to *assess* mediations, and try to *shape* them. The ethics of technology should aim to *accompany* technological developments, experimenting with mediations and finding ways to assess how one might deal with these mediations, and what types of living-with-technology are to be preferred. Ethics should deal with these mediations in a responsible way, and try to help the design technologies with morally justifiable mediating capacities. Verbeek underscores that actions and decisions of designers have public consequences, and therefore these decisions should be subject to public and democratic decision-making, as part of "a res publica" process [4 "*'Res', the Latin word for 'thing', also meant 'gathering place', or 'that which assembles', and even indicated a specific form of parliament. Things can thus be interpreted as entities that gather people and other things around them, uniting them and making them differ. Technological artefacts not only help to shape our lives and our subjectivities, they should also be approached as motivations around which humans gather in order to discuss and assess their concerns about the ways in which these things contribute to their existence. These are precisely the places where the morality of design should be located.*" [39].

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