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# Tele-Economics in MTC: what numbers would not show

Andres Laya[1,*], Amirhossein Ghanbari[1] and Jan Markendahl[1]

[1]KTH Royal Institute of Technology. Communication Systems (CoS) department. Kista, Sweden.

## Abstract

This paper elaborates on the relevance of Tele-Economic research to understand the effect that Machine-Type Communications (MTC) has on different markets and also the market forces affecting the adoption of services based on MTC. The paper is presented in a tutorial form, offering concept and definitions of economic terms that are gaining relevance in the technical community in the MTC context. The concept of services is further analysed in as a change in the telecommunication industry mind-set in order to tap into the economic value of MTC in the realization of the Internet-of-Things. Finally, insights are presented looking forward into the relevance of Tele-Economic research for 5G.

**Keywords:** Tele-Economic research, service enablement, Machine Type Communication, Internet-of-Things.

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## 1. Introduction

The opportunities that Information and Communication Technologies (ICT) offer to any industry considering the transformation of products and places into smart, connected system have stimulated academics and professionals from every discipline to explore and collaborate in concrete realizations of this vision. This paper elaborates on the relevance of considering research from different disciplines regarding this emergent communication enablement trend.

MTC[†] is a topic commonly discussed to provide of additional streams of revenues for mobile operators as one way to narrow the mobile revenue gap. Consequently, it is natural to see the appearance of enablement platforms as an approach to extend the connectivity provisioning into connectivity services that include usage monitoring, support of fault resolution, and some level of service enablement to support application developments. J. Morrish [1] makes an important contribution by suggesting that this connectivity between devices is not about a technical solutions; it is more about the applications benefiting from this connectivity. These benefits might be related to improving old functions or performing new functions.

In this respect, it is difficult to discuss in terms of a MTC market, since it is a set of technologies with supporting capabilities across different markets [1]. So, the fact that MTC is about supporting something highlights the need of research and development on the values and possibilities in specific areas.

We could argue that MTC first took off within the telecom industry, and has been widely promoted by it ever since. And it is precisely for this reason that the benefits and potential are clearer on the technology side than on the application (market) side. Many of the possibilities and concepts are rather abstract and mainly understood inside the ICT community. Even if there is an increasing interest in the consumer or societal impact, it has become essential for the technical community to find well-grounded evi-

[†] Machine-to-Machine (M2M) is usually referred to as the communication between remote machines and central management applications. Similarly, Machine-Type Communications (MTC) implies the communication where at least one element is a Machine. Since it is the working terminology used by 3GPP, MTC it is often regarded as the segment of M2M carried over cellular networks.

[*]Corresponding author e-mail: laya@kth.se

dence of the benefit that can be attained with MTC. Hence, the objective of this paper is to present how Tele-Economic research can support this goal.

Before presenting details on the meaning and scope of Tele-Economic research, let us reflect on the relevance of techno-economic modelling. The purpose of these models is to have supporting insights to steer a technology development into a market-feasible solution. Techno-economic modelling proved the relevance in the telecommunication sector with the development of frameworks and tools to study possible network development or migration paths [2], taking into account costs and revenue models of technology and user adoption. An instance of this standpoint is given in Telenor R&I review on the chronology of telecommunication research projects and programs using techno-economic methodologies [3]; starting with deployment models for the access networks, followed up by research related to business models, demand forecasts, costs models and sensitivity and risk assessments.

There is a vision that techno-economic studies are merely a new dimension of performance boundaries to narrow scientific development within economic performance metrics. The underlying aim of this paper is to show the potential and status of Tele-Economic research as complementing methods to enhance, direct and exploit the technology possibilities; by understand the market context where the technology is applied.

The driver for Tele-Economic research in MTC is to find and understand the real value and potential benefits of MTC communications, beyond the communication layers; in order to do so, we discuss in terms of the service ena- blement capabilities of MTC for solutions based on con- nected devices.

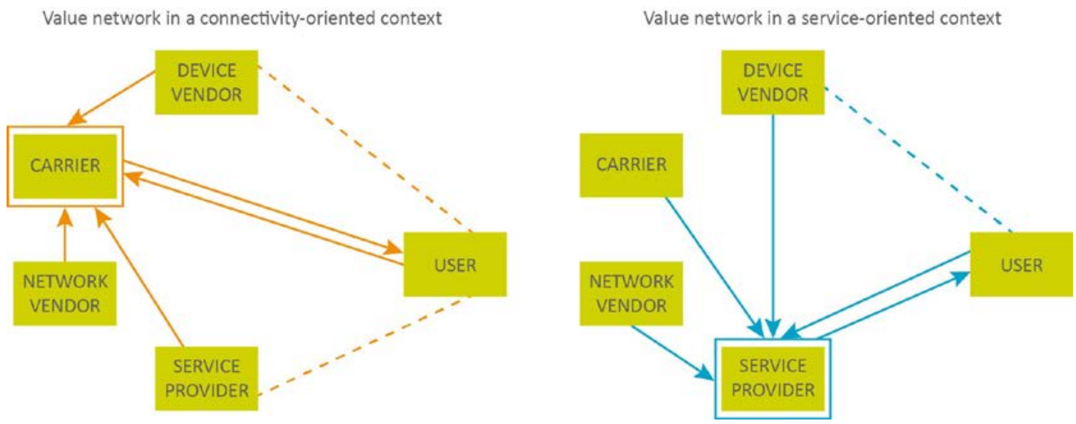


**Figure 1.** In mobile broadband, the business is discussed in terms of connectivity; the most relevant actor corresponds to connectivity providers (carriers). In MTC the business is discussed in terms of the service that it is enabled on top of the con- nectivity, hence, the most relevant actor is the service provider.

On Figure 1 we make a simplified mapping of the actors in the telecom sector to compare the focus on connectivity for mobile broadband services and the focus on services on top of the connectivity provision. When the discussion is on a connectivity-oriented context, the main players interacting with the final user are the mobile operators (or carriers); this constitutes the traditional organization of the telecommunication sector. On the contrary, the right-hand side of the figure represent the discussion in terms of the services provided on top of the connectivity, where the pivotal players are those firms providing value added services, such as over-the-top players. In this case, even if the communication is a fundamental enabler for the service, the involvement of mobile operators is many times described just as the providers of the data transport infrastructure.

MTC has boost a reconfiguration of the telecommunication industry, which is on an early stage and there are only predictions of the future panorama, however, there seems to be a common interest from the major maker players to position themselves as enablers of services based on MTC to tap into the economic value of the future vision on the Internet-of-Things. Naturally, this reconfiguration is resulting in closer discussions with non-ICT industries and, since MTC is about enabling services for other industries, input and discussions are merging from different angles. Some economic concepts and terms are gaining relevance in the technical community and it is worth clarifying their origins, usage and relevant in the MTC context.

*But does not all that research belong somewhere else?* It might seem so, but closer collaboration from different disciplines would benefit from a common level of understanding. Moreover, we see the increasing attention that funding research bodies are giving to interdisciplinary studies. This focus brings a challenge in language differentiation. Instances of notions from industrial management and economic research are closely influencing technology research. We aim at providing comprehensive material on some of these aspects to a technical audience in order to tutor on the meaning and scope of Tele-Economic research regarding recent and forthcoming challenges in MTC.

The paper is discursive and a tutorial in nature. The remainder of the paper is organized as follows: on the next section we present concepts and definitions with key references related to the service enablement. This is done, mainly, in order to familiarize the reader with the concepts used in the later discussions. Afterward, we discuss the relevance of Tele-Economic research for MTC, with strong focus on the service enablement. We continue with a section dedicate to the implications towards 5G research regarding MTC, highlight current technical considerations that are built on top of the service enablement mind-set.

## 2. Concepts and Definitions

The purpose of this section is to present concepts and definitions of common terminology that tends to be misapplied and, at times, abused. It is the most tutoring section of this manuscript, giving a necessary literature review on the multi-disciplinary context of this work.

### 2.1. M2M, MTC and IoT

Three terms, Machine-to-Machine (M2M), Machine-Type Communications (MTC) and Internet-of-Things (IoT); they entail complementing concepts but are often used interchangeably. They all imply the notion of connected autonomous devices, but we delimit them—based on literature comparison—as presented next.

M2M has an accepted definition as the set of wireless and wired communication between mechanical or electric devices [4] or, as presented by Whitehead in 2004, communication between remote machines and central management applications [5]. Anton-Haro and Dohler [6] extend the concept and include all the information and communication technologies able to measure, deliver, process and react upon information in an autonomous fashion. M2M and MTC are at times considered synonyms [7] [8], however, since MTC is the working termi- nology used by 3GPP, it is often regarded as the segment of M2M carried over cellular networks [9] [10]. These two are telecom terms and therefore they have a strong focus on the network side [11].

When it comes to IoT, Höller et al. [12] describe it as a set of technologies, principles and systems associated to Internet-connected objects, coinciding with the EIRC and ITU-T definition [13]. Clarifying that, in contrast to M2M, IoT includes the connection and access to the broader Internet. The term was first coined in 1999 by K. Ashton [14] to describe a "world of seamless connected devices that would save us time and money", based on the interconnection of the physical world with the virtual world of Internet [15]. In short, we argue that M2M—and MTC—are communication enablers for the broader concept of the IoT.

Recently, there has been yet another term with similar connotations; Cellular IoT—or CIoT—is a terminology used to denote IoT networks operating in licensed spectrum [16].

### 2.2. Techno-Economics

The term Techno-Economics does not count with a strict definition and it suggests different meanings depending on the context. Back in 1990, sociologist Michael Callon [17] introduced the concept of Techno-Economic Networks (TEN) as a solution to describe and analyse the interactions between actors influencing technology development; linking social and economic notions and arguing that actors define one another in interaction, by means of the intermediaries that they put into circulation. Perez [18] and Freeman [19] present the notion of Techno-Economic Paradigms (TEP) as a solution to describe and analyse the relation between long-term fluctuations in economic growth and the links with major technical changes [20]. Comparing these two notions, Green et al. [20] argue that TEN literature is focused on describing the emergence and stabilisation of technology, while TEP literature is focused on challenges related to diffusion of pervasive technologies.

By analysing these broad perspectives, we infer that Techno-Economics correspond to interdisciplinary efforts that consider social, economic and regulatory aspects to analyse the effect of technology innovation or intervene in its development. As a result, from a commercial point of view, this interdisciplinary field complements pure technological research to break the assumption that any technology development will eventually result in new commercial products or processes [20]. It is, therefore, a group of approaches dedicated to the "linkages between technological, economic and social change" [21].

### 2.3. Tele-Economics

Tele-Economics is a line of research on telecommunications that applies economic research approaches on the knowledge from the technology research. The purpose is to understand the effect that technology development has on different markets and also the market forces affecting the evolution of the telecommunication industry.

Tele-Economics includes topics such as the study of the behaviour of the telecommunication market, the organizations within this market, the customers and users. It also includes the analysis of costs and benefits, and the interactions and relationships among different actors, and analysis of operations.


**Figure 2.** Tele-Economics described as telecommunications and economics research interactions.

On Figure 2 we present a descriptive interaction between the two general disciplines, Telecommunications and Economics, highlighting four main stages. The two stages on the left represent demand from the market, which are considered *market Pull.* This market then corresponds to any market where Telecommunications can play a role or even Telecommunications market thereof. On the right side, the two stages represent the supply for market, which are the *technology push* (consider all ICTs). The stages Tele-Economics focus on:

**Needs in technology**: corresponds to research showing clear demand in the market for new technology. Findings relate to identification of gaps in the market for technology solutions.

**Technology development and maturation**: corresponds to the more technical stage in the interaction. In this stage a technology is either developed or enhanced. The aim of this stage is twofold:

- If this stage is the departure research point, a new technology is developed and is then passed on to viability study.
- If this stage has been reached after finding a need in the market. The gap drives the telecom industry to come up with a technique to address the demand.

**Viability of technology**: corresponds to analysis and performance evaluation of certain technology. This stage is related to work on deployment studies, and cost calculations applied to telecommunications. The relationship between different types of providers of networks and services including construction, operation and maintenance of infrastructure, the infrastructure requirements of services and users, marketing organization for the provision of networks and services and the interaction between technical solutions and on the other hand, market mechanisms, regulation and competition law.

**Innovation in the approach of using the technology**:
corresponds to research and innovation in the market and economic space to find novel methods to benefit from a technology. This stage is not related to technical development and is more focused on regulation and market structures including demand analysis, analysis of value and behaviour models for pricing. Additionally, it involves topics regarding the relationship between the service / network provider and users, analysis of the business models and cost structure analysis and the impact of regulation and licensing. Lastly, strategic decision-making by means of game theory methods falls within this stage.

The illustrated approach in Figure 2 can start from any of the four corners based on the fact that the research is demanded by the market or pushed by the technology. The important consideration is that the stages on either side (left/right) have closer interaction to each other and benefits from repeated cycles, providing input for further researcher before passing to the other side.

## 2.4. Value, Value Chains and Value Networks

Value is another terminology with many interpretations with often appearance in research and discussion environments. McQueen and Dobb [22] described value, in economics, as worth of a commodity in terms of other commodities, or in terms of money. Michael Porter [23] defined value as what buyers are willing to pay for products or services. In the context of our research, we define value as a measure of the benefit provided by a good or service to an actor, where, according to Keen [24] it is generally measured relative to units of currency.

Michael Porter first introduced the term Value Chain in 1985 [23] as the interrelated operating activities, which businesses perform, during the process of converting raw materials into finished products. The terminology since then has evolved and been put into different contexts. In 2001 Kaplinsky and Morris [25] defined value chain as a tool to describe economic activities that are required to bring a product or service from conception to final consumers. As presented in Figure 3, within the traditional vision of value chains, value in created in consecutive steps by activities that add value to the final product or service.

Normann and Ramirez [26] present a change in the perception of the value chain, by suggesting that it is no longer possible to define fixed positions for firms based on a set of activities along a value chain. Instead, they refer to the value constellations, or value networks, as a model to focus on the overall system, with focus on the value creation. The general difference in the concepts of value chains and value networks is presented in Figure 3.

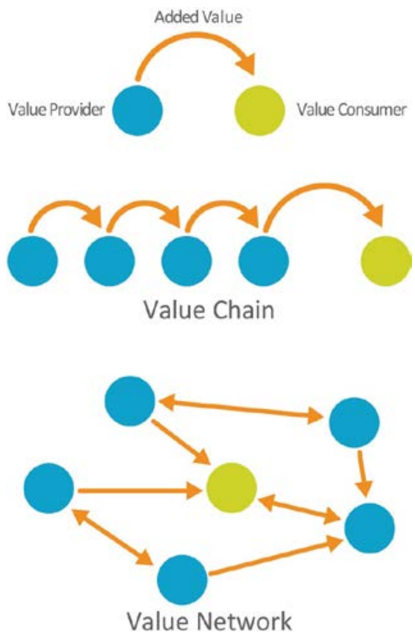


**Figure 3.** General representation showing the concepts of value chains and value networks

## 2.5. Business Models

As Morris et al. [27] believe, there is no commonly accepted definition for the term "Business Model," Nevertheless, it is commonly used. Different scholars tend to focus on different approaches while describing the term, which is mainly because they believe different issues are more important in the description [28]. Basically, Stewart and Zhao [29] consider Business Model "a statement of how a firm will make money and sustain its profit stream over time." Elaborating more on the details of constituent elements of a business model, Morris et al. [27] believe that "A business model is a concise representation of how an interrelated set of decision variables in the areas of venture strategy, architecture, and economics are addressed to create sustainable competitive advantage in defined markets". The competitive advantage then is translated to creating value by Osterwalder et al. [30] within the so-called Business Model Ontology (BMO). They believe that a business model should express the logics of a specific firm describing "the value a company offers to one or several segments of customers and of the architecture of the firm and its network of partners for creating, marketing, and delivering this value and relationship capital, to generate profitable and sustainable revenue streams".

There are several complementing academic resources that discuss and consider the following concepts of business models: value proposition, cost structure, profit potential, value chain, competitive strategy, value network, business model innovation, the actors, resources and activities [31] [32] [33] [34].

## 2.6. Business Ecosystem

This term is commonly used in the literature and finds a concrete definition in J.F. Moore's work [35] as "the network of buyers, suppliers and makers of related products or services" within a socio-economic environment that includes institutional and regulatory frameworks [15]. Furthermore, Mazhelis et al. [15] and Iansiti and Levien [36] argue that a business ecosystem evolve around a specific core, which corresponds to shared and common assets. Common assets could be presented in the form of platforms, technologies, processes, and standards that are fundamental in their businesses.

Also in [15], the authors consider IoT as a particular business ecosystem. They partake on the definition of *IoT Ecosystems* by considering a core composed of hardware and software products. These products then focus on connected devices, the connectivity itself, the solutions built on top of this connectivity, and the supporting activities of such solutions.

## 2.7. Services

According to Vargo et al. [37] a "*service* is the application of competences (knowledge and skills) by one entity for the benefit of another". This definition implies that value is created based on the interactive exchange between entities [38] [39]. The reason to present and discuss this term is to emphasize the fundamental shift from economic exchange based on goods towards markets dominated by the provision on services. They refer to this new mind-set shift as the Service-Dominant Logic. Leveraging on the "research manifesto for services science" by Chesbrough and Spohrer [40], it is possible to appreciate that services share essential elements, and we highlight the following common elements of services enabled by ICT: services by nature cause a close interaction of supplier and customer; they result from a combination of knowledge into useful systems; finally, they are characterized by the simultaneity of production and consumption of value [40] [41].

According to Lusch and Vargo [38], in the Service-Dominant logic, customers become co-creators of values, underlining the relevance of the interchanges in the relation between customers and suppliers. A distinctive quality of Service-Dominant logic is that it considers customers, employees and organizations as dynamic resources; denoting that all parties are simultaneously creators and beneficiaries of values.

We should make a distinction between the meanings of the term *service* between economics and computer science. For example, Thoma et al. present a technical survey on computer science where they identify services as one of the main building blocks of the IoT [42]. They present a definition of the term *IoT-Service* as "a transaction between two parties, the service provider and the service consumer. It causes a prescribed function enabling the interaction with the physical world by measuring the state of entities or by initiating actions which will cause a change to the entities." [42]. This definition limits the notion of service to computing functionalities and does not capture the aforementioned notions the service-dominant logic. Therefore, when making reference to MTC and the transformation of markets based on connected devices, it is more appropriate to refer to *IoT-enabled service*; on the prerequisite that such service relies on the availability of M2M or MTC.

## 3. The relevance of Tele-Economic research for MTC

Since MTC is regarded as an enabling technology, the purpose of performing Tele-Economic research on MTC is to analyse the context in which the technology is being used or might be of use. Therefore, Tele-economic research on MTC is not restricted to connectivity and deployment aspects. It can be used to differentiate barriers related to the lack of adequate technology from barrier associated to inconvenient business and market settings. Understanding these differences helps in channelling efforts to overcome diverse barriers, either by focusing on technology refinement or by finding and suggesting adequate changes in the business or market settings.

MTC is maturing, but even with a general industry growth there is a challenge in the understanding of the benefits that MTC could bring in different industries. Big corporations get the main message but much more focus should be on the costumers and their needs[‡]. It is important to make sure to get the best technology for each case but, when considering the transformation that MTC brings into a product or solution, the communication aspects are not generally a concern on the customer's side; they are just a fraction of the overall problem[§].

Our previous findings when examining different cases suggest that it is simpler to analyse the values and benefits of stand-alone solutions [43] but considering complex cases, such as Smart Cities, makes difficult the tasks of understanding what the values and benefits are. Besides, even if intangible values are elucidated—such as efficient resource management, optimized working times or continuous interaction with customers and users—the tangible economic benefits are yet unclear in many applications [28] [44][**]. This matter has been explored by academics and the transformation from product to service to tap into the MTC value is gaining a strong momentum, as we present in the following section.

[‡] Insights from an interview to the Chief Marketing Officer in a M2M Global Managed Service Provider firm.

[§] Panel intervention at the 2015 Johannesberg summit from the Global R&D Program Manager in a multinational engineering firm.

### 3.1. MTC and Services

As presented in Figure 4, when addressing MTC there should be a consideration of the shift from products to services. Instead of focusing on the development of MTC products and understand their value, the focus should be on the creation of experiences and co-creation of value.

Heapy [45] elaborates on this topic from a service design perspective, reasoning that value should be created through use, exploring beyond the point of sale. In this sense, MTC devices and networks are clearly positioned as value enablers in the IoT context. As described by Berkers et al. [46], the evolution of service based on connected devices have parallels with earlier telecom advances, which first integrated richer value-added services and then evolved into service delivery platforms that simplified the management and creation new services. A similar service creation enablement trend is evolving around MTC towards IoT-enabled services [46].


**Figure 3.** Change from product to service oriented solutions and offers.

Notably, MTC is about connected devices and therefore, at this stage, it is difficult to discuss in terms of a transformation from product to services; it is more suitable to discuss in terms of combination of products and services. In this sense, Product-Service System (PSS) "is a concept for business to improve their sustainability performance. The approach analyses the needs of consumers to be filled by products and services, and uses results as a basis for innovation" [47]. PSS covers the combined offering of products and services, instead of a sole focus on products [48]. Elfving and Urquhart [49] describe how telecommunication industry has been on a transition state toward a service focus on their business in recent years. Based on that, MTC can be considered an enabler of "smart products" and a driving force propagating the product-to-service transition to other industries.

[**] The challenge related to not knowing where the value is and how to capture it was highlighted during the *Enabling transformation by embedding intelligence* keynote at the Ericsson Research Open Day 2015.

As explained by Elfving and Urquhart in [50], PSS has evolved as a parallel approach to Service-Dominant Logic; which is based on the idea of changing a traditional view of products towards systems of products plus services. PSS highlights a change in the offering; which is that customer retribution is on the use of a system rather than acquiring the system. Tukker [51] presents different types of Product-Service Systems:

- Product oriented services: where the focus is on product sales and some additional services related to the product, advice and consultancy.
- Use oriented services: where the product plays an important role but the business model is developed for a service; this includes product lease, product renting/sharing, and product pooling.
- Result oriented services: where there is no pre-determined product involved and the agreement is on a result; including activity management and out-sourcing, pay-per-service unit and services based on functional results.

Based on these categories, we can argue that MTC technologies will be largely offered as product oriented services. At the same time, we consider MTC as an enabler of other product oriented services (related to monitoring) and, more importantly, an enabler of use- and result-oriented services for other industries.

We go back to Normann and Ramirez's [26] argument to suggest that it is no longer possible to define fixed positions for firms based on a set of activities along a value chain; therefore the focus should be on the overall system. This argument is the basis of the value network model presented in the previous section. We recap on this notion to highlight the implications in the MTC research context, which is that even MTC technical experts should be aware of aspects beyond connectivity, in order to channel their effort to challenges that can be solved by technical improvements. As a result, we believe that the study of MTC should never lack a context; and be solely studied from connectivity perspective. The context is then a system of systems, as implied by IoT [52].

## 3.2. IoT as the System of Systems

Here the work from Leminen et al. [53] [54] regarding ecosystem business models for IoT is particularly relevant; where they claim that businesses cannot be anymore understood from a single actor perspective and the value creation and exchange requires active involvement from all the relevant actors and needs to be understood across the network of companies. In the case of IoT-enabled services, enabling actors—including MTC actors and other communication providers—play a fundamental part; their involvement in the service provisioning is dynamic, therefore, these firms need to understand and develop the business and offerings conjunctively.

Mazhelis et al. [15] present a definition for IoT ecosystem from an ICT standpoint, with focus on the device and connectivity roles and services on top of the connectivity. Their organization is exhaustive, but it can be regarded as an elaboration for the IoT providers' ecosystem. The next frontier is to go beyond these providers' ecosystem and focus on the demand side, since experience is showing that solutions based on MTC require a detailed level of understanding of both: the connectivity field and the area on which the service is delivered. Moreover, as suggested by Leminen et al. [53], most of the critical challenges cannot be appreciated at a firm level, but rather on the ecosystem or network level and, more importantly, on the industry boundaries. The IERC [55] presents the same idea by suggesting that the purpose of MTC is to support applications that are not part of the ICT domain.

From Harbor Research [56] we can get a more direct statement, they elaborate that there are no significant ecosystems in the area besides early emergent alliances. Moreover, they claim that "business development among technology developers has not kept pace with their technology innovation. The tech tools may be 21st century, but the business thinking of the tool "creators" has too often remained in the 20th". They refer to the fact that technology firms should avoid the command-and-control type of relationships that suited the inception of MTC. It is possible to find support for the argument that the slow emergence of solid ecosystems is due to the fact that there are too many technologies and firms creating isolated solutions, resulting in a fragmented market. On the next section, we elaborate on this topic.

## 3.3. Discussion on Fragmented Market

There has been an increasing attention on the debate related to the shared and common solutions in the MTC context as an incentive to reduce investment costs and expand business opportunities [57] [58]. The IERC highlights the obstacles of having a fragmented[††] market [59]. Nonetheless, one needs to be cautious with referring to a fragmented market as a challenge; since it is just a condition in the market that opposes to concentrated market—which in turn is associated to monopolistic behaviour and innovation decay. It is perhaps the fragmented offering the factor influencing the rapid expansion and innovation in this sector. Furthermore, IoT and consequently MTC are fragmented by nature, because the end needs cannot be homogenized and systems become so

[††] A market is fragmented when there is no clear leader or dominant company in terms of market shares, i.e., no company is influential enough to move industry in desired direction.

complex that is not possible to serve them with a single solution [53].

The IERC [59] suggests that "focusing on vertical appli- cations risk reinforcing silos and prevents innovation". Endeavours towards *horizontalization* are coming from the telecom sector, in order to standardize solutions and scale their offer. In this sense, it is important to recognize the achievements on the standardization and global alliances in this respect [60] [61]. In short, enabling firms should have a standardized vision while innovation should be provided on specific aspects since precisely the vertical applications will be the revenue generators. Cur- rent market development corresponds to this argument; that meaningful solutions for industries and societies are achieved vertically, by fully integrating the non-ICT actors in the value design and development.

It is important to understand that even if standards are established and dominant designs are adopted, there could still be negative fragmentation in the offers. As shown in [28], having the same standard technology will not prevent an adverse fragmented market on the service level. This service level fragmentation can negatively affect the experience on the customer side, limiting the adoption of such services. Therefore, it is convenient to have the service and the user experience as the starting point for the further development.

Finally, a deviation in the notion of benefits of scales is taking place in several industries. While standards serve the purpose of providing tools to interconnect efficiently, "problems" cannot be solved from a top-down approach; solutions come from local contexts and this notion should be embraced, rather than being treated as a challenge. This can also be seen as an operator trend, with a change in focus from global to local as a strategy to achieve better synergies while keeping a trade-off with scales[‡‡]. Therefore, our final argument is that the main barrier towards IoT is not on the lack of reference architectures or technology fragmentation; we argue that the real barrier is that the value is not clear in many solutions.

In the next section, we discuss the emerging changes shaping the development of 5G, considering the growing interest in MTC.

## 4. Towards 5G

Andrews et al. [62] argue that 5G is not going to be an advanced version of 4G, but instead a paradigm shift including many high technical requirements that are highly integrative. Werner Mohr, chairman of the 5G Infrastructure Public Private Partnership (5GPPP) explicitly mentioned that 5G will not only be about a new radio access technology, also the network architecture will have a focus for development [63]. Even more, 5G should provide the integration of cross-domain networks. There seems to be an agreement on the premise that 5G should be able to provide a future-proof architecture that could be afterward driven and managed by software in order to address a diverse range of services.

Now the question is *why* we need such a "disruptive network". All generations of cellular communications up to 4G have been developed based on a set of technical requirements, in order to accommodate *better* user experience for end-users of cellular telephony. This has been due to the fact that the technology has had a vast potential to be enhanced and the market, yet, has not been saturated. At the same time, starting from 2G, some potential had been seen in this domain that could have helped other industries to transform to a better state; mainly based on data provisioning. Now for the emergence of 5G, recalling our discussions on Tele-economics, the "why" question at the beginning of this paragraph turns to: Is 5G going to be a *Technology Push* or a *Market Pull*?

If we look into market demand for 5G and seek for industrial needs, one valid example can be massive MTC. It is believed that many industrial MTC-based demands can be met by legacy technologies combined with improvements on 4G standards[§§]. For instance, one major initiative in this regard is the CIoT. GSMA launched the Low Power Wide Area Network Initiative to accelerate the rollout of complementary cellular networks for MTC. The focus is on "applications that have low data rates, long battery lives and that operate unattended for long peri- ods of time" [64]. The 3GPP presents a technical report that considers both the possibility of evolving the some of the current system and the design of a new access system to meet the requirements for a Cellular IoT sys- tem for the lower data rate end of the M2M market [65]. This initiative has the purpose of covering the existing MTC demand and deployments are expected by 2016.

Looking into the MTC demands from market, that can lead driving the emergence of 5G, it can be considered that Critical MTC for health, traffic safety, and industrial control will be the drivers. Looking back to our discussions on "MTC and Services", by focusing more on the importance of Tele-economic research, in recent years

[‡‡] As presented by Bengt Nordström, CEO at Northstream AB, during the seminar Key telecom vendor trends, *Key Operator trends and Thoughts about the IoT market* at Wireless@KTH on October 2015.

[§§] As presented by Sara Mazur, Vice President and Head of Ericsson Research, Ericsson AB, during Keynote; "Technology research for industries and society in transformation" at the Ericsson Research Open Day, September 2015.

there has been a transformation towards a service enablement mind-set by some actors [66]. This then makes 5G the flipping point from a technology push to market pull. As a result, we believe that Tele-economic research on MTC is "the" way to address efforts towards 5G.

Relating to the aforementioned change from technology push to market pull, major stakeholders of the telecom industry value network are following co-creation of value under the PSS concept in 5G. These are the legacy providers of solutions, equipment and services. For instance, Ericsson introduces the idea of logical network slices to enable operators to provide networks that meet the requirements of the wide range of cases, with a combination of SDN and NFV [67]. On the other hand, Nokia has presented the notion of a service enablement domain to allow operator the possibility to grant secure access to thirds parties to develop vertical services based on a SDK [68]. These two clear directives toward service enablement are also supported on ZTE´s vision that the development focus for 5G should not be about network capacity but rather on the user experience [69].

From the other side, the market demand for Critical MTC in 5G would cause a deeper integration of ICT in industrial processes, products and services, which will strengthen competitiveness of industries. This argument can be validated by Arcas' discussion [70], which believes M2M [MTC] adoption has been driven by value creation and not by technology availability. We argue that we will see a more reciprocate relationship in the evolution of requirements and supply of new solutions.

Further on, we rely on Simon Sounders' considerations for 5G [71], mentioning that it is important to look carefully into the users for 5G standards and what implications they might bring. We reached a shifting point and in 5G will explicitly target specific needs on vertical industries. "Rather than rushing out the next generation of cellular technology to meet arbitrary deadlines, time needs to be spent now thinking about how 5G can serve the wider societal and industrial needs" [71] [72].

Our concluding remark on this section is that industrial customers do not actually want 5G systems; these customers just want to solve problems on their industries.

## *5.* Final Remarks

We have elaborated on the premise that MTC implies more than technical solutions and it is about the applications benefiting from connectivity. In this sense, Tele-Economic research in MTC plays an important role in finding the real value of MTC communications, beyond the communication layers. Based on literature review, we show the reasons why even MTC technical experts should be aware of aspects emerging from different disciplines in regards to MTC and IoT, since they provide additional instruments to channel future development activities. As a result, we conclude that the study of MTC should never lack a context, which is largely related to the industry or sets of industries where the solutions will be of use.

In addition, we emphasize the role that MTC has as driving force for the product-to-service transition in the economy. Further on, we show how the service enablement mind-set in the telecommunication industry in having a profound impact in the development course of 5G standard, which has been largely focusing on addressing specific needs for vertical industries.

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