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Scenarios for MTC in 5G

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Executive summary

The report explores three core areas of machine type communication in 5G, namely *ultra-reliable low latency*, *national broadcast delivery* and *NB-IoT/massive sensors*. Six scenarios for the three areas are developed based on an analysis of political, economic, societal, technological, and environmental change factors. Each area is described through an optimistic scenario and a threatening scenario. The scenarios are summarized into four phenomena that describe plausible futures or development paths for MTC in 5G, namely *exclusivity* (low level of co-operation between actors in the ecosystem, with limited access for new players in the ecosystem), *integration* (high level of co-operation between actors in the ecosystem, with limited access for new players in the ecosystem), *fragmentation* (open access and low level of co-operation in the ecosystem), and finally *co-creation* (open access for new players and high level of co-operation in the ecosystem).

The report summarizes the scenarios and underlying phenomena in six trends for MTC in 5G. The identified trends highlight the following aspects: (a) connected devices will bring value to society and the environment, (b) 5G corresponds with green values and sustainability, (c) the potential of wireless connectivity in vertical industries will be recognized, (d) selling shifts focus from products to services, (e) the emergence of new players creates uncertainty among existing actors in the ecosystem, and (f) an increased focus on exploring co-creation opportunities.

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Abbreviations

AI	Artificial intelligence
AR	Augmented reality
IoT	Internet of Things
MTC	Machine type communication
mMTC	massive machine type communication
uMTC	ultra-reliable machine type communication
NB-IoT	Narrow-band IoT
PESTE	Political, economic, societal, technological, environmental (change factors)
URLLC	Ultra-reliable low latency communication
VR	Virtual reality

1. Introduction

Machine type communication (MTC) represents a novel transmission paradigm where machines send data without or with minimal human intervention [1]. Examples of MTC are depicted in smart city environments, where opportunities and innovative business models may be found related to city transport and logistics, smart power grids, e-health, home and building remote surveillance etc. MTC can be further classified into massive machine type communications (mMTC) and ultra-reliable machine type communication (uMTC). The former concerns the wireless connectivity of a number of terminals and devices, whereas the latter focuses on low latency and high reliability. Consequently, MTC will have strategic value also for 5G wireless networks. In fact, according to Statista [2], the number of connected devices worldwide is expected to grow to nearly 31 billion in 2020, and to 75 billion by 2025, whereas Gartner [3] estimates the number of active connected devices to 20 billion in 2020.

5G aims at serving a wide range of industry verticals, not only tap into mass consumer markets; 5G is designed for very low latency applications, high travelling speeds of its users, high accuracy in, e.g., determining user location, higher data rates and lower energy consumption. Nevertheless, there is still uncertainty concerning the shaping of the market and the emerging ecosystem (actor roles, choice of communication technologies in different environments etc.). In addition, 5G communication technology is envisioned to enter and create value in new territories, i.e., vertical industries such as agriculture, automotive and transport, education, financial services, health, manufacturing, energy, and so forth. Communication and connectivity do not necessary constitute the core of the verticals, but 5G aims at creating an ecosystem able to meet technical needs emerging in these vertical industries. This will allow for innovative business models and services. A major challenge for the ICT industry as well as vertical industries thus lies in identifying application areas and deployment opportunities that create value for different stakeholders.

In order to address this issue, the report focuses on scenarios for MTC in 5G, summarizing ideas and views of the Wireless for Verticals -project (WIVE 2017-2019, part of the 5G Test Network Finland). The project participants have defined core areas to explore, namely (a) **ultra-reliable low latency (URLLC)**, (b) **national broadcast delivery**, and (c) **NB-IoT/massive sensors**. The report is structured as follows. First, the scenario method is briefly presented. Second, an overview of the PESTE-analysis is provided, which forms the basis for the presented scenarios. Third, a matrix covering the phenomena and value-creation logic behind the scenarios is presented. Finally, the concluding discussion identifies and summarizes key trends for MTC in 5G.

2. Notes on method – scenarios depicting the future 5G market

The report summarizes scenarios for MTC in 5G co-produced during a workshop in September 2017, in which WIVE project members participated. The aim of the workshop was to create scenarios for MTC in 5G. Scenario planning [4, 5, 6] is a widely used method in foresight and futures research and popular for addressing complex issues, in which elements of uncertainty and ambiguity are combined.

An advantage of the scenario method is its ability to offer descriptions of several possible futures, and also a description of the development from today until the time of the scenarios [7]. Rather than claiming an ability to predict the future, scenarios allow us to construct multiple stories that encompass a variety of plausible futures [8]. According to Roxburg (2009) [9] scenarios have three major advantages, namely (a) expanding your thinking, (b) uncovering inevitable or near-inevitable futures, and (c) allowing people to challenge conventional wisdom. Our knowledge is based on the past, but still our decisions are about the future. The future can be divided into different categories, such as *possible* or what might happen, *plausible* or what could happen, *probable* or what is likely to happen, and finally, *preferable* or what we want to happen, which is more concerned with value judgement than current or future knowledge. Scenarios are, in other words, possible views of the world, and often described in a narrative form (as stories), aiming at providing a context and a setting for decision-making.

The scenario method used here followed the general approach of van der Heijden et al. (2002) [4]. The researchers' role was limited to process facilitators only with little substantive knowledge input on the focal issue. The project partner organizations and their participating members were the sources of knowledge and generators of ideas. The facilitators applied ground rules such as encouraging the discussion in general and posing questions of clarification.

The workshop was held on 7th September 2017. In the beginning of the workshop the three main areas in the project were chosen as relevant themes to discuss, namely (a) URLLC, (b) national broadcast delivery, and (c) NB-IoT/massive sensors. The workshop participants were divided into three smaller groups accordingly (3-5 participants per group). Each group had a designated facilitator. The first task was to create a time line of the key events and milestones during the past ten years (2007-2017) within the field (see Appendix A for a time line overview). Then, the participants were asked to discuss the theme according to the change factors in the PESTE framework in order to identify and collect probable driving forces, signs of change and weak signals. PESTE stands for **political**, **economic**, **social**, **technological** and **environmental** drivers of change. The participants discussed each dimension separately, making notes on a large spread sheet. The participants first identified key issues and relevant factors for each dimension, and then proceeded to exploring "polar outcomes" of the driving forces, i.e., defining two very different but possible and

plausible outcomes. These polar outcomes were then considered further and explicated into scenarios.

The process of discovering and establishing scenarios relevant for the WIVE project was thus designed according to the following steps:

1. Define general scope, major themes and stakeholders.
2. Define key drivers of change and basic trends and assumptions.
3. Define polar outcomes based on identified key drivers.
4. Synthetize and summarize.

The following project workshop, held on November 23rd, 2017, focused on ecosystems, actor networks, and actor roles. Discussions in smaller groups covered URLLC and media content delivery. The conclusions from the second workshop are included in the report to build an overall picture of the key trends and drivers of MTC in 5G.

3. PESTE-analysis of URLLC, media content delivery, and NB-IoT/massive sensors

The purpose of the PESTE-analysis is to prepare for things to come in advance. The quality of the content generated in the workshop should not be assessed according to how well the scenarios *predict* the future, but according to how well they help us *prepare* for the future. The main use cases of WIVE and the identified change factors are presented next, in conjunction with scenarios for each use case area (URLLC, national broadcast delivery, and NB-IoT/massive sensors).

3.1 Ultra-reliable low latency communications

URLLC refers to services and applications that require reliable data communications from one end to another, fulfilling sub-millisecond latency. Examples of deployment areas are remote surgery, intelligent transportation (automated driving, road safety, traffic efficiency services), or industry automation. In the WIVE context key issues were identified, which have impact on the future direction and deployment of URLLC in various business contexts and vertical industries. From a political and regulatory point of view the availability of frequencies and bandwidth is of importance, as is the decision-making activities on a national level. The overall economic development impacts, as clients are ready to invest in connectivity and digitalization of operations; this also requires an acceptance of wireless as a viable, cost-efficient, and reliable solution with value-creation potential (social change factor). Nevertheless, the agreement of standards drives both technological development and deployment. Based on the identified key issues, a positive development scenario and a threatening scenario were identified (see Table 1).

Change factors	Key issues	Scenario for positive development	Threatening scenario
Political (& regulatory)	Decisions are taken at a national level, e.g., with regard to power generation Current high hype on political side: - Guarantee of investments - Availability of frequency	Fast and bold policy decisions, e.g., incentives in favor of decentralized power High expectations can be fulfilled (Political decision to guarantee investments) (Frequency is provided)	Disappointments → backlash against industry (No or unclear political decision to support investment) (Frequency is not provided)
Economic	Overall economic development Variation among actors in terms of stability of business (long vs. short contract life cycles) Attitude towards asset ownership Shift towards more simple and cheaper solutions that are more transparent to end-clients	Positive economic development enables multiple actors across ecosystem to flourish and invest. Asset ownership is profitable enough. Actors are able to respond to shift while retaining sufficient profitability	Negative economic development damages especially actors with business models exposed to short-term market fluctuations. Asset ownership is unprofitable. Responding to shift erodes actors' profitability.
Social	Acceptability of wireless as a solution Trust in autonomous machines Redistribution of work Gap between current layman perception and actual state of development	Wireless is accepted and sufficient trust is built over time Job losses in some areas balanced out by new jobs in other areas Beneficial new innovations introduced sufficiently quickly to convince public	Wireless and autonomous machines not accepted; accidents erode trust Job losses outweigh job gains; laid-off employees protest vocally Public tired of waiting, interest and propensity to invest goes down
Technological	Agreement on standards Reliable low latency communication needs to exist Trust/security also a technological issue Need to get computing nearer to the customer (on the premises) Need to have the frequency (→ link to political) More precise and flexible network planning Aggressive beam forming on higher frequencies for higher user-specific reliability	Wide agreement on standards → good interoperability, helps solve trust & security issues Needed frequency is made available Broad technological basis	Agreement is not reached → costs rise, interoperability is restricted, trust & security risks multiply Needed frequency is not made available Technological basis fractured /differentiated across verticals

Change factors	Key issues	Scenario for positive development	Threatening scenario
Environmental	Interpretation of environmental effects of 5G	5G understood in terms of green values → helps cut travelling, enables more efficient machine use [real-time asset management, optimization of how machines work], devices need to be self-powered so must be energy-efficient (→ link to technological)	5G understood in terms of health issues [this was not discussed during the workshop but emerged afterwards]
Weak signals	Startups looking for new opportunities into markets, can run any type of radio ("software radio", if frequencies available)	Startups cooperating with larger actors	Startups may generate disturbances for existing actors in the network
Megatrends	Desire for convenience, automated everyday life Overall megatrend towards sharing → network sharing Artificial intelligence (AI) and machine learning Learning from the past; on-demand networks Someone needs to offer service of transparency → service maps, "nettitutka" type of app?	Greater affordability, more payers ("clubs", e.g. Tesla owners?) On-demand networks become technically possible, gain popularity Network availability improves	Technology and regulatory solutions must be in place Lack of frequency Multiple players in one area locked into proprietary solutions Network security weakens. Billing/pricing more complicated, less transparent to individual payer

Table 1. URLLC PESTE-analysis

A positive development scenario – open and collaborative ecosystem

Power is decentralized due to innovative and rigorous policy making, advocating incentives among businesses. The ecosystem is developing as actors are able to invest in technology development and process efficiency in order to ensure continuous profitability. The deployment of wireless in different contexts creates value for companies, their employers as well as their customers. Wireless replacing wired solutions is commonly accepted and is becoming a trend, due to early adopters reporting cost-savings and reaching both sustainability goals and increased efficiency as a result of a focus on wireless and digitalization. Interoperability due to wide agreement of standards as well as access to required frequencies have facilitated the development and deployment of URLLC in vertical industries. Some work profiles are eliminated or redefined. Companies invest in training and education of employees. New work tasks and profiles are created. It is also noticeable that new ventures are forming in the area of wireless, which boosts economic development and creates job opportunities. The ecosystem embraces the new, smaller players and collaborative networks are formed within the 5G ecosystem.

A threatening scenario – unprofitable and fragmented ecosystem

Decision-making has not been in favor of technological development as the use of frequencies is still unclear for the players on the market. Investments are rarely supported, meaning that the industry is experiencing a backlash as regards furthering URLLC in vertical industries. Concurrently, vertical actors are inhibited by general economic development, making them reluctant to invest in wireless connectivity. In fact, many vertical industries do not consider wireless connectivity, remotely controlled vehicles or autonomous machines reliable enough to deploy them more widely across activities. In addition, interoperability is an unresolved issue as there is no agreement on the technological level (standards), which augment costs and risks for vertical actors. Some workers are loudly protesting, receiving the public's sympathy and support against the companies aiming at replacing workers with robotics and automated systems. The companies experience damage to their corporate brands and business in general. The public is also coping with fear towards the 5G network and its many base stations, not knowing which the health risks are. Nevertheless, some innovative individuals and teams see potential and startups are rising, which cause turbulence in the ecosystem; the existing actors are trying to cope with the stagnant market, whereas new players emerge and are regarded mainly as threatening existing positions. There is a risk of lock-in as proprietary solutions are developed.

3.2 National broadcast delivery

5G is generally thought to disrupt media consumption, as it enables faster and more reliable connectivity, better quality, and a promise to drive innovation in content. In the PESTE-analysis two scenarios were identified, namely one optimistic and one threatening.

An optimistic scenario – dynamic and open ecosystem

The optimistic scenario relies on a broad ecosystem, which is dynamic and non-exclusive. Spectrum sharing and policies enable access also to broadcasters, which eventually leads to a blurred role division in the ecosystem, opening up of new business opportunities as companies define their scope more broadly. Costs are kept at a low level. Media content services are personalized and based on social interaction. The interaction between consumer and media is instant and constant, which requires a seamless service provision and high quality as regards both connectivity and content (or applications). The consumers seek interactive and immersive experiences, such as live sports and stadium events. Content may be produced and provided using AI. The acceptance of virtual and augmented reality is widely spread. The ecosystem strives at facilitating the everyday life of consumers through offering media content through any medium possible over 5G networks, changing our media content consumption patterns, information search routines, social interaction as

well as use of media services. The companies are purposefully driving change within the media sector, allowing for advanced media consumption.

Change factors	Optimistic scenario	Threatening scenario
Political	Role for everyone in 5G spectrum (also for broadcasters) Roles become blurred, any actor can have any/several roles	Broadcast spectrum decreasing Traditional, clearly defined roles are protected and preserved
Economic	Less costs for all actors. More new business opportunities.	Fragmented business and fierce competition (Too) fast reaction times needed Business opportunities - (too) large investments required
Social	More personalized services for consumers Social interaction is at the core Fast and constant interaction with media	Privacy and cyber security Who owns and controls what? Who is responsible for what? The role of governments etc.
Technological	Seamless services and connections for end user; more/new applications Interactive experiences, e.g. sport/stadium event More/flexible capacity available for increased needs Content provider = AI	Too complex for single actors Too expensive for single actors AI becomes a threat Difficult to predict long term changes without dynamic ecosystem
Environmental	5G integral part of dynamic overall ecosystem End users benefit the most VR, AR, "screens" are everywhere	Risk of one actor overtaking entire ecosystem, e.g. connectivity provider (5G mobile operator) End users suffer the most Cost effects for end user and other stakeholders
Weak signals	Easily detected and acted upon, driving change within the entire media sector	Too many signals, changing too fast - hard to detect and act upon
Megatrends	5G has potential for changing whole ecosystem	Mobile operators gain too much control Customer behavior is difficult to predict accurately

Table 2. Media content distribution PESTE-analysis

A threatening scenario – fragmented and exclusive ecosystem

The ecosystem depicted in the threatening scenario relies on exclusivity and is fragmented. The process towards more flexibility is slow or non-existent. Spectrum scarcity prevails. Incumbents are reluctant to change traditional roles and are slow at reacting to consumer needs and technological change. Companies are highly competitive and only a few are able to invest in order to exploit or create business opportunities. Privacy and security issues are dominating discussions and causing confusion among media consumers. The regulator and decision-makers are not intervening fast enough, nor are they supporting the development of the ecosystem around 5G technology in the media sector. Each company strives as serving their own customers but find it difficult to interpret the needs of the media consumers. Media content actors view mobile operators or connectivity

providers in a position to orchestrate the ecosystem, leaving content providers in a vulnerable position and media consumers in a situation, where they suffer from high costs for connectivity.

3.3 NB-IOT/massive sensors

The generic IoT connectivity scenario involves a massive number of machine-type connections. One of the fundamental challenges of MTC in IoT is to enable data transmission from a massive number of devices in a timely and efficient manner. Two scenarios were identified as regards NB-IoT/massive sensors in the WIVE context – one carrying an optimistic viewpoint or a dream state and another depicting a threatening viewpoint or a worst-case scenario.

An optimistic scenario – socially value-creating ecosystem

In the optimistic scenario sensors are everywhere, used broadly both on the consumer market and in industries. In fact, using sensors in different areas of business and everyday life has become somewhat of a trend and regarded as "cool". The development so far is facilitated by agreements on spectrum sharing, in which multiple networks coexist in one spectrum band. As 5G connectivity is designed to accommodate a large number of devices, traditional spectrum allocation is unable to meet the rising demand. Spectrum sharing also allows for the use of under-utilized spectrums. The scenario depicts reasonable regulatory requirements on commercial services and a reasonably controlled environment for spectrum, e.g., a global common spectrum. To some extent, this enables new players to emerge and create growth. Security issues are not a major factor in the scenario, even though advancements in this area are necessary on a continuous basis. Prices for devices are held low and battery technology has experienced a significant improvement, meaning that sensors and devices do not have to be replaced recurrently. The standardization work has been successful, aiding in ensuring also interoperability across devices and providers. In general, sensors are regarded as environmentally friendly and as a sustainable choice for monitoring and surveillance; they are energy-efficient and induce less commuting to both near and offset locations to check functionality.

A threatening scenario – exclusive and fragmented ecosystem

The sensors have not been deployed on the consumer market to a significant degree; they are limited to industry use. There is spectrum scarcity due to spectrum management being fragmented and too controlled. The devices and sensors have high costs and there is a lack of developer community creating applications for the use of massive sensors and utilization of NB-IoT. Security issues have not been resolved and hacking attacks are common. Consumers, in particular, are unaware of privacy requirements, which information to share to whom and where, etc. In general, distribution of power in society is becoming unbalanced and leading to hierarchies. Sensors are used, e.g., to detect workers not efficient enough, taking too long breaks or being too stressed or tired to perform tasks,

which leads to immediate dismission. Sensors are thus in some cases used to control humans under certain conditions, rather than enabling and facilitating work.

Standardization processes are lagging behind, which leads to a fragmented ecosystem. Different standards are not interoperable nor designed to communicate with each other. Consumers experience frustration over the situation, e.g., the mobile device is not interoperable with the provider of smart lightning in the house, meaning that the consumer cannot easily operate the smart home via the mobile device. There are coverage issues that have not been resolved, involving, e.g., rural areas and basemtents in buildings. In some cases, malfunctioning sensors have caused damage or dangerous situations for humans, vehicles etc. Also, the lifespan of sensors is shorter than expected, leading to cumbersome and costly exchange operations, which require manpower.

Change factors	Optimistic scenario	Threatening scenario
Political	Allowing access to spectrum to more actors → open market through spectrum sharing Reasonable regulatory requirements on commercial services EU/global common spectrum	Fragmented, controlled, limited spectrum Not enough bandwidth
Economic	New players create growth Low prices for devices	High prices for devices Developer community missing
Social	Security issues have been solved An increased focus on cyber security	Hacking too easy Privacy, amount of sharing info Distribution of power in society uneven as the use of sensors is limited to industry
Technological	Battery technology improvement Good security Successful standardization work Interoperability across devices and providers	Intelligent transport systems as an example → interoperability issues Different standards do not communicate with each other Standardization process lagging behind
Environmental	Remote surveillance → less commuting Sensors help saving energy	Coverage issues not resolved (basements in buildings, rural areas) If sensors do not work properly it may cause damage The lifespan of sensors is shorter than expected Exchange costs related to damaged or malfunctioning sensors are high Effort and time to find malfunctioning sensors are high and require manpower
Weak signals		
Megatrends	MTC becomes a hit/trend/cool (among end-users) Leveraged and integrated throughout society	Sensors limited to industry use Niche, i.e. only relevant for big factories and industry Does not reach end-users, and does not add value to other parts of the society

Table 3. NB-IoT/massive sensors PESTE-analysis

3.4 Summarizing the scenarios for MTC in 5G

In all, six scenarios were created. The scenarios share similarities, which can be summarized in phenomena or potential processes relevant for the development of MTC in 5G. A plausible phenomenon is **fragmentation**, occurring in the threatening scenarios, and describing the prohibition of growth, ecosystem development, and subsequently value-creation. An example of a fragmented path is the threatening scenario of NB-IoT/massive sensors. Similarly, **exclusivity** describes risk of high costs, lack of interoperability, and unequal terms for both companies and customers. The threatening scenario of national broadcast delivery and URLLC are examples of exclusivity. Co-operation and collaborative constellations between different actors are described to some degree but with moderation and limited openness of the ecosystem. This phenomenon is referred to as **integration** and is visible in the positive development scenario of national broadcast delivery. A high degree of collaboration and an open ecosystem providing access also to new players that boost growth and development, on the other hand, can be referred to as **co-creation**. Co-creation as a phenomenon is common for the positive development scenarios of URLLC and NB-IoT/massive sensors. Figure 1 summarizes the underlying phenomena of the scenarios.
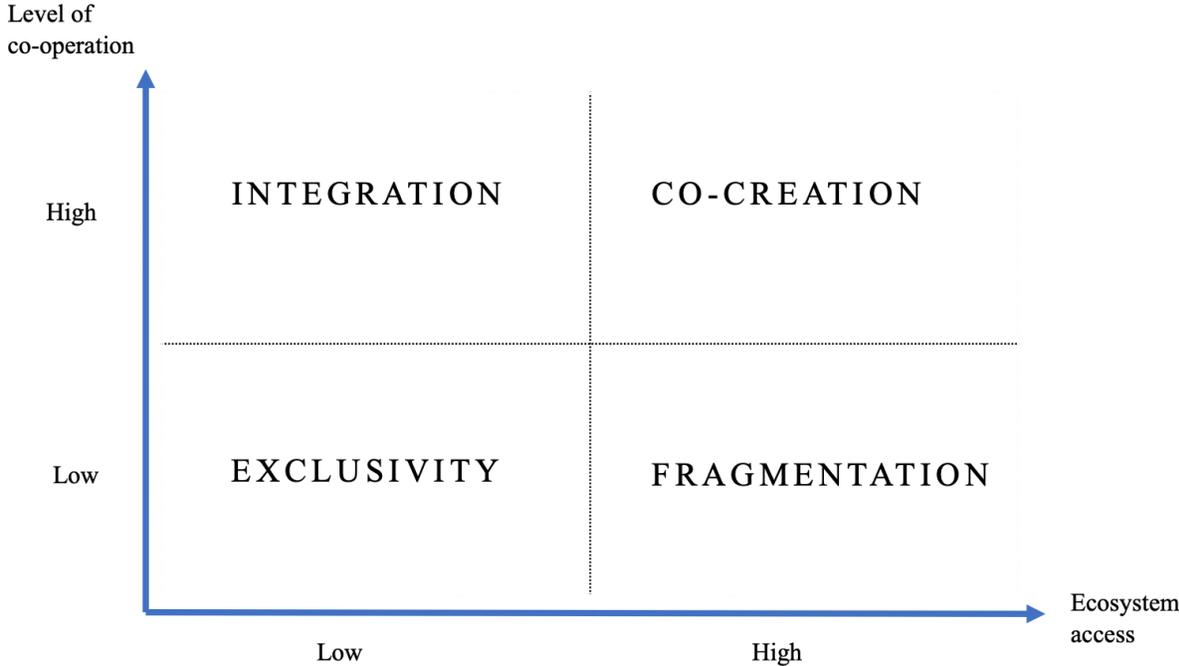

Figure 1. Scenario matrix for MTC in 5G

The identified phenomena affect the development of the ecosystem, its ability to facilitate the wider deployment of 5G and MTC in vertical industries, and the continuous growth of ecosystems. Ecosystem access is thus of importance especially for the vertical industries, in which wireless

connectivity is not defined as a core aspect but may provide innovative solutions and new opportunities for business and cost-reduction.

4. Summary – key trends for MTC in 5G

The scenarios developed for MTC in 5G, and 5G in general ideally point at an open ecosystem and inclusion and collaboration as a base for technological development. Uncertainty relates to decisions on spectrum (sharing and/or scarcity), the role of new players, security issues, as well as profitability (costs, investments and general economic development). Collaboration is key especially regarding standardization and interoperability issues in the IoT-era, but also in terms of value-creation and realizing the potential of MTC and 5G in vertical industries. The benefits of 5G and wireless connectivity as a core feature in vertical industries, in which communication or digitalization has not previously played a major role, must be made visible and transparent to potential utilizers of the 5G network. Based on the scenarios, the following key trends for MTC in 5G are identified:

- *Connected devices will bring value to society and the environment*

As already noted, the number of connected devices is expected to reach 20-30 billion in 2020 [2, 3]. IoT devices include connected cars, machines, meters, wearables, consumer electronics etc. 5G is expected to extend the range of applications for connected devices. Predictions place IoT and wireless connectivity as the drivers of indispensable consumer technology, which will bring benefits to society and the environment [10]. With 5G IoT can be fully utilized and existing structures imbued with capabilities they were not originally designed for. For instance, the collected data can be turned into insightful action in favor of the environment and society at large.

- *5G corresponding with green values and sustainability*

5G allows for remote monitoring, surveillance and control, which diminishes the need for manpower to access local and remote areas for maintenance checks. The use of sensors will play a crucial role in coping with sustainability challenges. Similarly, immersive 5G services offer a replica of the real site to its user (AR, VR) and eventually less commuting. Remote meetings using mixed reality technology correspond to the same environmentally friendly goal.

- *The potential of wireless connectivity in vertical industries will be recognized*

The characteristics of 5G allows for replacing wired solutions with wireless connectivity, which has the potential to impact various sectors such as healthcare, energy, automotive and transport, public safety, manufacturing, media and entertainment etc. Furthermore, 5G is already rooting itself in city infrastructures (smart cities), home environments (smart homes) and in agriculture (smart agriculture). Nevertheless, the benefits of 5G are not evident in all industry sectors and its value-

creating potential is yet to be discovered. Building strong ecosystems and providing use cases and demonstrations of services and applications is thus of importance. Also, collaboration is necessary among actors in vertical industries as the technological competencies of a particular vertical actor may be limited.

- *Shift from selling products to providing services*

Value-creation in the 5G and IoT-era does not necessarily mean new product or service offerings for companies. Rather, the offerings are delivered more efficiently, taking sustainability and the environment into account and produced with lower costs. Nevertheless, value can be created also by focusing less on hardware sales and more on service business surrounding hardware, a shift identifiable in the scenarios as well. Convergence of AI, IoT and robotics will enable new business models, i.e., new tools for capturing value.

- *Uncertainty in existing ecosystems as new players emerge*

New players in the 5G ecosystems are, for instance, electricity brokers within the Smartgrid or spectrum brokers, acting as enablers and gatekeepers. Other potential new entrants are application developers and virtual operators, which may act as disruptors or instigators. Incumbents and existing players, however, have the opportunity to act as champions, driving change and development by choosing a role and position in the ecosystem (e.g., platform developer, service developer) and thus entering new business areas or orchestrating existing ecosystems.

- *Increased focus on o-creation opportunities*

Co-creation opportunities depend on common goals and mutual value-creation. Products and services are personalized and perhaps even assembled in a plug'n play kind of way rather than purchasing parts from different vendors. Startups and larger players cooperate.

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Appendix A: Time line 2007-2017 – critical events