MTC Value Network for Smart City Ecosystems

Amirhossein Ghanbari, Oscar Alvarez, Jan Markendahl

Department of Communication Systems (CoS)
School of Information and Communication Technology (ICT)
KTH Royal Institute of Technology, Stockholm, Sweden
{amigha, oaa, janmar}@kth.se

***Abstract*—Looking for new markets and revenue streams, the future Smart Cities comprise a good opportunity for traditional actors of the telecommunication industry. This opportunity requires a new mindset among these actors that corresponds to re-positioning in the Smart City value chain. This means that, in order to play a role that can not be overlooked, Telecom actors should perform rather different blocks of the Smart City value chain compared to their traditional activity blocks in Mobile Telephony value chain. The Fifth Generation of mobile telecommunications technology (5G), by some actors, is then considered as the major ICT enabler for this new paradigm.**

This paper intends to highlight the role of Machine Type Communications (MTC) for enabling Smart Cities. In order to do so, we introduce the building blocks of Smart City followed by four use cases from Intelligent Transport Systems and Digital Built Environment. We use these cases as the proof of concept for defining the generic MTC activities in the context of Smart City. Eventually the paper introduces the MTC value network in the context of Smart City, based on the resources associated with the activities.

***Index Terms*—5G, Machine Type Communication, MTC, Smart City, Value Chain, Value Network.**

I. Introduction

A sustainable Smart City is often defined as an innovative city that uses Information and Communication Technology (ICT) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects [1]. The question then would be what is the role of ICT in this “smartization” process? In this sense, what is commonly required/asked from ICT is typically a “supernatural” platform that does many things, like sensing, connecting machines, collecting data, making smart decisions, and commanding back the machines. But focusing on the communication part, the role of ICT on one hand is to collect information from the machines and send them to the applications; and on the other hand it should transfer the “smartness” from applications to machines.

Considering 5G as the paradigm shift in ICT that is supposed to enable Smart Cities, this system should include many high technical requirements that are highly integrative with other industries. This integration then happens via Machine to Machine (M2M) communication solutions. The role of M2M solutions is then to sense, analyze and integrate the key information of core systems in running cities. As a result, the relevance of ICT in Smart Cities is twofold: first, how to enable a horizontalization platform for other industry verticals and second, integrating ICT infrastructure in other industries involved. In this article we focus on the latter.

Looking into the Smart City ecosystem, the network of suppliers [2] includes ICT providers and subsequently M2M providers. Considering M2M technologies as the enabling ICT tool for cities to become *smart*, then MTC would be the part where Cellular Telecommunication Networks come into the play (Figure 1). This highlights the role of Telecom actors in Smart Cities.

Different actors are trying to position themselves in the M2M market by providing variant sets of solutions, including information management, network deployment, system integration and so on [3]. As a result the M2M ecosystem includes traditional telecom actors and new actors that are also seeking for strong positions, targeting different roles. This creates a complex situation that becomes a challenge for 5G to happen.

In this context, this paper aims to provide useful insights on how actors in provisioning MTC are related to each other and ultimately identify *Who does what*. In order to clarify the topic of the paper, the following research question is introduced:

- Where is the place for the Telecom Actors in the Smart City ecosystem?

The rest of the article is structured as follows: Section II describes the methodology followed by Section III that introduces the relevance of MTC in Smart City. In this section we present four use cases which belong to two major building blocks of Smart Cities. Section IV then, based on the usecases, describes the MTC activities in this context and identifies their related resources. In section V, we introduce the MTC actors in Smart City and present a generic model for MTC value Network in Smart Cities. Section VI then concludes the article by answering the research question.

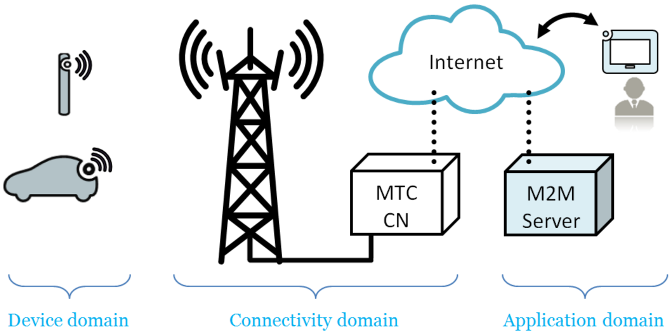

Fig. 1: Sample MTC Architecture based on ETSI M2M

II. Methodology

The methodology includes a two-stage approach. The first stage provides information on practices of M2M based "smart" solutions for Smart Cities. We use the "ARA model" [4] as a framework to analyze four use cases in the context of Smart City. The ARA model focuses on identifying M2M Activities, Resources associated with them, and Actors who perform activities based on the resources. The second stage provides an analysis with the objective to identify recurring patterns across different cases. The analysis is focused on producing insights into how MTC actors cooperate and distribute their roles, and also to identify and understand drivers and obstacles for introduction of repositioning and cooperation strategies.

For analyzing data, Analytic Induction and Grounded Theory methods will be used [5] [4]. These two are iterative methods that alternate between collections and analyses. The iterations continue until no cases dismiss the hypothesis or theory. Analytic induction stops when the hypothesis and grounded theory ends with a validated theory. Value Analysis and Empirical Data Analysis will be performed. The value analysis framework consists of conducting content analysis of collected data and studied literature in order to understand the context of the actors' decisions, intention and opinion. On the other hand, Empirical Data Analysis framework will be mainly used in order to perceive the current situation in the market and major drawback of implementing a coopetetive system.

III. MTC in Smart Cities

M2M and MTC are at times considered synonyms. M2M is defined as a set of wireless and wired communication between mechanical or electric devices or the communication between remote machines and central management applications [2]. In a broader scope, M2M includes all the information and communication technologies able to measure, deliver, process and react upon information in an autonomous fashion. Since MTC is the working terminology by 3GPP, it is regarded as the segment of M2M carried over cellular networks [2]. MTC in Smart Cities then refers to the exchange of information over cellular networks

Fig. 2: Sample Smart City value chain

between autonomous devices in control and monitoring applications without human intervention [6].

An oversimplified Smart City value chain is illustrated in Figure 2. This chain mainly corresponds to ICT enabled Smart City solutions where the role of M2M and MTC is quite highlighted. Since it is impossible to map all performed M2M activities in this chain, we rather dig deeper into Smart City based M2M/MTC activities, find out related resources, and eventually identify the value networks for MTC in Smart Cities.

Trying to map MTC value network into the Smart City ecosystem, first we define five different building blocks for the Smart City concept [7]:

1) Economic, Social & Privacy Implications
2) Developing E-Government
3) Health, Inclusion and Assisted Living
4) Intelligent Transportation Systems
5) Digital Built Environment

This way it is possible to navigate among various MTC enabled use cases in Smart Cities and identify the main activities being performed.

In this paper we chose two use cases from Intelligent Transportation Systems, and two from Digital Urban Environment. In this section each use case is described and major MTC activities performed are identified.

A. Intelligent Transportation Systems

ITS definition: Intelligent Transportation Systems (ITS) can be defined as the application of advanced information and communications technology to surface transportation in order to achieve enhanced safety and mobility while reducing the environmental impact of transportation.

- Connected Vehicle Services

In this paper we will focus on one specific service within ITS; Connected Vehicle Services. Connected Vehicle Services is commonly defined as the set of services based on ICT and provided during the driving experience. This category includes a number of services including: Remote diagnostics, eCall (Emergency call), Mediaroom-Infotainment or Insurance billing

In the context of Connected Vehicles Services provisioning, a number of activities have been identified. The main activities identified are: Connectivity provision, SIM card provision, Platform management and provision,0 and user management and relationship. Considering these main activities, we can observe different setups regarding collaboration between actors providing these services. In order to illustrate these different setups we will briefly describe two already existing services: Volvo Connected Car, and Tesla Motors.

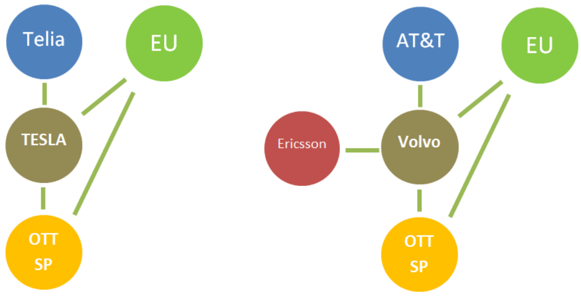

Fig. 3: Tesla VS. Volvo

Volvo Connected Car

Volvo is currently offering a service named Volvo Sensus connect, which basically is a commercial offering embedded in Volvo vehicles that allows the user to obtain services related to and enabled by ICT. This concrete commercial offering has been commercialized in the US. The setup for the Volvo Sensus connect has been aiming to enhance collaboration between a number of actors, allowing each actor to focus on its field of expertise. The activities are distributed as follows: AT&T is taking care of connectivity and SIM card provisioning, Ericsson is in charge of monitoring, management and automating connected devices deployment, and Volvo is providing end-user management. On top of the Volvo Sensus platform, Over The Top (OTT) providers can offer their own services. An example of these services are media streaming services like Spotify or Netflix. The value network is shown in figure 3 - Right.

Tesla Motors

Being one of the most innovative car manufacturers in the world and aiming to disrupt how the car industry works, Tesla Motors has a slightly different approach regarding Connected Vehicle services. Tesla Connected services are taking this concept one step further, fostering ideas like software updates enabling autonomous driving in passenger car. The concrete case we are considering is the service offering for the Nordic region.

In addition to be a cutting-edge car manufacturer, Tesla has selected a different approach when developing Connected Vehicle services. Tesla's strategy has been integrating and controlling all possible activities vertically. Therefore Tesla concentrates activities on end-user management and in monitoring, managing and automating connected devices deployment; leaving connectivity provision and SIM card provision in hands of Telia. In a similar way as the previous use case, OTT providers are enabled to provide their services on top of Tesla platform. The setup for the Tesla motors use case is shown in Figure 3 - Left.

B. Digital Built Environment

Broadly defined, the term Built Environment refers to the human-made space in which people live, work, and recreate on a day to day basis. It provides the setting for human activity, ranging in scale from buildings and parks or green space to neighborhoods and cities that can often include their supporting infrastructure, such as water supply or energy networks. Closely connected with energy efficiency in built environment, this building block also includes Energy Efficiency and Smart Grids.

- Smart Grids:

Smart Energy or Smart Grid is one the most important aspects of the Smart City concept, enabling responsible management and operation of energy networks in cities. The integration of communication infrastructure, mathematical modeling techniques and simulation techniques is a powerful tool in this context. The concept of Smart Grid also includes the idea of "prosumers" that is the idea of integrating decentralized energy generation in nowadays' centralized energy grids, enabling households to produce their own energy and sell/buy from the energy grid depending on their consumption. This also holds for the potential storage capacity for both electrical and thermal energy within energy networks, which can be achieved by intelligent demand side management [8]. A major requirement in Smart Cities in this regard is to leverage energy consumption between different producers and consumers that directly translates into reducing the pollution generated by today's cities and the emerging mega cities [9].

Consorcio Energético Punta Cana Macao (CEPM)

The Dominican Republic has been facing a number of energy challenges in recent years, related to substandard service, inadequate capacity and frequent black outs. These challenges are also connected to its increasing importance as a tourism destination. In order to tackle these challenges the sector has gone through a process of liberalization, where companies like CEPM have provided innovative energy solutions. One of the services provided by CEPM is: reliable Advanced Metering Infrastructure (AMI) solution which would withstand rigorous power fluctuations and provide remote monitoring and management of its electrical grid.

Together with General Electrics Digital Energy and Ingenu, CEPM has enabled over 24,000 smart meters to speed power restoration and increase reliability of services to CEPM's customers. The solution offered robust, two-way communication between CEPM and its end users, providing accurate reporting and monitoring of energy operation and consumption. Due to its limited infrastructure investment, CEPM was able to deliver energy services cost-effectively, resulting in significant savings to its customers. In this setup Ingenu plays the role of connectivity provider and GE Digital Energy provides different devices needed i.e. smart meters.

The underlying communication technology used to enable these services is Random Phase Multiple Access

(RPMA), a low-power wide-area channel access method used exclusively for M2M communications.

- Waste Management:

Smart Waste is part of the smart city concept, focusing on municipal solid waste. Navigant Research defines Smart Waste as the integration of advanced technologies into a strategic solution that enhances sustainability, resource efficiency, and economic benefits. The use of these technologies result in more integrated waste management offerings that go beyond the traditional use of labor, diesel trucks, and open pits to discard waste. Waste management is getting smarter as new technologies are implemented in different areas. Here we focus on applications of Smart Waste making use of M2M technologies.

Early experiments with M2M type solutions in waste management industry involve a scale for measuring the mass of waste in the garbage truck - or similar - before emptying the load at the waste station. The waste management system is seeing rapid changes. The change from landfills to incineration is shaping the structure of the system from municipal into larger areal networks. This will have an effect on how waste management is organized, what technology is used and how business is done. Today there is, however, limited evidence of new M2M based solutions being developed/implemented [10].

Bigbelly Solar Inc.

BigBelly Solar Inc. provides solutions for the management of waste and recycling. It offers solar intelligent waste collection systems to manage the process of collecting solid waste, as well as solar compactors, and companion recycling bins and kiosks. CLEAN™ by BigBelly is a wireless network for monitoring and management software that provides real-time and historical data to managers/workers to plan waste collection routes and pickups; Connect™ is a turnkey smart waste and recycling system that ensures customer engagement and satisfaction. It serves municipalities, cities and towns, college and university campuses, parklands and beaches, government and military installations, and institutional customers [11].

An elaboration on how Bigbelly works as a system in the US is as follows:

- Compactors are upgraded with wireless hardware.
- CLEAN sends data through standard SMS format to its online server (requires adequate cellular phone signal, currently provided by AT&T).
- Operational data becomes real-time.
- Collecting is monitored to eliminate unnecessary pickups and free up workers from on-street status checks.

In order to provide these services the activities are distributed as follows: AT&T providing connectivity and SIM card provisioning, Ericsson in charge of monitoring, management and automation of connected devices deployed and Bigbelly handling device provision and software service provision (visualization and management tools for cities). This setup is shown in Figure 4 - Left.

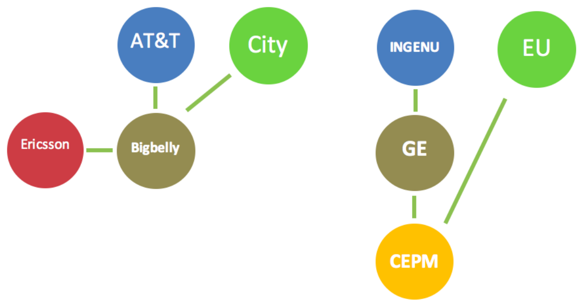

Fig. 4: Bigbelly vs. CEPM

IV. MTC Activities & Resources

In this section we introduce a set of generic activities associated with M2M solutions offered in the Smart City context. Afterwards, we discuss the “M2M resources” associated with these activities. These activities are based on studied usecases. The main idea is that these activities cover all major MTC activities performed in such setups. The constructed model for these roles has then the ability to map all different possible M2M solutions into it. This way we create a framework (Figure 5) for analyzing the activities and identify which activity is being performed by its corresponding actor, based on the possessed resources. The generic activities related to M2M and subsequently MTC are as follow:

1) Provision MTC network
2) Provision M2M device
3) Provide Connected Device Platform (CDP)
4) Provide Application Enablement Platform (AEP)
5) Provision M2M service
6) Manage Customer relation

This framework first categorizes the activities into three domains; a) Service, b) Connectivity, and c) Device. Each domain here directly translates to aforementioned Figure 1. Since two major activities correspond to “M2M Platforms” first we discuss what is meant by M2M Platform.

A. M2M Platforms

An important part of the M2M ecosystem comprises the platforms, which includes CDP and AEP [12]. Correspondingly, provisioning these two platforms is considered as major roles in the value chain.

*1) **CDP: Connected Device Platform**:* CDPs are software elements that facilitate deployment and management of connected devices for M2M applications over cellular networks. CDP allows devices to connect to Cloud and should be compatible with different software platforms (e.g. Java, Android, etc.) in order to include as many devices as possible. CDP is usually a service portal that covers billing and policy control, bearer service, service ordering and subscription, and SIM-card management.

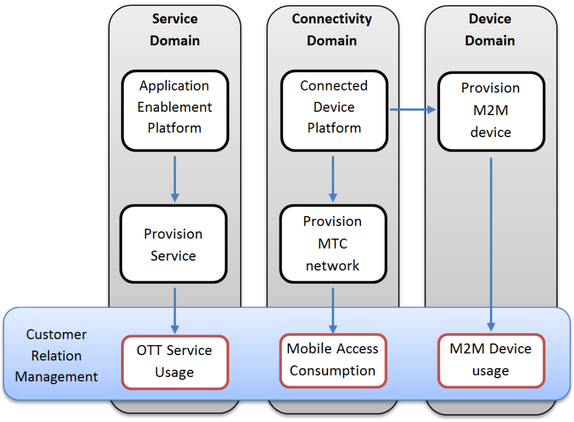

Fig. 5: Relation among MTC activities in Smart City

*2) **AEP: Application Enablement Platform**:* AEPs are designed to provide the core features for multiple M2M applications. They ease the data extraction and normalization activities, so M2M applications and enterprise systems can easily consume machine data. AEP also includes developing tools, enabling developers to create new M2M applications and services.

B. MTC Resources

When it comes to the role of ICT in Smart City, a set of resources enable the MTC actors to participate and perform different sets of activities. The importance of these resources lies in the fact that missing these resources disables an actor to perform a specific activity. By a resource it is meant anything which could be thought of as a strength or weakness of a given firm. More formally, a firm's resources at a given time could be defined as those (tangible and intangible) assets which are tied semi permanently to the firm [13]. Examples of resources are: brand names, in-house knowledge of technology, employment of skilled personnel, trade contacts, machinery, efficient procedures, capital, etc. [14]. Defined pedagogically, resources can be categorized into six major categories [15]; financial, physical, human, technological, organizational, and reputation.

1) MTC Infrastructure:

When providing communication services, the need of communication networks appear naturally. Within communication networks two different types can be identified: Core Network and Cellular Access Network. The core network is the central part of the communications network, facilitating the connection between different sub-networks. The cellular access network (also known as radio access network) is the interface between the end-user and the core network, basically using wireless technology. The MTC Infrastructure is traditionally owned by a MNO, since it is the same as the mobile telephony cellular infrastructure. In the introduced cases, we also have seen emerging actors who are specialized MTC Network Operators who own their own infrastructure.

2) Application Enablement Platform:

A software platform that acts as a common ground for development of services and applications on top of the physical infrastructure. AEP can also provide an open environment for collaboration between industries and support innovation in the context of smart sustainable cities.

3) M2M Data:

One very important resource when introducing Smart City and M2M services is the data originated for the End Users in the city. Data can be defined as all the information obtained from the usage of a number of services in the city environment; communication, Internet services, transportation services, energy consumption, car-sharing, parking, logistics, etc. The added value in Smart City comes from obtaining a big amount of data, processing it and extract useful information for decision making.

4) End-user:

The final goal of these services is to provide useful information and services to the End User, whom will be able to make better decisions on how to interact with the city. In the provisioning of services, a number of actors are involved and it is not feasible that the End User has relation with all of them. The usual relations with the user are with either the service provider or the M2M device provider (in some cases). In this sense, different stakeholders are sharing this resource event though not all of them have direct relation with it. It could be concluded that customers are the economic resource which are subject to be cultivated by the producer [10] [16].

V. MTC Actors in Smart City

Since MTC corresponds to utilizing cellular technologies as the access network for M2M services, traditional actors in the mobile telephony value network are viably active here as well. Mobile Network Operators (MNO) as the typical carriers that control and operate cellular networks are capable of operating the MTC network. Telecom Equipment Vendors (TEV) as the traditional manufacturers of the telecommunication equipment, typically provision the technical procurement for the MNOs. But, according to the shift in the value chain, the TEVs have recently participated in different roles that historically have been assigned or taken care of by others; such as MNOs. Even roles like provisioning new demands such as Connectivity Platforms are now being provisioned by some TEVs.

Figure 6 illustrates the major business relations for MNOs and TEVs in the Mobile Telephony case. A Managed Service Provider (MSP) is typically an entity that offers end-to-end solutions; such as network operation management in this case. Based on proposed MTC Activities, Resources, Actors, and most importantly the framework introduced in figure 5, five major groups of actors can be identified in the MTC value network. Besides the End

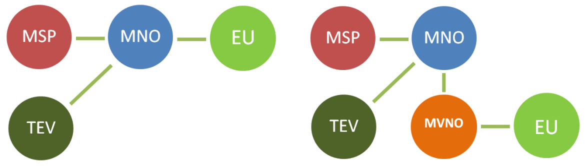

Fig. 6: Traditional Value Networks of Mobile Telephony

Users (EU), these actors are the most likely entities who can own either of the resources mentioned earlier in order to perform MTC activities. These actors are: a) End User, b) Service Provider, c) MTC network operator, d) Device Provider, and e) MSP.

According to the cases studied earlier, we showed that rather than traditional Telecom actors (i.e. MNOs and TEVs), there are other actors who might be even more competent in provisioning any of the activity blocks of MTC. For instance, a specialized M2M cellular network operator (MTC network operator) can be considered a better option to provision MTC network. Service Providers of M2M solutions also in some cases take control of the entire value chain by handling the EU; a previously dominant position for MNOs in Mobile Telephony (Figure 7 - Right). On the other hand, TEVs and MNOs have shown interest in different activity blocks. Another major actor in this setup is then an entity which performs the role of *provisioning CDP*. It can be seen that this activity is mainly performed by the firms who have a history in provisioning connectivity in the sense of automating connected devices. Some examples can be either outsourcees of network operations for MNOs (MSPs) or the ones which have been active in automation of industry verticals (e.g. General Electrics, Siemens, etc.).

VI. Conclusion

Figure 7 illustrates two major setups of the MTC value network in Smart Cities. According to our description of the MTC activities, telecom actors are capable of performing multitude of activities in MTC value network in Smart Cities, but based on their resources. This directly concerns the competences they can acquire and/or have. Considering "connectivity domain" as their main playground, provisioning AEP is also an activity being performed by some TEVs in recent years. This way, telecom actors mainly correspond to either MTC network operators and/or MSPs (supporting role for provisioning AEP, CDP). An interesting observation here is the absence of MNOs on "owning" the End User.

In terms of resources, it is important to consider that the actor who owns the end user -as a resource- is the most likely to have control over the value network. This value network should be considered when developing/deploying 5G systems, as it should allow collaborative setups to happen. Finally, it could be concluded that 5G and ICT will play the enabler-support role for making Smart Cities happen and not much more; so would the telecom actors.

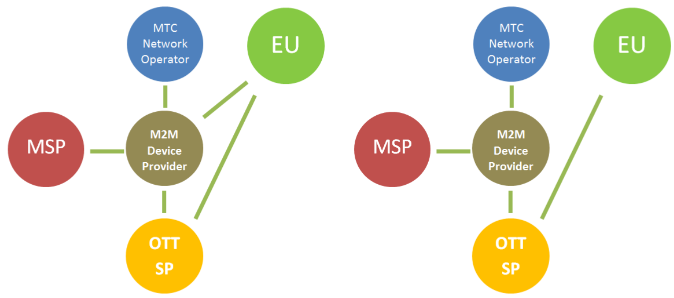

Fig. 7: Two major setups of MTC Value Network

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