Market, Standardization, and Regulation Development in Machine-to-Machine Communications

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Abstract: **The evolution of M2M (Machine-to-Machine) systems is gaining momentum in recent years. Ubiquitous wireless and wireline connectivity, and declining prices of communication modules are the main drivers of such a positive trend. While the potential market opportunities for M2M are immense, there are still many open issues: global market and standards fragmentation, privacy and security, numerous technological challenges (e.g. device management, network scalability, device authentication on the provider's network, charging rules), as well as incompatible and incomplete regulation policies in different countries. In this paper we give an overview of the current state of the M2M market and standardization efforts in the complex and diverse M2M ecosystem. Standardization bodies (e.g. ETSI, 3GPP, ITU-T) have become more active in the standardization of M2M systems because of its growing market demands. This paper also gives an insight into the regulation processes, with the focus on specific ongoing projects in the USA and in the European Union. Finally, it shows how EU directives are transposed into Croatian legislation and presents one of HAKOM's projects proposed in cooperation with academia, industry, and network operators.**

1. INTRODUCTION

The M2M abbreviation can have different meanings: Machine-to-Machine, Mobile-to-Machine, Machine-to-Man, etc. In this paper, M2M stands for "Machine-to-Machine". Sometimes in literature, a term MTC (*Machine Type Communications*) is also used in the same context as M2M. Another abbreviation that is very often tightly coupled with M2M is IoT (*Internet of Things*) [1] [2]. Although M2M and IoT largely overlap, there are areas that are specific to each domain, and neither domain is categorized as a subset of the other [3]. According to [4], "things" and devices in the IoT context are usually not capable of actively participating in M2M applications since they do not possess necessary communications abilities. For example, objects in supermarkets marked with RFID (*Radio-Frequency Identification*) tags are part of the IoT domain, but when they are read by an M2M scanner they also become a part of an M2M domain. However, it is quite likely that with the advance of each domain and their abilities to integrate more objects within the existing systems, boundaries between M2M and IoT domains will become further blurred.

From regulatory point of view M2M is commonly between National Regulatory Authorities understood as communications between machines with no or little human intervention. Main regulatory issues, especially for small countries, represent number portability, lawful interception, personal data protection (usually placed in clouds), and open M2M platforms.

An M2M concept is neither revolutionary nor completely new since it has been present in various forms over the years. Different applications of M2M concept exist in various areas of our lives, either as ideas and prototypes that still need to be implemented, or as full-fledged products ready for mass deployment. However, what is today different than just 10 years ago is the potential for mass adoption across different industries, fuelled by a number of converging factors such as ubiquitous wireless and wireline connectivity, and declining prices of communication modules. The M2M sector has been awakened by the opportunity to bring connectivity and intelligence to machines, sensors, and other devices. However, there are still significant barriers for its growth (e.g. fragmentation of solutions, network misalignment, security,

privacy, service capabilities, testing, and certification of devices) that need to be overcome before the M2M market can reach its full potential. Therefore, the next logical step is the standardization of the M2M domain. It needs to be incorporated into all levels of M2M systems: from standards-based architectures, platforms, and frameworks that allow the development of specific applications, to creating new standards required to address M2M communication at the global system level. Reaching such a consensus on a global level requires significant effort from various standardization agencies and a number of credible industrial partners. Apart from the standardization efforts, certain regulatory agendas that are tightly coupled with specific M2M solutions (such as those in healthcare, sustainable energy, and logistics) also add additional push to the M2M market growth. Today public authorities and governments are aware that there are challenges in the M2M ecosystem that cannot be addressed by the industry alone. Therefore, they have started to play an active role both in stimulating the investment into M2M applications by setting up ambitious incentive programs and in policy-making. The goal is to ensure a long-term trust in the viability of the M2M industry [4]. According to the Mobile Market Development, an annual growth of 25% of mobile M2M device delivery is expected by 2015 [5], while Ericsson's prediction is that by 2020 50 billion devices will be deployed worldwide [6]. M2M systems will not just include billions of devices, but they will also offer MNOs (*Mobile Network Operator*) the ability to extend their businesses, provide new types of services, and bring billions of dollars of new revenue streams.

This paper is organized as follows. In Section 2, we give an overview of the current state of the M2M market that has influence on M2M standardization in a sense that different verticals (e.g. eHealth, Smart Grid) are being standardized. Section 3 brings prominent standardization efforts in the M2M domain with focus on several use cases representing different M2M market verticals. Section 4 shows examples of M2M regulatory projects developed in the USA and in the European Union. Also, this section explains how EU directives are transposed into Croatian regulatory legislation. Finally, Section 5 concludes the paper and .

2. STATE OF THE M2M MARKET

Today, privately-owned companies and governments are the main M2M market drivers. Nevertheless, their motives and requests are quite the opposite. The business sector is driven by the idea of reduced expenditures and increased efficiency, while governments seek solutions that provide sustainability and socioeconomic security. Specific M2M solutions are capable of addressing all of the aforementioned requirements.

The M2M market is still quite fragmented and vertically oriented. Just a few years ago the development of different applications that are today considered as a part of the M2M domain was independent. M2M applications and technological diversity offer new business concepts in numerous market verticals, but also make business models and the associated value chain more complex. Interoperability between solutions is still limited, therefore standards that are in development should focus on end-to-end connectivity and on bringing cohesion to the fragmented M2M market.

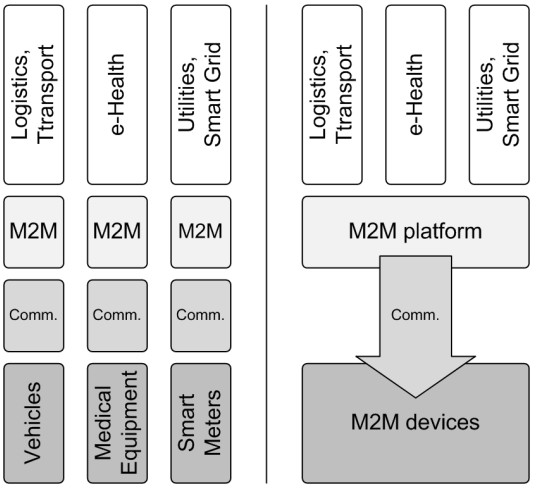

Figure 1 – Horizontal M2M platform approach

Market consolidation and its associated revenue expansion are only possible with the development and adoption of technical norms and acquiring a new, horizontal perspective (see Figure 1). This implies coherent framework valid across a large variety of technologies, architectures, and processes. The development of open M2M platforms, which are capable of extending and reusing specific vertical modules should be in the focus of the current M2M market development. Those open M2M platforms should also serve as interfaces between different vertical modules on one side, and different M2M devices and communication modules on the other side. In order to achieve such M2M market aggregation, it is necessary to define capabilities that can be reused across various applications. This should, if done properly, allow further development unbiased of the various aspects of M2M applications, and direct focus primarily on business logic.

The horizontal approach has encouraged MNOs to acquire a more active role in the new M2M ecosystem. They are not only providing network access, but are also actively participating in the development of new M2M platforms or entering into strategic partnerships with their developers [7]. These changes are not the only ones in the M2M value chain. The traditional value chain is comprised of several roles:

- hardware suppliers: provide devices with built-in M2M modules that are capable of communicating with specific vertical solutions;

- wireless/wireline network access operators: enable communication between M2M devices and a vertical solution through their network infrastructure;
- vertical application providers: tightly coupled with a specific vertical application (e.g. eHealth, transportation, smart metering);
- users: represent consumers of the deployed M2M systems;

Each of the mentioned roles is rather self-explanatory. The new, transformed value chain has defined several new roles. Although the number of stakeholders has increased, their unit revenues are experiencing significant growth. Horizontal platforms and network optimizations for M2M communication are the main reasons for such a trend. An approach based on reusing carefully designed building blocks does not require the development of a completely new system, rather it focuses on upgrading the existing applications with new features. This brings additional flexibility to platform providers who are now not tied with specific applications, and are able to support the development of a wide array of M2M solutions. The separation of users and subscribers is also strengthening the income because now it is possible to conclude an agreement with various users regardless of their subscription status. Transformed value chain extends the roles of the traditional value chain:

- SIM card providers: responsible for SIM card distribution;
- hardware suppliers: provide devices with built-in M2M modules that are capable of communicating with specific vertical solutions;
- wireless/wireline network access operators: enable communication between M2M devices and a vertical solution through their network infrastructure;
- M2M platform providers: support the establishment of M2M communication between various network elements, provide basic service capabilities for M2M device management, and interfaces for application programming;
- vertical application providers: tightly coupled with a specific vertical application (e.g. eHealth, transportation, smart metering);
- support providers: support specific services used in vertical applications;
- subscribers;
- users;

There are many different M2M application areas, and as many possible their official and unofficial divisions. However, certain patterns can be observed. Earlier M2M deployments are based on existing network technologies, address predominantly B2B (*Business-to-Business*) applications, and are usually in the area of telemetry and fleet management. As technologies and associated standards became more mature, M2M solutions started to deal with more demanding issues, entered the area of more complex B2C (*Business-to-Consumer*) relationships and more diverse applications (e.g. Smart Grid, eHealth, Smart City, and Building Automation). Moreover, engineers have become aware of network misalignment for specific M2M demands and the necessity of their optimization for achieving truly networked environment with seamless and automated flow of data and services.

3. STANDARDIZATION

Current networks are optimized for H2H (*Human-to-Human*) interactions, and communication in such systems can greatly differ from M2M traffic patterns. It is important that communication technologies evolve and develop competitive capabilities to efficiently support M2M solutions in a universal and collaborative manner [8].

M2M applications unify efforts from many different industries and technologies, and frequently require custom hardware or software components. This brings additional complexity to the implicitly complex systems, increases development and operational costs, and prolongs time-to-market milestones. Standardization is the next logical step, and currently there are several significant efforts around the world that are trying to cope with the mentioned issues [9]. As of today, many standards forums and organizations, such as ETSI (*European Telecommunications Standards Institute*), IEEE (*Institute of Electrical and Electronics Engineers*), and 3GPP (*Third-Generation Partnership Project*), have actively engaged in M2M standards development [10].

ETSI produces globally applicable standards for ICT (*Information and Communications Technology*). In 2008, with the aim to provide an end-to-end view of M2M standardization, it has established M2M TC (*Machine-to-Machine Technical Committee*) [11]. Most of their standards regarding M2M analyze different use cases (see Table 1). The objective is to cover enough use cases to ensure that all of the important requirements of M2M systems are captured so that the associated architecture work provides the foundation for a potentially large number of M2M applications. They have also put significant effort into defining basic M2M terminology [12], as well as its service [13] and functional requirements [14].

Table 1 – ETSI use cases

Standard	Area
TS 102 691	Smart Metering
TS 102 732	eHealth
TS 102 857	Connected Consumer
TS 102 897	City Automation
TS 102 898	Automotive

Considering the positive impulse of M2M standardization activities in recent years, ETSI is currently joining 6 other standardization organizations from around the world (ARIB (*Association of Radio Industries and Businesses*) in Japan, ATIS (*Alliance for Telecommunications Industry Solutions*) and TIA (*Telecommunications Industry Association*) in the USA, CCSA (*China Communications Standards Association*) in China, and TTA (*Telecommunications Technology Association*) in South Korea) to form a global M2M initiative: OneM2M [15]. This global partnership is trying to mimic the model of its predecessor (3GGP), and is encouraging the development of a single global standard for M2M communication.

Except for specific standardization bodies like the aforementioned, ITU-T (*International Telecommunication Union – Telecommunication Standardization Sector*) has also recognized M2M as a driver for electronic communications development. Therefore, the ITU-T launched a focus group on the Machine-to-Machine service layer (FG M2M) [16] which will study activities currently undertaken by various organizations working on standardization in the field of the M2M service layer specifications that are trying to identify key requirements for a common M2M service layer. The goal of this group is to identify a minimum set of common requirements of vertical markets. Initial focus is set on health care and application programming interfaces (APIs), and protocols for eHealth applications and services. Three sub working groups are formed covering each aspect of the group's objectives: "M2M uses cases and service models", "M2M service layer requirements" and "M2M APIs and protocols". Special interest of ITU-T is one of M2M markets – the smart grid. Although this group is not directly bound by M2M services, ITU-T has established focus group on smart grid with main objective to identify potential impacts on standards development.

3.1 Smart Grid and Smart Metering

Smart grid and smart metering use cases are handled by the ETSI under two technical reports [17][18]. The published work is strongly related to the mandate of the European Commission on smart metering [19].

Both use cases deal with the improvement of energy use efficiency, thereby encouraging the reduction of greenhouse-gas emissions and energy consumption in general. Smart meters provide customers, energy distributors, and suppliers with accurate and easily accessed information on the amount of consumed utilities (electricity, gas, water, heat). They allow remote meter readings which eliminate the need for human employees to visit remote locations in order to acquire measured values. Such an approach also eliminates the need for estimated bills because meter readings supply the user with accurate and real-time data, which further allows smarter ways of controlling and organizing utility consumption.

3.2 eHealth

The document [20] collects use case descriptions for eHealth applications in the context of M2M systems. Proposed applications enable the RPM (*Remote Patient Monitoring*) and record fitness information, provide elderly with the ability to age independently, and support disease management.

RPM enables healthcare personnel to remotely monitor various patient health-related parameters (e.g. blood pressure, body temperature, pulse). It allows physicians to use sensors connected to a network to collect and analyze patient's health information, and eventually treat him/her before the condition becomes more acute. This way unnecessary trips to hospitals can be avoided, patients are given qualitative and immediate treatment, and healthcare system is able to save money by using smart decision making.

Disease management is a process of remote monitoring of patient illnesses such as diabetes or cardiac arrhythmia. It supports an alarm function which is triggered once the measured patient data indicates a critical health condition and deserves physician's attention.

Certain M2M eHealth applications are used to enable the elderly as independent life as possible. This is achieved by monitoring their vital signs, tracking their movement and activities, and ensuring that they are regularly taking prescribed medications.

M2M applications can be used to monitor and record fitness indicators (e.g. heart and breathing rates, energy consumption, rate of fat burn) during training sessions. Acquired data, such as the frequency and duration of workouts, running distances or calorie consumption, can be logged and uploaded to a server for further analysis, establishing the user's health profile, or planning new workout programmes.

3.3 Automotive

Automotive M2M applications refer to automated assistance during accidents, as well as to tracking, location-based, and various interactive car services [21].

Assistance during vehicle accidents is implemented as an emergency automated call service. Currently, intensive standardization and regulatory efforts are conducted around Europe in order to develop and implement a universal eCall service. This work is inspired by the early examples of such services deployed by some of the largest automobile companies: General Motors OnStar service in the USA and Peugeot, BMW, and Volvo in Europe.

Another segment of automotive applications is more diverse and includes tracking of stolen cars, various location-based services, fleet management, and "pay-as-you-drive" car insurance service. Interactive automotive M2M segment encompasses various commercial and entertainment services (e.g. on-demand video, interactive gaming, and broadband Internet access).

3.4 City Automation

In the context of the present document, M2M city automation applications encompass use cases involving the traffic control, street light control or public transportation industries where the involved M2M communication modules may be embedded into a city infrastructure or transportation vehicles [22].

Road traffic within cities depends on numerous criteria. However, it is a major problem in bigger cities at least once or twice a day (e.g. traffic jams, accidents, construction work). Situation can be improved with a traffic flow management system which integrates traffic flow sensors, information displays, and dynamically changeable traffic signs, and can react to continuously changing the traffic situation and manage traffic more efficiently, encouraging the reduction of fuel consumption, air pollution, congestions, and the time spent in traffic.

Another major issue in cities is the public transport system (e.g. busses, subways, street cars, trains) efficiency. The idea is to provide passengers with fresh information on availability of public transport vehicles, which allows them to plan their daily migrations and select alternative routes in case of traffic jams.

The third important segment of the current city automation use case is the regulation of street lights. It is obvious they do not need to shine always the same, and smart management of their intensity helps reduce the city energy consumption and indirectly the CO_2 emission.

3.5 Connected Consumer

Technical report [23] regarding the connected consumer use cases is still in the early draft phase, and therefore it has not developed any applications so far. However, it is important to mention a growing trend of M2M solution implementations into consumer electronics (e.g. e-Readers, digital picture frames).

4. REGULATION

Regulation plays an important role in M2M market development. It provides rules for evolution of M2M standards that are going to be applied within a specific country or a region. Examples are the US Energy Independence and Security Act [24], the European Commission mandates for smart metering [19], and the deployment of smart grid solutions [25].

Achieving a certain compliance level in the use of M2M technology and equipment on a regional or even global level is a necessity for the future development and growth of the M2M market. There are numerous examples of technologies that have motivated standardization and later regulation. However, there are also standards that have been specifically developed to address a prevalent need for a regulatory incentive, such as the eCall project [26].

4.1 Regulation in the USA

M2M regulation in the USA has been mostly focused on smart grid deployments. In 2007, EISA (*US Energy Independence and Security Act*) was issued [4]. It assigned the primary responsibility to coordinate development of a framework to achieve interoperability of smart grid devices and systems to NIST (*National Institute of Standards and Technology*). Two years later, ARRA (*American Recovery and Reinvestment Act*) accelerated the development of smart grid technologies [27], investing $4.5 billion in electricity delivery and energy reliability activities to modernize the electric grid, and implement demonstration and deployment programmes. NIST was awarded part of these funds ($10 million) transferred from the Department of Energy to help develop a comprehensive framework for a nationwide, fully interoperable smart grid for the US electric power system. As a result of this financial incentive, NIST in 2010 developed the Smart Grid Framework 1.0 [28] which provides a conceptual reference model for smart grids and places particular focus on interoperability. Interoperability (with the creation of the *NIST Smart Grid Interoperability Panel*) is seen as an essential means to protect the smart grid investments. The framework initially identifies domains, actors, and interfaces, as well as 17 PAPs (*Priority Action Plans*) whose aim is to evaluate the standards gaps for which resolution is most urgently needed to support one or more of the smart grid priority areas. The final 2.0 version of the framework, which adds 22 additional standards, specifications, and guidelines to the 75 standards NIST recommended in the 1.0 version, was published in February 2012 [29]. It expanded the view of the architecture of the smart grid networks, invested additional efforts to enforcing security, including the development of a Risk Management Framework to provide guidance on security practices, and introduced a new framework for testing the conformity of devices and systems to be connected to the smart grid.

4.2 Regulation in the European Union

The eCall 3GPP standards [30] and [31] have been developed to bring rapid assistance to motorists involved in car accidents. The European Commission has mandated its implementation anywhere in the European Union by 2014. The project is also supported by the ACEA (*Association des Constructeurs Européens d'Automobiles*), European Automobile Manufacturers Association, and ERTICO, Europe's ITS (*Intelligent Transportation System*) organization. The idea is based on a proprietary SMS-based solutions developed by car manufacturers such as BMW, Peugeot, and Volvo. It aims to install a "black-box type" device in all vehicles that will automatically dial 112 in the event of a serious road accident, and enable the reliable

transmission of accident data from an In-Vehicle System to the Public Safety Answering Point via the voice channel of cellular and Public Switched Telephone networks, as well as Global Positioning System coordinates to local emergency agencies [4].

Another important European regulation project involving M2M technology is in the area of smart energy. In 2008 EU Heads of State and Government set a series of demanding climate and energy targets to be met by 2020, known as the "20-20-20" targets: 20% reduction in emissions, 20% renewable energies, and 20% improvement in energy efficiency [32]. As part of this ambitious plan, smart metering is gaining importance in recent years and is rapidly becoming regulated across various EU States. Three European Standard Organizations (ESOs) – ETSI, CEN (*Comité Européen de Normalisation*, European Committee for Standardization), and CENELEC (*Comité Européen de Normalisation Électrotechnique*, European Committee for Electrotechnical Standardization) – have been mandated to develop a set of standards needed to deploy interoperable smart metering systems [19] and to allow the implementation of smart grids into the European internal market [25], with placing considerable pressure on their deadline implementations. Also, the proposed approach has been taking into account that the analyzed use cases are part of broader M2M application requirements, thus enabling a strong push of the industry toward a horizontal architecture approach, as described in Figure 1.

4.3 Regulation in Croatia

Croatia as a country that will join the European Union next year is fully compliant with the European regulatory framework and the European directive has been transposed into the Croatian legislation in its entirety. However, there are still many open questions which regulatory framework does not resolve, and each member state decides for itself in which direction regulation should go. The best indicator and example are the numbers used in M2M services. The National Regulatory Authority has an obligation to reasonably use its numeric range and protect the numbers used in the country. The M2M service market in Croatia is in its very early stages and massive expansion is expected upon smart metering implementation for utility companies. M2M services spread far beyond the borders of the country's territory and usually open many issues related to the customer protection, used numbers, legal interception and monitoring of traffic, and protection of the electronic communication market.

To make this as one whole part, Croatian National Regulatory Authority HAKOM (*Hrvatska agencija za poštu i elektroničke komunikacije*, Croatian Post and Electronic Communications Agency) has prepared a project in cooperation with the academia, industry, and operators in which the theoretical foundations of market regulation would be set. The project will be based on two assumptions that must be fulfilled:

1. The openness of the platform
2. The use of national numbers

In order to protect the interests of smaller countries and to open the M2M services market, it is necessary to ensure the openness of the M2M platform. Mobile operators are usually platform owners as well, however due to the market development they should provide access to the M2M platform for M2M service providers and hosting their services on the M2M platform.

Also, the use of national numbers is a prerequisite to ensure the development of services and the M2M market within the country in which the operator is located. Of course, the use of ITU-T E.212 [33] numbers on a global scale is always a possibility for operators and thus covering the needs of multinational companies. The problem with using foreign numbers lies in the legal interception of calls and data retention. In the mobile network, the IP address for roaming users is obtained from the home GGSN thus preventing the detection of a potential criminal activity because the tracing of such users is more difficult.

As a result of the aforementioned we believe that the M2M market could develop quickly in the upcoming years, while meeting the above criteria. A prerequisite is to define a special numbering range exclusively for M2M services that will be included in the Croatian national numbering plan.

5. CONCLUSION AND FUTURE WORK

The Machine-to-Machine (M2M) system consists of different devices communicating using different communication technologies. Ubiquitous wireless and wireline connectivity, and declining prices of M2M communication modules have had a positive impact on the M2M market growth and have induced the diversity of application verticals (e.g. eHealth, smart grid, automotive). Because of the vast number of available verticals, and with the view to ensure their interoperability, it has been perceived that standardization in M2M domain is needed. The main purpose of standardization, which is based on different use cases, is to extract the main features of M2M communication in order to simplify the development of new M2M services. However, standardization bodies do not take into consideration the differences in national or regional legislation policies. Therefore, to ensure unobstructed use of available M2M applications, it is mandatory to involve certified regulatory bodies on national or regional levels.

The main task of National Regulatory Authorities in the upcoming years is to open M2M market and at the same time to protect current situation on other markets, as well as the usage of national numbers for domestic M2M services like smart metering.

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