Protocols for WSN: M2M

I5SSCM11 - Communication

Daniela Dragomirescu

Joao Nunes
Pauline Berta
Njord Løkebø
Catherine Vaugelade Berg

National Institute of Applied Science (INSA), Toulouse, France
Department of Electrical and Computer Engineering
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I Introduction

We often hear about M2M communication, which is the abbreviation for machine-to-machine, to designate all the data exchanges carried out between several devices without human intervention. This technology is spreading day by day because of the increase of the use of IoT (Internet of Things), which has put this notion back at the heart of today's issues.

Indeed, all the devices or services must now communicate with servers in an autonomous way. Thus, the communication between different machines can be done by many means already in place such as Wi-Fi, Bluetooth, RFID etc, however, new operators with greater autonomy are beginning to appear such as Sigfox, a telecommunication service.

To deal with this means of communication, we will separate our study in different parts.

First, a small introduction on how M2M works, then a wide view of what architectures and technologies are used and the security and power consumption of M2M systems.

Finally, we will study which are the major domains that can potentially use M2M communication and present some examples set up by different airlines.

II The functionalities of M2M

What differs the M2M network from LAN and WAN networks are that they are exclusively used to allow machines, sensors, and controls, to communicate. Beyond this, these types of networks are much the same. The connected devices share information with the network so that other devices can extract this. This process allows a human (or an intelligent control unit) to assess what is going on across the whole network and issue appropriate instructions to member devices. When talking about M2M, one often also talk about oneM2M.

OneM2M is a global initiative to develop standards and specifications to enable the machine to machine communication market. As mentioned, this technology allows physical objects or machines to be connected to the internet. This means they can communicate and share information over without the need of human intervention. OneM2M standardizes the architecture that defines an IoT Service layer. The horizontal architecture defined by oneM2M provides a common service function, using a common framework and uniform API's, to enable applications in multiple domains.

Some of the functionalities of oneM2M:

- secure end-to-end data/control exchange between IoT devices and custom applications by providing functions for proper identification
- authentication, authorization, encryption
- remote provisioning activation
- connectivity setup
- buffering
- scheduling
- synchronization
- aggregation
- group communication
- device management

It is much easier for oneM2M solution providers to deal with complex connectivity choices by abstracting out the details of using underlying network technologies, underlying transport protocols and data serialization. The role of the oneM2M service layer is to handle this, so that the programmer does not have a lot of knowledge in each layer. This allows the programmer to focus on the application development instead of focusing on how the underlying layers work. This could be compared to writing a file to a file system without worrying about how the hard disk and their interface works.

We can therefore compare the IoT Service Layer in oneM2M to the operating system for IoT providing API's to IoT applications, in the same way as a mobile OS does for the smartphone.

There are three levels in the IoT Service Layer: Applications, Operating System and Connectivity.

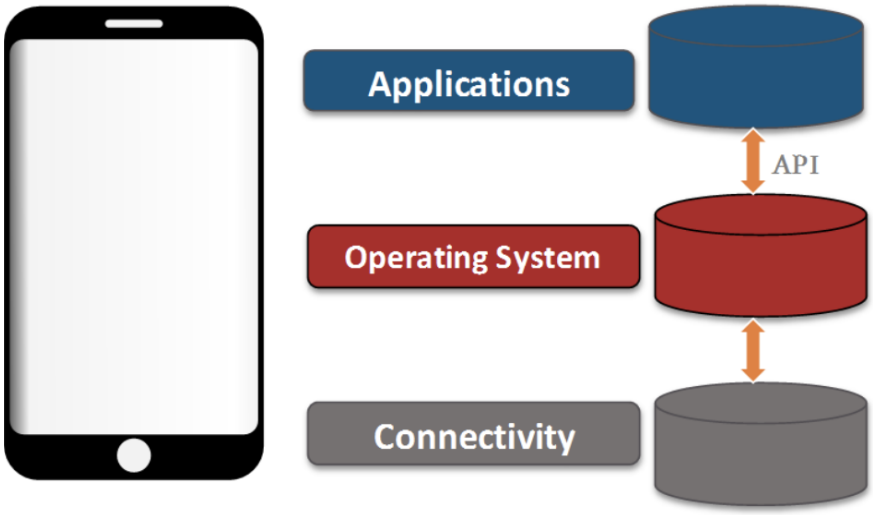

Figure 1: Service layers

Connectivity Layer: This layer provides connection, with wires or wireless networks, to the internet.

Operating System: This layer collects data transfer requests from the applications layer. The operating system optimizes and controls the use of the network by device and provides security.

Applications Layer: The Application layer controls the connectivity layer and built-in sensors via API's provided by the Operating System. This means applications are becoming portable.

In this report we will focus on the M2M technology.

III M2M technology, multiple architectures allowed the creation of 5G

III.1 M2M technology, multiple architectures allowed the creation of 5G

When we think about M2M technology, like discussed before it basically means that various machines communicate with each other. This kind of communication is usually the type of communication we can see on telecom infrastructures where we have a tradicional "star" architecture. The "star" architecture is when several sensors or other objects communicate with a central telecom node.

Figure 2: Central telecom node

With the evolution of telecommunications, other architecture began to be adopted and with the incredible growth of the number of devices communicating, each network became more and more complex. Let's start with one of the first M2M complex architectures, using the 3GPP network.

III.1.1 First complex architecture, using 3GPP

Since 2008, several communication operators decided to start selling SIM cards that could be used on machines. That meant that machines could communicate using GSM or UMTS. In order to allow the growing number of machines to communicate with each other, some key concepts were implemented :

- MTC Device
- MTC Server
- MTC User

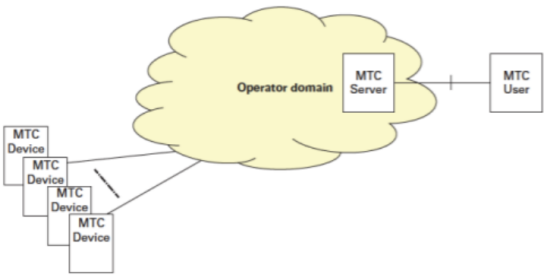

Figure 3: Operator domain

The idea behind this concept is that the MTC server will have to manage the communication between each machine and ensure that every scenario is taken into account. For example, if the conexion as to be a secure connexion and the response time has to be short, it is the MTC server that has to manage all the other communications to ensure that these parameters are respected.

With this M2M architecture, there are three types of conexion possible:

- The direct mode, where the devices communicate directly with the user or application server.
- The indirect mode, where the devices communicate, throws the "interworking gateway" that manages the interface, the network and the MTC Server.
- The hybrid mode, where the two modes described before are used.

The use of the indirect mode is particularly useful when we have multiple MTC Servers, because it allows us to identify the exact MTC server that has to get the data from a particular sensor or machine, but also in the other direction, when we want to get data from a particular sensor on demande, we'll know which Server to ask. Using the MTC-IWF (interworking gateway), can also be helpful for the security of the communication and to hide the complexity of the network. In addition to that, all these concepts allow the operators to add tax information on each communication and so easily charge clients for the use of the network.

III.1.2 Benefits from virtualisation

After the introduction of SIM cards on various types of machines, the number of devices wanting to communicate with each other started to grow immensely, and to help with the costs and develop new concepts, the virtualisation was brought to the M2M communication network. Basically, this consisted of replacing the telecom systems by Linux servers with a virtualisation layer and specific software. Elements like the MTC server or the MTC-IWF server became software fonctions and by consequence could be deployed a lot faster and easily.

These changes allowed some great improvements on flexibility for the network. If we take the example of a machine supporting different communication protocols, like Wifi, 4G, LoRa, this machine would have multiple protocol layers so it can manage the different communication types. With virtualisation, we can reduce the device to its hardware and virtualise the software layer with the possibility of having this layer on the device memory, or on a server somewhere. This particular possibility comes very handy when the network has to be updated because the software layers are easily modifiable, and it allows the network to absorb the growing number of devices without compromising the performances.

III.1.3 Use of the cloud and edge architecture

With the benefits of virtualisation and the fact some of the functionalities are executed on the network and not on one of the servers specifically, it is basically as if the software was on a "cloud"

and this “cloud” was a tool to give an abstraction level to the system.

The “cloud” architecture is the most common nowadays. The network is composed of various machines collecting data and sending all this data to the “cloud”. In the “cloud” all the data is analysed, transformed and then presented to multiple applications. For the cloud we can have three different types:

- The Private cloud, where a company can have it’s own network of sensors and have these sensors send the information to their own data center, to be processed. For example electricity companies have their own set of connected sensors with their own data center.
- The Public cloud, where sensors communicate with a cloud provided by a third-party company as amazon.
- The Hybrid cloud, where some applications are on the companies private cloud and others are on a public cloud. For example, applications that allow the user to manage its professional network will be based on a private cloud, but other applications that use the information available to transform it and sell it to clients can be on public cloud. At the end, this solution combines private and public clouds.

With the time, and with the extensive use of the cloud architecture a new architecture was brought into the M2M network, the edge architecture. The idea behind the edge architecture is basically that some of the applications are on the edge of the cloud architecture. These applications can be third-party applications being executed on the operator network.

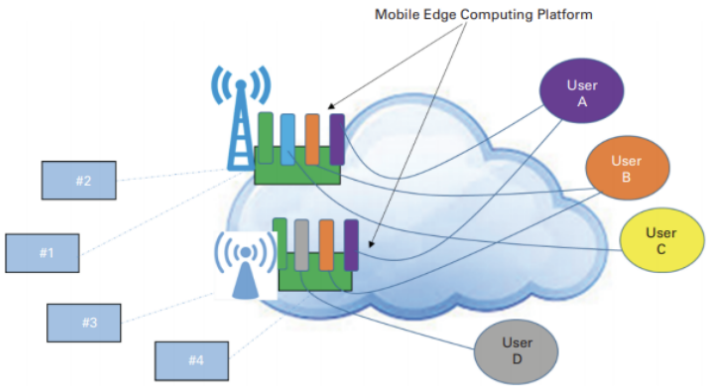

Figure 4: Mobile Edge Computing Platform

This particular architecture as several benefits:

- The response times between the machines and the applications are lower.
- Some of the data traffic can stay in the outskirts of all architecture.
- A pre-processing procedure can be applied to the data joining the network by the outskirt applications, and reduce the amount of data actually processed by the network.

For example, when a security camera feed as to be processed, it can be compressed on the outskirts applications of the network, and so when it actually is on the network, it will not take as much space.

III.1.4 The bandwidth used on the multiple M2M technologies

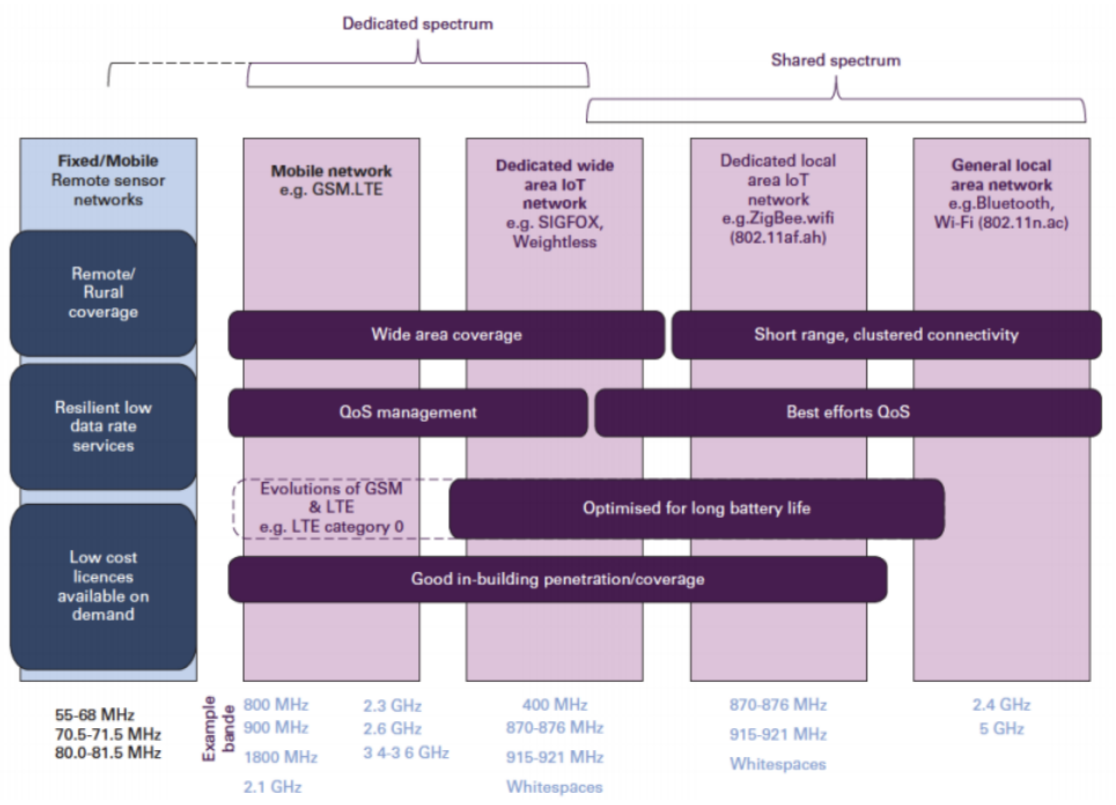

Figure 5: The bandwidth used on the multiple M2M technologies

As we can in figure 5, the spectrum is basically divided in two, one being the shared spectrum and the other being the dedicated spectrum. On the spectrum bands still usable we have the 5 GHz. This frequency is already used by the wifi 802.11, but several rules were put into place to allow the cohabitation of all these technologies using 5 Ghz.

The evolution of our current telephone network (4G) is the very controversial 5G. This new technology comes with latency times inferior to 1ms, power consumption divide by 10, speed increased by 30 times, and the list of performance benefits goes on and on. But the determinant factor of 5G is its ability to support billions of devices with a density superior to 106 /km2 and expected battery life of more than 10 years.

The benefits and characteristics of 5G makes it perfect for the next go-to option with IoT especially for connected sensors that live in complex and critical environments like autonomous cars and smart cities. These performances will of course be managed using the architectures we saw before, and other new concepts that are still to be implemented.

IV M2M Security and power consumption

IV.1 M2M Security challenges

Due to the nature of M2M communications and the reliance on several different types of networks, M2M systems have to manage all the potential security threats stemming from other network-based communications. In addition to this many M2M devices will have certain resource restrictions on their built-in security systems, as most network security algorithms typically demand a particular level of complexity that many low-power IoT devices will not be able to provide. This can make it difficult to foresee and prevent certain breaches, as one would have to take into account all the possible attacks that other network protocols already suffer from.

Physical attacks are easier to achieve on an M2M system because the devices that make up the network are numerous, spread out and and in locations where they may be easily reached by adversaries. Being physically accessible leaves these devices vulnerable to different malicious interventions. Modification to software, installation of malware and even destruction of the device itself are examples of actions that are feasible when physical access is given to potential attackers. Another potential threat are side channel attacks, where the power consumption or timing information can be collected from a nearby device in order to retrieve and unlock encryption information

Another type of defilement are logical attacks, an action that targets the functioning of the device itself without making changes to the device's software or hardware. An example of this is impersonation, where an attacker emulates a back-end server to receive information meant to be kept inside the M2M system. This can be detrimental as many IoT systems are planned to treat and process potential confidential information, like sensitive medical records or financial transactions. It can also be harmful for the integrity of the information, resulting in a lack of trust in the users that the data provided by the system is reliable and therefore depreciate the whole purpose of the M2M structure.

IV.2 M2M Power consumption

The electrical power usage of devices in an M2M network depends on several factors and can vary quite a bit as there is no "standard" M2M device with a set power consumption to base information from. However, given the nature of many of the sensors and agents that usually have to be constructed with portability and low-power usage in mind, it is safe to say that in general M2M systems have a relatively low energy consumption.

V Fields and examples of use of this technology

V.1 Several domains which use the M2M technology

M2M communication is used to carry out logistics by controlling various devices remotely.

In the industry it is a privileged communication concerning inventory management, supply chain monitoring, ... but also in the medical field. Indeed, this technology allows doctors to follow the medical evolution of their various patients by monitoring their vital parameters in real time without being in their presence.

An equivalent system operates in the implementation of so-called smart houses. The M2M communication will allow to control, remotely and in real time, the different electrical appliances, the stores, the lighting, and many other equipment arranged in the entire house, going as far as generating a shopping list for its user according to the food left in the fridge and his eating habits.

This mode of communication is spreading as far as the Internet of Things and is used for mobile payments made through Google Wallet or Appel Pay.

Online marketing is also mainly based on M2M technology, the exploration of different sites on the Web represents a machine-to-machine communication. In the same way, the appearance of advertisements during a navigation on the Web is due to a communication between machines based on the different actions previously performed on your device.

In the professional context, small companies frequently use the services offered by M2M communication in the form of application servers that are part of a client-server network. The use of this technology allows them to exchange data, to host Web servers, ... and even to access a data exchange server from any machine, to interact with it as if it were a file.

V.2 Example of the use of M2M communication in aeronautics

V.2.1 The example of Air France's baggage tracking in airplanes

Air France has set up an e-Track system in 2014 to track the baggage of regular passengers at any time to avoid the loss of one of them. To do this, they have relied on M2M communication.

KPN, a communication operator, and Fast Track Company are in charge of developing this tracking and have developed a system composed of two elements. A label composed of two screens and positioned on the outside of the baggage, called the e-Tag, allows the display of information related to the passenger's flight. It stores all the data on an RFID chip. Inside the baggage is a GPS system, the e-Track, which communicates using a GSM and Bluetooth connection with an application capable of targeting the baggage in question.

V.2.2 The example of Air France KLM's intelligent predictive maintenance

This second example also concerns the field of aeronautics and more particularly Air France KLM, the leading group in terms of European intercontinental air traffic.

Seeking to turn more and more towards the use of connected objects, the company has decided to deploy its digitization programs using M2M technology, with the aim of increasing automation for example. One of the major projects consists in organizing a follow-up of the various equipment on board, such as the inventory of fire extinguishers, oxygen cylinders, ... Indeed, a real-time follow-up of the rate of use of this equipment can be very useful to optimize the duration of their use and efficient maintenance.

The monitoring of tools on board is also concerned. The standardization of the use of these tools within the demonstrators is one of the major objectives of the company.

The development of some projects is highlighted, such as the geolocation of the various equipment on the tarmac or the transportation of pharmaceutical products or high value-added goods. The M2M communication would be able to allow an efficient, remote, and real-time monitoring of the storage temperatures, pressures, and shocks that these products may undergo during their transport from one point to another.

The use of these technologies remains a major challenge for the company. Resources can be mobilized in the right place, at the right time, at any time and without delay, to optimize investments and have a better vision of the company's activities.

All this reflects the company's desire to move towards intelligent predictive maintenance, which consists of sending industrial resources for maintenance before they have had time to break down. The quality of the equipment could only be better and allow the implementation of new and more efficient services.

In connection with all this, a major aspect related to the good resolution of the problem is the importance of the implementation of technical standards allowing the improvement of the efficiency of understanding between the company and its partners. The standardization of data and information systems is one of the most important objectives for Air France KLM since the standards of the connected objects should not correspond to the company's regulations.

VII Conclusion

After all the different analysis on the M2M protocol and after investigating it's benefits and disadvantages we can conclude that this protocol has helped the evolution of telecommunications and the way devices communicate with each other. At the start, the basic architectures and technologies offered allowed communication but without a big amount of data being transmitted, and different devices emitting data. We saw that with time, M2M architectures and technologies evolved to the 5G network we see now, just starting to be deployed, with all the big steps in performance, and low power consumption that comes with it. We also saw that security was and still is a big problem, and the general public is more and more aware of that, so progress is being made in that field. To conclude this report, we can say that without a doubt, M2M is becoming a part of every industry and technology domain, and the more we use it, the more capable and powerful the network and the concepts become.

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