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Introduction

Machine-to-Machine (M2M) means that no human intervention is required whilst devices are communicating with each other. It refers to technologies that allow both wireless and wired systems to communicate with other like devices. M2M is considered an integral part of Internet of Things (IoT) and brings several benefits to the industry and business. As M2M communication is on the rise, M2M applications and connectivity are becoming a major focus for market players such as communication service providers (CSP) and industry vertical application developers.

M2M uses a device (such as a sensor or meter) to capture an event, which is relayed through a network (wireless, wired or hybrid) to an application that translates the captured event into meaningful information.

In an M2M system:
- Devices connected on the same network exchange information with each other
- Device data can be collected and devices can be controlled directly without human intervention
- Data collected from the devices can be utilized in a wide variety of services

Some of the examples of M2M communication are:
- Devices (water meters) monitored by means of sensors [in “uplink”]
- Devices (electricity meters) monitored by means of sensors [in “uplink”]
- Devices (valves) instructed to actuate [in “downlink”]

M2M Architecture Overview

Diagram 1: M2M Architecture

M2M Architecture involves various components that participate in collecting, analyzing and processing information. The major components in M2M Architecture are:
• **Devices:** These are monitoring components (e.g. Sensors) that are installed at various sites which transmit/receive data based on events that occur due to changes in parameters of components that are connected to an M2M network (e.g. Sensor installed on a pipeline).

• **Gateway:** These are various IT applications that receive, understand, analyze, process and present the data received from the sensors. These could be gateway appliances that collect the data, applications that analyze and process data, and User Interfaces (including web) that display the relevant information about the data. These applications are typically made available on the cloud using various cloud computing technologies supported by cloud computing hardware.

• **Back-End:** These are predominantly key IT applications that make use of the analyzed data and perform decision making. (e.g. Billing, etc.)

Typical M2M architecture includes an application domain, a network domain, an M2M device domain and one or more direct connections or gateways from the M2M area network to the network domain. Because M2M device area networks can use a variety of communication technologies (RFID, ZigBee, M-BUS, IEEE 802.15, 6LoWPAN), a gateway layer becomes important. The solutions for communication between the gateway and M2M applications include LTE, WiMAX, xDSL, and WLAN. In the application domain, clients will often include dashboards for data virtualization, status monitoring, reconfiguration, and other functions.

**Popular M2M Markets**

Some of the popular M2M markets are as follows:

**Building Automation**

Smart Cards revolutionized the payment systems decades ago. Now, emerging M2M technologies are doing the same for smart buildings and their owners. Key advances in smart building technology are being used in the new era of energy efficiency and carbon footprint reduction.

Today’s M2M building management technologies can be used to perform real-time remote monitoring and control the entire portfolios of buildings. With today’s advanced technology, owners can expect energy efficiency to improve 15 to 20 per cent in the first year, even at buildings where strong energy management programs are already in place. In addition, smart building systems can automatically
calculate carbon and other greenhouse gas emissions, thereby streamlining the corporate social responsibility reporting process.

Some of the technologies contributing to making buildings smarter, are:

1. Wireless meters (electricity/water/gas) and sensors
2. Internet and cloud computing
3. Powerful analytics software
4. Remote centralized control

**Smart City**

The world is swiftly becoming more urbanized, thanks to growing global populations and migration from rural areas to cities. The resulting stress to virtually all global systems may only be solved by the concept of smart cities.

While it is becoming a bigger and bigger challenge to maintain the necessary supplies of water, energy, food, communication and transport to meet growing demands in urban centers, a complete replacement of old and established city infrastructures would be unrealistic in terms of cost and time. However, digitalizing the existing infrastructure would allow it to collect and analyze data in order to respond intelligently to all domestic needs, allowing cities to grow without fear of infrastructure overloading.

The smart cities market includes smart parking, smart street lighting, smart litter bins, smart traffic flow, pollution monitoring, smart homes, smart buildings, smart grid, smart industry automation, smart healthcare, smart education, smart transportation, and smart security.

**Smart Grids**

With global energy demand set to double by 2050, concern about climate change, carbon emissions and the security of supply is driving new pressures in the utilities industry. Current legislation requires utility industries to find ways to reduce carbon dioxide emissions, lower energy consumption, and introduce alternative fuels. Increasing customer expectations means that utilities need to find ways to deliver better customer service.

The Smart Grid gives utilities the means to meet these challenges - remote data management and monitoring capabilities, automation and control, and the systems for the effective utilization and safe management of transmission and distribution networks. The Smart Grid not only enables utilities to
deliver electricity in a sustainable, economic, efficient and secure way, but it also opens up opportunities for the development of other new low carbon technologies such as electric vehicles and smart homes.

**Industrial Automation**

Manufacturers optimize production with M2M solutions for tracking, monitoring, and remote diagnosis. Today’s M2M solutions and big data analytics take industrial automation to the next level. M2M devices/sensors monitor plant and machinery remotely round the clock and provide alerts when errors occur. Industries gain a better overview of the condition of their equipment and can react quickly when something goes wrong. It is also easier for them to produce mass customized products and remotely adjust output to fit demand.

Industrial automation has revolutionized the manufacturing of semi finished and finished goods. Maintaining plants has always been vital for meeting customer demand and preventing downtime. With M2M solutions such as remote monitoring, companies gain an overview of the condition of their equipment centrally via an online portal, eliminating the need for regular manual checks. M2M devices/sensors connected to the control unit of the machines can also send an alert to the manufacturer when something goes wrong. This accelerates the repair time and cuts operational costs. Companies also gain flexibility by using M2M to adjust automated production processes so that they can fit their production to the current demand or other factors. Since most companies prefer to lease production equipment to reduce the risks of ownership and gain tax advantages, equipment owners can also rely on remote M2M services to track and monitor their gear and its use.

**Healthcare**

M2M in healthcare is rapidly developing. Medical information transmitted in real time through M2M technology helps to relieve demands on healthcare professionals and increase industry efficiency and response times.

The potential of M2M technology in the healthcare industry is rapidly being discovered and explored. Rising demand in patient care has placed increasingly heavy responsibilities and pressures on medical staff. Nearly a billion people worldwide suffer from chronic illnesses that require continuous monitoring. The healthcare industry will need to find better ways to reach and treat patients, and M2M technology is one of the ways to achieve that.

Remote monitoring devices can allow doctors and caregivers to keep track of the health of patients who are not in the hospital or within their sight. Common conditions that are increasingly being monitored
while patients are at home include irregular heartbeats (cardiac arrhythmia), high blood pressure, glucose levels of diabetic patients and blood lipid levels. Medical staff can be alerted to changes in their patient's health and provide treatment quickly when necessary. M2M technology can also be used to monitor medication uptake by patients or when a prescription is due to run out.

Automotive
The direction towards intelligent cars and transport systems utilising M2M technology is shaping the future of how we drive, what we do on the roads, and the safety of road travel. M2M technology is being used by car manufacturers to enhance safety and functionality in vehicles with complete in-built systems. Remote diagnostics can alert drivers and solution centres to possible problems and solutions. M2M communication between vehicles and road infrastructure, together with traffic news, helps drivers with navigation by informing them about collisions, road signs and warnings. On a macro level, M2M applications have also been used to reduce traffic congestion and carbon emissions. Monitoring and predicting traffic movements are areas that can be explored with M2M technology.

Role of Big Data in M2M
Advances in technologies have enabled the emergence of Big Data. Big Data is used to describe a massive volume of both structured and unstructured data that is so large that it's difficult to process using traditional database and software techniques. In most enterprise scenarios the data is too big or it moves too fast or it exceeds current processing capacities. Big Data has the potential to help companies improve operations and make faster, more intelligent decisions. Without the highly acclaimed Hadoop based platforms, processing semi-structured and unstructured data would still be virtually impossible. Without reduced processing and storage costs, Big Data would remain an expensive and highly experimental endeavor for a few leading edge enterprises. Without improved networks and cheaper data traffic rates, data from individual data sources would remain isolated and unavailable for data mining.

In short, the technological landscape has developed to the point where it is clear that Big Data presents tremendous opportunities for organizations and enterprises to develop and improve customized services and experiences delivered to customers by capturing, processing and analyzing data from an increasing range of sources. Additionally, it is clear that data captured from M2M devices must also be incorporated into Big Data analyses.
Big Data is a factor that will, to a large extent, determine the future growth rate in the M2M industry. M2M will connect increasingly more nodes that will provide data from endpoints. Data will be more granular, more frequent, and more accurate, with bigger data sets or even live data streams. All of this results in what is called Big Data.

The convergence of M2M, Big Data, and the cloud will provide key capabilities for building next-generation systems and expanding the Internet of Things (IoT). IoT will sustain communication and data sharing for billions of connected devices and systems. The number of connections and endpoints is so large that it requires IPv6 addresses because the IPv4 addressing scheme cannot accommodate the volume of sensors, smart phones, smart factories, smart grids, smart vehicles, controllers, meters, and other devices that will be transmitting data over the Internet.

The sheer volume of data from human users and M2M applications will require advanced analytics capable of exploiting Big Data and the computing power of the cloud. It's no surprise that the convergence of IoT, Big Data analytics, federated databases, and other technologies is now being called the Internet of Everything (IoE).

Building IoT will be an an exercise in integrating disparate devices and carrier networks, multiple communication protocols, and a wide variety of applications. It will often require integrating legacy networks and applications. The new M2M applications are and will continue to be complex, using geographically dispersed devices and services, a mix of connectivity, and logic in the data center and edge devices.

How to handle that diversity is one of today's major challenges. Large-scale M2M projects, such as building a smart city, will not be successful using the fragmented, domain-specific approach of M2M solutions designed for specific M2M applications. Successful large-scale M2M/Big Data/Cloud implementations require an integration focus and a data pipe that can move massive amounts of data from heterogeneous sources.

**Challenges of Big Data in M2M**

Big Data is set to offer companies tremendous insight, but with terabytes and petabytes of data pouring in to organizations today, traditional architectures and infrastructures are not up to the challenge. There are many challenges in the path of Big Data handling in M2M such as:

1. **Meeting the need for speed**:
In today’s competitive business environment, companies not only have to find and analyze the relevant data that they need, but must also find it quickly. Data analysis helps organizations make decisions much more rapidly, but the real challenge is to go through the sheer volumes of data and access the level of detail needed - all at a high speed. Some possible solutions to this is increasing the hardware capacity, parallel processing, and using grid computing harnessing many machines to process single sets of data. These approaches allow organizations to explore huge data volumes and gain business insights in near-real time.

2. Data understanding:
In addition to receiving big data at high speed, it is also important to understand the context of the data received. Without knowing from where the data comes, what audience will be consuming it and how the audience will interpret the information, the data received is meaningless.

3. Maintaining data quality:
Even if the speed is met and big data is properly understood for proper context, data will still be meaningless if a decision cannot be made by analyzing it, due to inaccuracy or untimely reception. So, it is equally important to address data quality in the big data context.

4. Displaying meaningful results:
Data analysis can take place when the results are presented in graphical or other formats. It will be difficult to plot the graph with such huge data points. For example, consider a scenario where u have 5 billion rows of data that need to be compared. The user would have a hard time browsing through so many data points. One solution to this is clustering or grouping the data together, with which data can be visualized more effectively.

**Big Data Analytics**
The majority of raw data, particularly big data, doesn't offer a lot of value in its unprocessed state. Of course, by applying the right set of tools, we can pull powerful insights from this stockpile of bits. With data in hand, you can begin analyzing through:

1. Predictive Analytics:
Predictive analytics is the next step up in data reduction. It utilizes a variety of statistical, modeling, data mining, and machine learning techniques to study recent and historical data, thereby allowing analysts to make predictions about the future. The purpose of predictive analytics is not to tell you what will happen in the future. It cannot do that. In fact, no analytics can do that. Predictive analytics can only forecast what might happen in the future, because all predictive analytics are probabilistic in nature.

Sentiment analysis, for instance, is a common type of predictive analytics. The input to the model is plain text and the output of that model is a sentiment score, whether it's positive, negative, or something between +1 or -1. In this case, the model computes the score, but it's not necessarily predicting the future. Rather, it's predicting data that we don't have, which is the sentiment label, whether it’s a positive or negative sentiment.

2. Prescriptive Analytics:
The emerging technology of prescriptive analytics goes beyond descriptive and predictive models by recommending one or more courses of action and showing the likely outcome of each decision. Prescriptive analytics is a type of predictive analytics. It's basically when we need to prescribe an action, so the business decision-maker can take this information and act. Since a prescriptive model is able to predict the possible consequences based on different choices of actions, it can also recommend the best course of action for any pre-specified outcome.

Benefits of Big Data Analytics

1. Device Maintenance:
   a. Time for next patch upgrade
   b. Energy management
   c. Inventory management and track replacement

2. Proactive Healthcare:
Capture and analyze real time data from medical monitors to predict potential health problems before patients manifest clinical signs of infection.

3. Monetize Machine Data:
   a. Monitor performance, usage and capacity details to uncover up-sell and cross-sell opportunities
   b. Maximise the lifespan and performance of high value medical assets
4. Optimize Support Operations:
   a. Reduce MTTR and support escalations
   b. Preempt failures with proactive support
   c. Troubleshoot with accurate information
   d. Proactive consultation to customers on approaching expiry dates

Conclusion
The convergence of M2M/IoT, cloud computing, and Big Data technologies is both an opportunity and a challenge. These technologies give us the engine for a powerful new generation of services and applications. But there will be trials, such as overcoming complexity and security threats, which are best addressed by adhering to standards and using powerful tools for integration and interoperability.

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