Machine to Machine (M2M) Technology
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Introduction

Communication is a vital aspect of everyday life, both in business and in the personal sphere. Information and communication technology (ICT) has had a dramatic impact in person to person communication through the advent of cellular technology, the Internet, and the smart phone. The same can be said for communication between people and machines and also between machines. In the last two decades, advances in ICT has seen the development of the concept of machine-to-machine (M2M) communication and the Internet-of-Things (virtual representations of uniquely identifiable products in an Internet-like structure). The introduction of M2M has seen a transformation in how businesses operate both internally and externally as part of a value chain, as well as the plethora of consumer products utilising M2M technology to assist consumers with everyday tasks.

What is M2M?

M2M is a broad label that can be used to describe any technology that enables networked devices to share information and perform actions, without the manual assistance of humans. As M2M is a broad label, it does not define specific technology, such as wireless or wired networking or the information and communications technology that is utilised.

M2M technology involves five important technological parts: intelligent machines, M2M hardware, communication network, middleware and applications.

1. Intelligent Machines
To implement M2M, data must be obtained from machines/equipment and then send the data through a network. These machines must have the capability to “talk”, i.e. apperceive information, process information (namely, computing capacity) and transmit information. There are two fundamental methods to provide machines with the capacity to “talk”: to embed M2M hardware when manufacturing the machines, or retrofit M2M hardware into existing machine.

2. M2M Hardware
M2M hardware is the component that makes it possible for machines to be provided with the capacity of remote communication and networking. This type of hardware is mainly used to extract information, obtain data from various machines/equipment and transmit
such data to the communication network. Existing M2M hardware are classified into five categories:

1. **Embedded hardware** – Hardware that are embedded into machines and provide the machines with networking and communicating abilities (refer to Figure 1). Such products include wireless embedded data modules in support of current wireless mobile communication networks.

2. **Retrofitted hardware** – In many industrial applications of M2M, a large number of equipment are not equipped with M2M communication and networking capabilities from the equipment manufacturers. Thus, M2M hardware that can be retrofitted to these machines are designed to satisfy the communication and networking capacities of such machines (refer to Figure 2). Examples of this type of hardware include I/O (Input/Output) devices collecting data from sensors, and connectivity terminals that perform protocol transformation functions and send data to the communication network.

3. **Modem** – When hardware transmits data onto the mobile communication network, the public telephone network or the Ethernet, they are playing the role of a modem (refer to Figure 3).
4. Sensors – The sensors used in M2M systems are “Smart Sensors” which are provided with the capacity to apperceive, compute and communicate (refer to Figure 4). Sensor networks made up of smart sensors is an important component of M2M technology. A group of smart sensors provided with the capacity to conduct communications, form a wireless network in an ad hoc pattern, coordinating the apperception, collection and processing of information concerning the objects within the geographic region that the network covers, and distributing such information to observers.  

![Figure 3 M2M Modem](image)

![Figure 4 Examples of Sensors](image)
5. **Location Tags** – A location tag is like the “identity card” of respective machines and commodities, making it possible for machines to identify and distinguish one another. Technologies in common use include bar code technology and radio-frequency identification (RFID) technology\(^2\) (refer to Figure 5).

![Figure 5 – Location Tag with Bar Code and RFID](image_url)

3. **Communication Network**
A communication network transmits information to a destination. Communication networks hold a core status in the overall framework of M2M technology, which includes\(^2\):
- Wide area networks (WAN) – wireless mobile communication network, satellite communication network, Internet, public telephone network.
- Local area networks (LAN) – Ethernet, Wireless Local Area Network (WiFi), Bluetooth.
- Personal area networks – (ZigBee and sensor network).

4. **Middleware**
The middleware plays a bridging role between communication networks and the IT system. Middleware includes two parts: M2M gateway and data-collection / integration components. The gateway is the “translator” in the M2M system and it obtains data from the communication network and transmits data to the information processing system. Its main function is to conduct the conversion between various communication protocols\(^2\).

5. **Applications**
Data collection or integration of components, means turning data into valuable information. It involves conducting processing of raw data and the presentation of results to observers who need such information\(^2\).
Applications in Manufacturing

M2M systems have various applications in the manufacturing sector. These applications include:

1. *Exchange of data between devices, control applications and data gathering systems* – With advances in information technology, manufacturers are deploying low power, low cost wireless communications. Many machines are built as modular components with standard logic and control hardware. The manufacturer has a lot of choice in machine components, such as capper, conveyors, loaders or labellers that can be manufactured separately, then plugged into the completed machine. M2M comes into play once the components are installed and recognise each other once the bus connections have been made. Then, communication between controllers typically starts immediately and automatically without additional programming or configuration.

2. *Industrial automation* – The migration of networking into automation will have profound benefits into industrial automation applications. Device networking enables manufacturers to achieve greater efficiency and productivity on the factory floor by providing centralised access and control of all types of industrial automation equipment.

3. *Remote maintenance and monitoring of machinery*– M2M monitoring solutions allow manufacturers to supervise equipment remotely in real time, enabling them to provide timely service and repairs to avoid costly breakdowns. For example, in a factory, sensor data from a hydraulic press is automatically transmitted to the manufacturer who can see that hydraulic fluid is below recommended operating levels. A team is sent to perform preventative maintenance and forward the data to the manufacturer to assist in design refinements.

4. *Maximising the productivity of production equipment*– M2M technology can play a large role in monitoring productivity, with a specific focus on OEE (Operational Equipment Effectiveness). The OEE can be calculated in real time from data received from production equipment. The data can include job information, including component information, quantity, standard and actual cycle times. The data can also include downtime information and machine specific operation data. The OEE information can be accessible through a Web browser. An example of software used in collating M2M for factory Key Performance Indicators (KPIs), from Rockwell Automation is shown in Figure 6.
5. **Shift from reactive to predictive maintenance**—Using M2M data from production equipment, condition based monitoring can be implemented to monitor the condition of equipment based on real time data. Maintenance work can be planned on actual equipment condition instead of time based maintenance schedules. Manufacturers can use the machine data to predict and avoid potential equipment failure.

6. **Improving inventory control**—M2M data can be used for monitoring the usage of consumables, work-in-progress (WIP) and finished goods. Inventory data can be shared with suppliers to prevent stock outs. Vendor Managed Inventory (VMI), where the supplier manages their stock on their client’s site, is an application where M2M has made significant gains. An example of where M2M technology is used is in industrial vending systems (refer to Figure 7). Benefits of M2M enabled industrial vending systems include:
   1. Reduced consumption and shrinkage (e.g. control who has access to what supplies and how much).
   2. Pay only for vended options.
   3. Minimisation of “walking and waiting” time.
   4. View real-time usage and inventory.
   5. Automatic reordering and replenishing.
In addition to traditional styled vending machines, a locker-style distribution unit can be used to dispense larger items such as chemicals, paper goods, hand and power tools, calibrated test equipment, and other such equipment. Non-consumables such as power tools can be equipped with RFID tags to help manage and confirm their return at the end of a shift.

Figure 7 – Industrial Vending Machine

7. **Tagging of high-value assets and inventory** - Tracking and tagging of valuable assets and inventory such as computers and data storage devices increases security and reduces theft.

8. **Enabling inventory condition monitoring** - For manufacturers of perishable goods, tracking the condition of inventory—e.g., humidity, temperature, pressure, light—ensures the effectiveness of medicines, shelf life of products, and/or safety of items intended for human consumption.

9. **Operate at peak efficiency** - An M2M system can enable a manufacturer to directly track energy efficiency, sustainability and environmental compliance. Upper-limit alerts generated by the application system in the M2M system gives managers time to minimise energy costs and avoid environmental, health and safety fines.
10. **Integration of quality assurance and product management activities with Enterprise Systems (e.g. Enterprise Resource Planning – ERP)** - Manufacturers can integrate M2M data into enterprise systems such as CRM, ERP, or data warehouses — optimising critical business processes. For example, product data flowing through a CRM or ERP system can also be sent to billing or into a supply chain management system — helping to eliminate error-prone manual steps and providing new sales opportunities for business processes such as:

1. Consumables management
2. Usage-based billing
3. Warranty management

Additionally, integration with quality assurance or product management can help enhance product features based on real-world data that shows usage patterns or equipment issues. Various aspects of enterprise system integration is illustrated in Figure 8.

Figure 8. Integration of M2M data with Enterprise Systems

Figure 9 depicts a “connected factory” where M2M is used in various facets of a manufacturing organisation.
Future Opportunities in Manufacturing

It is anticipated that future opportunities will increase the degree of “connectedness” between devices and equipment, both internally within the factory environment and also externally, within the manufacturer’s supply chain. Research is being undertaken to utilise M2M systems as part of a vision of the factory of the future. A consortium of manufacturers in Germany has been established to develop a pilot plant, known as SmartFactoryKL, to research and demonstrate the use of M2M and other ICT technologies in new applications in a manufacturing environment. According to the website of SmartFactoryKL,

“The manufacturer-independent research and demonstration plant of SmartFactoryKL illustrates the vision of the factory of the future: Diverse components of different manufacturers (networking) are connected with each other within it. Intelligent components are able to take over independently contextual tasks and to work self-sufficiently (self-organization). In addition to that, SmartFactoryKL is modifiable and extendable in a user-defined way (flexibility). And last but not least, major focus is put on the user-friendly configuration of the operating systems (user orientation) despite the fact of increasing complexity.”
Various applications of M2M technology has been demonstrated in SmartFactoryKL as shown in the following examples.

1. **Support of maintenance processes via location information**
   The use of location information in industrial applications is a central element of the factory of the future. Future factories may require maintenance staff to utilise a navigation application based on a Wearable-PC which supports the seamless guidance of maintenance staff to the place where a fault has occurred. Besides experiences in the use of spatial context information in factory systems, the challenge consists of a combined use of indoor and outdoor positioning technologies.  

![](image)

**Figure 10 – A wearable PC for maintenance staff**  

2. **RFID Workshop Trolley**
   In the course of the flexibility of industrial plants, information about the location of products and production, means the need for positioning systems become increasingly important. The idea to locate work in progress (WIP), to take stock at the push of a button or to locate mobile machine components, will drive demand for positioning systems within a factory. In a future factory environment, a workshop trolley can be used to locate work in progress within the factory. These trolleys would be equipped with RFID-readers, collecting reliable data about the location and the direction of motion, based on transponders embedded in the ground (refer to Figure 11).
3. **Universal mobile operator units**

In modern production environments field devices and plant modules from different manufacturers can be installed which are all differently connected, controlled and handled. Up to now, these control panels are limited to a few communication technologies and protocols, for example WLAN and Profibus. In a future manufacturing environment, a single, universal control panel may be connected to multiple plant equipment from different manufacturers and may be able to control the equipment. This universal control panel (refer to Figure 12) has to be flexible, be able to communicate with varied devices from different producers, be proficient in their communications technologies and adapt to the current system status and the particular user. This type of control panel will use, in addition to the common but frail WLAN, the Bluetooth-Technology which is aligned to security and RFID technology. 

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**Figure 11** – A workshop trolley equipped with RFID readers

**Figure 12** – Universal control panel
The concept of the universal control panel can also be translated to tablet PC’s and smart phones (refer to Figure 13).

Figure 13 – Tablet PC and smart phone used as a universal control panel

M2M Technology in Manufactured Goods

In addition to assisting businesses in day-to-day operations through communication of data between machines, M2M communication is increasingly making an impact in consumers’ lives through the incorporation of M2M technology in seemingly mundane products.

**Smart Appliances**

An example of using in M2M technology is the incorporation of Near Field Communication (NFC) tags, a short range RFID technology, into home appliances. Through the use of a controller application, data can be transferred from a smartphone or laptop to other devices (refer to Figure 14). Through their smartphone or laptop, consumers can start their laundry, check what’s in the fridge, or have the floor vacuumed, all while they’re away from home. Additionally, it’s possible to control the washer or range oven from the couch through the remote controller of a smart TV.
Smart Meters & Thermostats
M2M technology can be seen in the use of smart meters (refer to Fig 15), an electronic device that records consumption of electrical energy and communicates that information to the utility company for monitoring and billing purposes. Smart meters enable two-way communication between the meter and the central system and can also gather data for remote reporting. Smart meters can be used by the utility company to smooth out electrical demand in their electricity grids. The utility company sends a signal to the smart meter to request that electricity consumption (often of a particular device) is reduced or temporarily halted. This can be automated through the deployment of devices such as smart thermostats (refer to Fig 16) to adjust HVAC (Heating, Ventilation, Air Conditioning) settings and through ‘smart load control switches’, which may be used with air conditioner compressors and electric storage water heaters.
Wearable Technology
M2M technology is being introduced to everyday wearable items, such as the “smart watch” and the “smart glass”.

Smart Watches
A smartwatch is a computerized device (refer to Figure 17), which in addition to timekeeping, possess additional functions. These functions may include supporting mobile apps or a mobile operating system, operating as a portable media player, offering playback of FM radio, audio, and video files to the user. In addition to these functions, some smartphone models feature full mobile phone capability, and can make or answer phone calls. Incorporating M2M technology, a smartwatch may collect information from internal or external sensors. It may control, or retrieve data from other instruments or computers. It may support wireless technologies like Bluetooth, Wi-Fi, and GPS. However, it is possible a smartphone may just serve as a front end for a remote system, as in the case of watches utilizing cellular technology or Wi-Fi20.
Smart Glasses
Smart glasses (refer to Figure 18) are a wearable computing device in the form of computerized eyeglasses and typically possess enhanced data processing functionality similar to a smartphone or tablet and are able to run mobile apps. Through the use of M2M technology, smart glasses also include features such as augmented reality overlay, GPS and mapping capability. As components continue to shrink, the potential for what can be squeezed into these head-borne wearable computing devices is limitless.22
Conclusion

The application of M2M technology in manufacturing provides a basis for improving productivity, enabling industrial automation, transforming maintenance activities, as well as improving the management of stock and assets. Current research into expanding the use of M2M technology in the manufacturing environment will see in the near future, the increased employment of RFID and Bluetooth communication technology as part of a factory-wide positioning system, to accurately account for and locate all stock on the shopfloor and assist maintenance personnel in locating and identifying maintenance breakdown activities.

The advancement of small, low cost identification tags (Near Field Communication) has assisted the introduction of M2M enabled home appliances, allowing the consumer to remotely control household tasks through the use of a smart phone or a laptop. M2M technology has also seen a new category of consumer products appear – Wearable Technology – promising a transformation in personal communication and lifestyle as a result of access to the Internet and the ability to communicate with other devices.
References

1.1 http://whatis.techtarget.com/definition/machine-to-machine-M2M - extracted 19/2/14
15. http://smartfactory.dfk.uni-kl.de/en/content/demo/technological-demo - extracted 26/2/14
22. http://www.smartglassesnews.org/review-google-glass - extracted 27/2/14