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A Survey: Machine to Machine Communication

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Abstract

Machine-to-machine (M2M) communication is considered as one of the next frontiers in wireless communications. Freed from the traditional constraint that terminals communicating wirelessly with networks should be largely „manned" by humans, communication from and to M2M devices is expected to open up a large number of possibilities in terms of new use cases, services, and applications. M2M will also bring benefits for the general masses and market opportunities for various related stakeholders, such as manufacturers of M2M devices and components, service providers, and communication network operators. This paper considered a review on Machine to Machine communication and performs further work in future.

Keyword: *M2M Communication, Home networking, Smart Grid.*

1. M2M Communication

Machine-to-machine (M2M) or machine-type communication (MTC) is expected to be one of the major drivers of cellular communications in the next decade. The term M2M communication covers a wide area of use cases and applications, thus resulting in context of cellular systems in highly diversified use cases, deployment scenarios and requirements. However, one common denominator is that today's mobile cellular systems are primarily designed for human communication [1].

The relatively broad definition of M2M communication, or more precisely, the wide range of associated use cases, constitutes a challenge for the design of mobile cellular networks. Although this variety is in principle beneficial in terms of opportunities, it also makes it more difficult to define common characteristics and accordingly, requirements fundamental for the system design of M2M-optimized cellular systems [1].

When two electronic systems communicate autonomously, that is to say without human intervention, the process is described as Machine-to-Machine (M2M) communications. The main goal of M2M communications is to enable the sharing of information between electronic systems autonomously [2] [3]. Due to the emergence and rapid adoption of wireless technologies, the ubiquity of electronic control systems, and the increasing complexity of software systems, wireless M2M has been attracting a lot of attention from industry and academia [4] [5] [6].

There has been a great deal of interest in the machine-to-machine (M2M) communications and Internet-of-Things (IoT) recently. Billions of M2M devices are expected to be connected, and a major portion of them are through wireless media [7]. M2M communication is expected to open doors for new type of applications and services that include smart metering, telemetry, surveillance, healthcare, transportation, utilities, and remote maintenance and control. These applications and services demands communication protocols that are different from the traditional communication protocols used in human-to-human networks. Research activities are ongoing in academia and industry. M2M communication standards have been actively developed in standard bodies (e.g., ETSI TC M2M, 3GPP machine-type-communications, IEEE 802.16p, etc.). The goal of this workshop is to bring various state-of-the-art research activities in academia and industry together and understand the future M2M communication requirements and potentials [7].

2. Generic M2M Architecture and M2M Application Areas

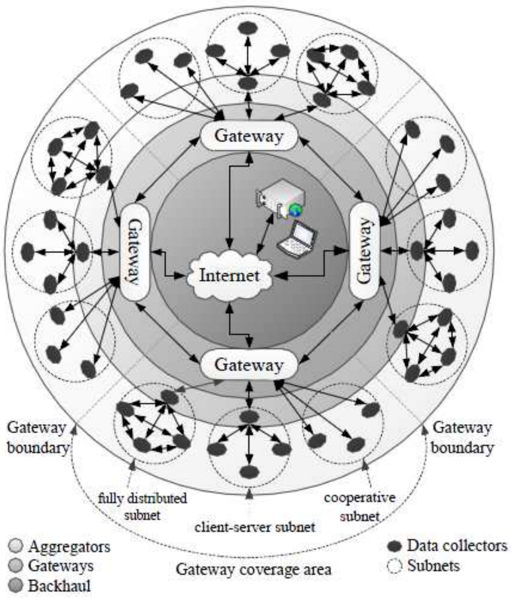

Figure 1: Generic M2M communication architecture[8].

A generic M2M communication architecture is shown in Figure 1. To support the high number of M2M devices (billions to trillions) that are expected to be part of an M2M network, hierarchical communication architectures have been proposed [5]. At the highest level, the goal of M2M architectures is to aggregate information from data collectors, and to apply some decision-making function to this information to produce decisions which are then executed.

Several data collectors (e.g. temperature sensors, location sensors or heart rate monitors) are used to collect information from multiple locations. Data collectors gather data in areas that are small compared to the total area covered by the M2M architecture. The data collectors are usually separated in physical space and can collect information from various types of sources. For example, one data collector could record the ambient temperature in one location, and another could record the current consumed by a television set in another distant physical location[8].

In M2M architectures, data collectors of the same type are connected to small networks (e.g. Body Area Networks (BANs), Zigbee, and Bluetooth), called subnets. Each subnet uses a network technology appropriate for the type of information to be collected and distributed [8].

The network technology which is employed determines the subnet architecture. Three types of subnets (fully distributed, client-server and cooperative) are shown in Figure 1. In a fully distributed network, all nodes (e.g. various computers on a home Wi-Fi network) are connected as peers and share data amongst themselves. One of the nodes (e.g. a router’s Wi-Fi module) acts as a super-peer that has the ability to connect through some gateway (e.g. a router’s ADSL connection) to the Internet. In a client-server network, all clients only communicate with the server; an example would be portable media players connecting to a media server. The server then relays appropriate information to other clients (e.g. wireless speakers). The server also has the ability to connect to the Internet through some gateway (e.g. a home router). A cooperative network is not, strictly speaking, a subnet. None of the nodes (e.g. BAN sensors) communicate directly with each other as is the case on a subnet, but rather via the gateway (e.g. a cellular phone).

The collected data is then aggregated at possibly multiple layers of aggregation points. The number of aggregation layers depends on the expected number of M2M devices and how these devices are logically grouped. At each aggregation layer, data from multiple data collectors can be aggregated by applying some intelligence to the data. This means that the aggregation function is not merely assembling the data, but it can also reduce the amount of data retransmitted. This can be achieved, for example, through filtering data based on relevance, or by extracting higher-level information from aggregated data. Data aggregation is used to allow M2M devices to have low cost, consume little power and have a limited operating area. This is required to enable a system of billions to trillions of these devices.[8]

Multiple local subnets using different communication standards can communicate with each other using some gateway which provides Internet connectivity or a similar backhaul network. The gateway typically interfaces with at least one device on each subnet to which it is connected, and is also connected to other gateways. An end-user can connect to a server to access information collected from the M2M data collectors. This server may be connected to the Internet or some other backhaul network. The function of the M2M server is to perform final processing tasks on the collected data, to store the data, log the transactions that occurred and to make the data available online to the various users of the M2M system [8].

3. Uses of M2M Communications [9], [10]

Metering and control of electricity, gas, heat, and water. Smart meters are immobile devices with very long maintenance intervals (several years), which is a challenge for meters which are solely battery-powered. Communication between the meter devices and the providers today is characterized by long time intervals. However, for future smart power grids, much shorter time intervals may be necessary (several minutes down to seconds), as the abilities to control the energy-network are manifold and closed-loop control will be implemented.

• eHealth denotes the envisioned use of cellular devices to monitor the health state of the user, such as blood pressure, heart beat rate, etc. While this information is usually aggregated at the device and then transmitted as bulk message, the device could also react on emergency events, implying stronger requirements on latency and transmission reliability.

• Intelligent Transport Systems (ITS) describes the use of communication to enhance transport security and efficiency.

Recently, cellular communication technologies are one of the candidates for car-to-x communication, which has strong requirements on latency and mobility.

• Surveillance is one aspect of the larger use case "public safety", where video cameras are transmitting either constantly, or at certain event triggers, a relatively low data rate video stream. The requirements on QoS corresponds thus to "normal" video streaming [1].

Table 1: Requirements of Different M2M uses Cases on Communication

	Smart meters	eHealth	ITS	Surveillance
Mobility	None	Normal	High	None
Message Size	Low	Medium	Medium	High
Traffic Pattern	Regular	Random	Random	Regular
Device Density	High	Medium	High	Low
Latency Req.	Low	High	High	Medium
Power Eff.	High	High	Low	Medium

4. Requirements for Mobile Cellular Networks

An analysis of the M2M requirements, performed e.g. in [9], [10], reveals that the challenges from M2M communications arise mainly from the following requirements:

a. Support for a very high number of devices per cell.
b. Support for different traffic characteristics of M2M communications such as small message size and regular transmission intervals.
c. Low latency and high reliability.
d. Low and ultra-low power consumption.
e. Support for different mobility profiles

Finally, the requirement that human-to-human communication (i.e. normal operating network) must not be negatively affected by M2M communications.

5. Challenges[1]

I. Congestion in the random access channel, both for network entry and for contention-based bandwidth request mechanisms. A large number of devices attempting to access the channel at the same time needs mechanisms for prioritization and isolation between different access classes and device types.
II. Group management and addressing of devices.
III. Very long idle times to reduce power consumption.
IV. Efficient, low-overhead handling of small message sizes in conjunction with large transmission intervals.
V. Mobility management optimized for stationary or very high mobility scenarios.
VI. Lightweight and low-overhead security mechanisms.

6. Application of M2M Networking

6.1 Smart Grid

The smart grid is defined as an electrical grid which is specifically designed to improve the efficiency of power transmission, enhance the quality of service to utility users, and to reduce the economic and environmental cost of power generation, distribution and consumption. The smart grid is a combination of a power network and an information network. The distributed nature of an electrical grid, the sensors required to aggregate usage information, and the various tiers of decision making (from home energy management to power generation scheduling) makes M2M principles particularly applicable to the smart grid. For this reason, the smart grid is considered one of the strongest driving forces for M2M communications [2].

In the smart grid, all devices in every home monitor their power consumption, aggregate the data and send it to the servers of the power utility. Multiple aggregators exist in the smart grid. One aggregator is present in each home to aggregate home device data and to optimize local electrical power consumption. Neighborhood aggregators can also exist to aggregate data from multiple homes. After neighborhood aggregators send their collected data to the power utility servers, the power utility company knows how much and when power is consumed by each house and which devices are consuming the power. This allows the utility company to preemptively increase power production to meet transient power requirements, turn off devices that are putting too much strain on the network, monitor the health of all devices in the power network and to improve billing for power usage [11].

6.2 Home Networking

The main purpose of home networking is media distribution, but home networking can also include elements of the smart grid as described earlier. Media distribution systems include media storage (media server), media transportation (Wi-Fi, Bluetooth, Ultra-WideBand (UWB) and media consumption (High Definition TeleVision (HDTV), smart phones, tablet computers, desktop computers). Home networking is currently receiving significant attention as an M2M network [6]. A home network is composed of various smaller home device sub-networks. Each sub-network can contain an aggregator that in turn connects to the Internet gateway (router). Examples of such sub-networks are Zigbee sub-networks (electrical appliances, air conditioner), Wi-Fi sub-networks (laptop, printer, and media server), UWB sub-networks (HDTV, camcorder), smart grid sub-networks (smart meters, smart thermostat, smart switch), body area sub-network (smart phone, monitoring instrument, body sensors) and Bluetooth sub-network (music center, portable audio player) [12]. Possible aggregators include a cellular phone for the BAN subnet and power meters for the smart grid subnet. Devices exist in the home that can be0020connected to the Internet to provide extra services to consumers. One example where the M2M paradigm might be employed is where a fridge in a home forms part of an M2M network. The fridge is able to collect data about the number and state of items that it contains, for example the number of eggs that remain and the amount of milk a container has. Many fridges can then be connected, via the Internet and their respective home routers, to report on stock numbers and states. The reporting can be done to a grocery store chain, which can run a dispatch chain that will replenish food items in all the houses that it oversees.

6.3 Health Care

Health care M2M networks are sub-networks within home networks. They are used to monitor peoples' health and inform those being monitored, as well as possibly their doctors, of any abnormal conditions that might occur. Data collectors in a health care network are body sensors to monitor various measures of good health, including blood pressure, temperature, heart rate, and cholesterol. Body sensors are connected to an on-person gateway, such as a smart phone, which also acts as the aggregator for all data collectors. Sensors send data to the smart phone which sends data over the Internet to health monitoring servers. Applications run on the servers that monitor the health of patients.

The M2M paradigm allows for the health of an entire population to be monitored in real time. Ambulances can be immediately dispatched to accident scenes and patients can be monitored at their homes just as effectively as in hospitals. A patient's doctor can also immediately be informed if her patient suffers a heart attack, for example. Health care M2M can also help to track the progression of a virus outbreak by monitoring specific symptoms of the population. Patients that are suspected of being infected by the epidemic can be notified to seek medical care.

7. Conclusion

Machine-to-Machine (M2M) communication is now playing a market-changing role in a wide range of business world. M2M communication applications and scenarios are growing and lead the way to new use and business cases. This contribution highlights the architecture of M2M communication, challenges which arise from the different M2M traffic and deployment characteristics on the radio interface of mobile cellular systems, as well as the current efforts in research and standardization to address the M2M communications requirements**.**

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