Review on Cognitive Radio Technology for Machine to Machine Communication

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Abstract. Recently, due to the rapid and fast ever growth number of connected devices/machines starting from our house hold appliances to the large industrial machines connected through wired/wireless communication network is becoming greater or larger. Hence, the electromagnetic undesirable state and interference become very critical issue as the spectrum resources we have is limited. However, a cognitive radio technology which automatically detects available channel spectrum, then accordingly changes its transmission or reception parameters to allow more occurring or operating at the same time in wireless communications in a given spectrum band at one location is a promising method for the challenges machine to machine communication facing this days. In this paper work, some detail survey of machine to machine communication and cognitive radio technology is introduced. Moreover, the challenges and advantages we get from combining cognitive radio and Machine to machine will be discussed.

Keywords: Cognitive radio · M2MS communication
Spectrum detection and sharing

1 Background

1.1 Introduction

The fast and continuous growth of the amount of data to be transferred/received through wireless communication networks is one of the main motivations to seek for the application of new communication systems all over the world. Nowadays, people are allowed to conveniently exchange voice, audio, video, emails and images with anyone, any-time and any-place with any terminals, machines or devices. In addition to the conventional human communications, new aspects and use of machine-to-machine (M2M) communications are drawing overwhelming attention in both the academia and the industry [1].

The M2M wireless communication has recently included to where devices can connect and communicate over wireless channels with less or without human intervention. The data are produced, processed, and exchanged through a fully automatic fashion. Very few human intervening and control is substituted by

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Table 1. Number of connected devices [2]

World population	6.3 billion	6.8 billion	7.2 billion	7.6 billion
Connected devices	500 million	12.3 billion	25 billion	50 billion
Connected devices/person	0.08	1.84	3.47	6.58
Year	2003	2010	2013	2020

self-configuration, self-management, self-organization, and self-healing processes from smart services, such as smart city, grid, home, meter, etc. M2M communications reduce prices and allow a large degree of efficiency that affect individual as well as industrial uses [1,2].

Any devices can be connected with M2M system networks and be larger in number the world population as depicted in Table 1 below. The joined devices in the system involves entities like: power and gas meters that report usage data, wearable monitors that tell a doctor when a patient needs to come in for a check-up, traffic monitors, and cars that describe their place and condition to authorities in the event of an accident, any other sensors, cameras, computers, pumps, heating modules etc.

As indicated in the table above there are a number of issues that M2M Communication by having billions of devices connected/inter connected, our world is facing some problems like the main reason of spectrum congestion due to the scarcity of the limited spectral resources, power consumption and electromagnetic pollution problems. Furthermore, wireless coverage to rare density around countryside areas (M2M facing blockage in remote areas), due self-existence or co-existence interference problem and large number of different machines as well as diverse services, which causing diversity in network protocols and data formats(machines heterogeneity) is experienced [2].

To tackle these problem by looking at the spectral tuning to deal with the ceaseless increment of connected machines, currently some researchers proposing a new communication paradigm cognitive radio technology for machines to raise the scalability, flexibility, efficiency and reliability of M2M communications. Cognitive radio technology enabled machines are able to sense and utilize idle frequency bands in their environments. This technology utilizes the existing in possibility that wireless system has when they are context attentive and capable of readjustment based on their environment conditions and their own attributes.

Usually, two systems coexist in same frequency ranges which are named as the primary user and the secondary user in M2M system. The primary user has the sole right to use the assigned frequency spectrum. The secondary user is the opportunistic access unused spectrum from licensed frequency spectrum, e.g., TV broadcast systems. By adding a new cognition dimension, cognitive radio for M2M is intelligent and easily adjustable and much more capable than normal M2M communication. For example, using cognitive in M2M communication can extract unused radio spectrum resources such that the notorious spectrum congestion problems in conventional M2M can be highly maintained [1].

1.2 Objective

1.2.1 General Objective

The main propose of this paper work is to explore application of using cognitive radio technology in machine to machine communication.

1.2.2 Specific Objective

The specific objective of this paper is:

- To make a detail survey on machine to machine communication.
- To discuss some main challenges of M2M communication system.
- To explain the practical applications of cognitive radio in detail.
- To discuss fundamental characteristics of cognitive radio technology.
- To analyze the difference between conventional and cognitive radio M2M wireless communication system.

2 Machine to Machine (M2M) Communication

2.1 Introduction

Machine communication system depict mechanisms, algorithms and technologies that enable networked devices, whether it is wireless or wired, and services to exchange information or control data seamlessly, with only very limited human interaction. It is about enabling direct communications among electronic devices, and it can use both wireless and fixed network communication [3].

2.2 General Architecture of M2M Communication

The characteristics of M2M communications are completely different from those of traditional system networks. M2M networks are framed of very large amount of nodes, since the main target of participating in communication is a device or object. Because most devices/objects are battery operated, energy efficiency is the greatest significant issue, as for the machines senses itself or its physical surrounding condition, the aggregation per connected things becomes very small. However, data are generated from a large number of objects, and because the data generation period, amount, and format are all different, a large quantity of data is generated. While M2M communication can occur with very limited human intervene, functional constancy and sustainability are also required.

In 2009, the ETSI were established the M2M technical committee with the purpose to develop an end-to-end architecture for M2M communications. According to ETSI, an M2M system is composed of the five key elements with its functions are mentioned in [4,5]. In the M2M domain, a potentially large number of nodes and M2M gateway (GW) are integrated to enable automated and diverse services. Each embedded node as flexible and smart device should be equipped with various functions, such as data acquisition, data preprocessing, data storage, distinctive address, wireless transceiver, power supply, etc. [7].

In the network domain, a high quantities of heterogeneous Points of Attachment (PoA) potentially coexist. Here, convergence of heterogeneous networks (e.g., xDSL, LTE, WiMax, WiFi, etc.) in an optimal way supply cost effective and reliable channels for sensing signal information packet transmission from M2M to the application layer.

Finally, in the application area, various real time services for remote management monitoring are provided and can be classified into several categories, such as traffic, logistic, business, home, etc. Back-end server is the key component for the whole M2M communication system. It makes the integration point for all gathered data from M2M device area [5].

2.3 Challenges of M2M Communication

Currently M2M communication has an active application in different areas such as surveillance, intelligent transportation, emergency alert, ehealth, security, smart grid, home automation and smart metering. Hence, a capably large number of machines are deployed with the purpose of gathering information and transmitting it over a network to processing units. LTE cellular networks try to present a strong contender for M2M communications due to its native IP connectivity and its scalability to support a massive number of devices in wide areas [8].

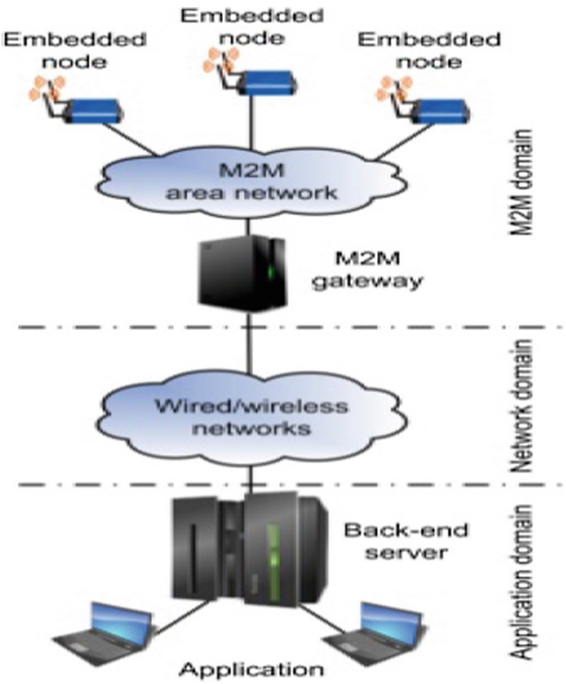

Fig. 1. General M2M communication architecture [6]

The major challenges for M2M communication networks include the following:

1. Group-based of M2M: The ultimate propose of grouping a number of M2M machines is to make easier the traffic pollution on the air interface by reducing communication loads between an M2M device and 3GPP E-UTRA and EPC. Additionally, an other very curial main requirements in wireless M2M network system is to lower energy dissipation [9].

2. Heterogeneity: The technological potential requirements to integrate many types of devices, especially,in terms a of their technologies and services are the main highly expected achievements from M2M communications in current and future networks to be successful. At the device domain, this includes a lot of various features in terms of packet/data exchange capabilities (e.g., data rates, latency, and reliability, flexibility in handling different technologies, availability of energy, computational and storage power, etc. [8]).

3. Scalability: One of the main consideration when we deal with M2M communications is scalability. Of-course, the produced information as well as the network traffic will rise as the number of devices raises from time to time, which may contribute to the scalability issues. Lets consider, for instance, the case of several devices trying to simultaneously perform network authentication. Since the existing mobile technologies have not been designed to hold up such a massive number of machines, this would probably will be the main consequence of traffic network system pollutant [10].

Therefore, the design of scalable authentication mechanisms is very important particularly in the case of real-time scenarios. On an other point of view, some scenarios (e.g. home automation, city automation,) going to include numerous M2M machines that ensure their data exchange using the common key. In the case of a have in common key, a scalable key management plan that modifies the update of the shared common key following state changes (join/leave of devices) is required [4].

4. Security: Within the same spectrum resource application area, there may be individuals or organization with different access rights. Hence, an afforded organization or individuals should not be able to see information which he is not appropriated to.

5. Energy Management: Energy management reaches up-to energy harvesting, conservation, to consumption is an overwhelming issue in the M2M communication context in 3GPP LTE/LTE-A networks. Decreasing energy dissipation and consumption is one of the main problems in M2M communications. The development of novel solutions that maximize energy efficiency is essential. Network protocols will have to deal with inherent characteristics of M2M communications such as long sleep cycles, energy and processing power constraints, time-varying radio propagation environments, and topologies varying with node mobility [8].

3 Cognitive Radio (CR) Technology

3.1 Spectrum Scarcity

Radio spectrum may be one of the most tightly regulated resources of all time. From simple cell phones to garage door opener, nearly almost all wireless machines depends on access to the radio resource spectrum. But access to spectrum has been chronically limited ever since RF transmissions were first regulated in the early 20th century [11]. This all will be exchanged/replaced by new technologies that use spectrum more efficiently and more cooperatively, unleashed by regulatory reforms, may soon overcome the spectrum shortage [12].

3.2 Spectrum Sensing and Sharing

Spectrum sensing is one of the very significant portion CR techniques that enables the secondary users that makes able to measure, sense, learn, and be aware of the portions related to the radio environment, availability of spectrum and power, user requirements and applications, available networks infrastructures, local policies and other operating restrictions [13]. This functionality enables the primary users to adapt to the dynamic environment by detecting and opportunistically using spectrum holes without causing interference to the primary network [14].

3.3 Spectrum Mobility

When the channel state at a particular time becomes very bad or if channel is occupied by licensed users, using the same spectrum band is detected, spectrum mobility issues arise. If the channel bands in use is required by a licensed user, the unlicensed user must vacate those spectrum band and continue its communication in another vacant portion of the spectrum. Several methods have been proposed to design spectrum mobility in order to reduce delay and loss during spectrum hand-off. Spectrum hand-off is handled in IEEE 802.22 by using the method of IDRP, which supports the network to recover its normal activity maintaining an acceptable level of QoS [15].

4 Cognitive Radio in M2M Communications

4.1 Architecture of Cognitive Radio for M2M

As depicted in Fig. 2 below expresses the proposed Cognitive radio M2M networked system architecture. The network parts are categorized into two principal components: the licensed system and unlicensed M2M system [16].

Generally, a cognitive M2M network is only allowed to access the spectrum holes in an opportunistic way, without causing disturbance to the primary network. Cognitive machines communicate with others by opportunistically accessing the spectrum and finding free spectrum bands. At the same time, a cognitive machine carry out a function like data generation/processing/actuation and controlling of the physical appearance. A cognitive AP is an data collecting/transfer point in a LA cognitive M2M network. And also, some performance as an packet/data entrance to the surrounding networks, for instance, the Internet. A Secondary BS governs the machines that are exchanging information within its network area/scope in a centralized Cognitive M2M system. The alternative spectrum geo-location database is communicating with all the secondary BSs, and responsible for coordinating the spectrum allocation among multiple cognitive M2M networks [1].

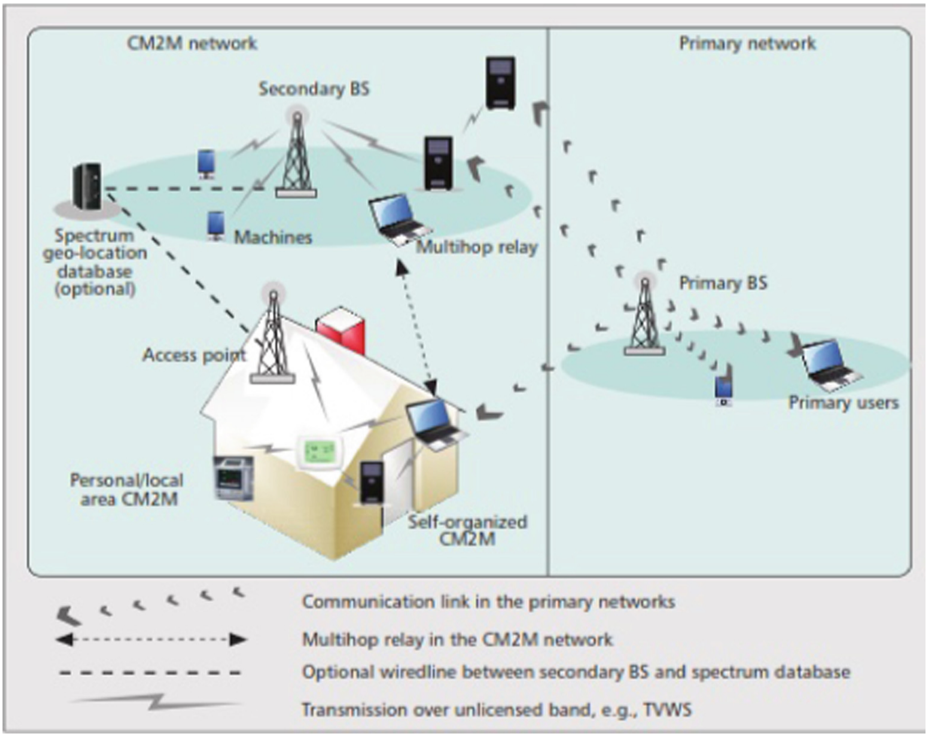

Fig. 2. Cognitive M2M network architecture [1]

4.2 Proposed Solutions of M2M Communication Issues Using Cognitive Radio Technology

The M2M communications main objective is to support a huge numerous smart devices so they can function properly. The usage of this technology to M2M is a capable way to make M2M more efficient in terms of spectrum utilization. Some of the basic challenges are:

(1) Device massiveness: The fundamental practical applications of cognitive radio spectrum is to reach shortcoming of spectrum resource scarcity in present data/package communications. Mitigation/lowering of spectrum congestion is one of the main target for using CR in M2M communications. The main challenge in M2M communications is the ever increasing number of devices/machines want to inter the system. This poses a significant challenge for any existing communication network. CR technology handles large-scale information exchange by utilizing larger portions of the resources.

(2) The need to be green: Cognitive machines in a secondary network has to have the potential of adaptively tuning their receiving/transmission power levels depending on the operating environments, free from assurance of interposing primary system network and meanwhile, not causing spectrum pollution. Such intrinsic context-aware and adaptable performance differs CR technology as a key enabler for the future generations environment-friendly radio systems from others [1].

(3) Interference reduction: Users almost everywhere experiencing an intensive electromagnetic interference within the internal primary networks and with external/secondary users. Due to this and other reasons the performance of M2M communications may be becomes highly poor. By increasing the potential of software dependable re-adjustable of CRs, machines are able to rapidly switch among different wireless modes, and hence potentially be allowed to radical mitigation of the interference with other machines or the external radio environment.

(4) The management of heterogeneous machines and protocols: An M2M network comprises a large number of different machines as well as diverse services, which may cause significant diversity in network protocols and data formats. The cognition ability is beneficial for M2M communications to deal with the machine and protocol heterogeneity. An M2M network will be more efficient and flexible if all machines are smart enough to communicate with the others freely [2]. Weightless.

5 Conclusion

Cognitive radio technology play very important role in the growth of current wireless M2M transceivers technologies. Densification of existing wireless communication networks with the massive addition of devices/machines and a provision for peer communication is one of big challenge. This dramatic development of wireless M2M communication applications have remarkably increases the demand of free spectrum bands. Hence, cognitive radio technology is showing possibility of best achievement for employing the unusable/available frequency spectrum resources with an efficient manner in the way of opportunistic spectrum utilization.

Generally, this work presents a review of how to exploit the existing radio spectrum resources in a dynamic and opportunistic way, by using CR techniques in M2M communication. And also, this distinctive M2M applications that can play a critical role in our future life were illustrated. Finally, the Challenges of

CR technology in M2M Communication and proposed solutions were pointed out in order to initiate further researches.

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