D2D COMMUNICATION TECHNOLOGY: AN IMPORTANT TOOL FOR RESERVOIR AUTOMATION AND MANAGEMENT SYSTEMS.

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ABSTRACT.

Device to Device(D2D) communication is an essential part of the future automation and improvement of the gas station that can be seen as a “network of networks” consisting of multiple seamlessly integrated radio access technologies. Devices unanimously communicate with each other in a gas station in a bid automate and manage the process. Such devices include sensors, microcontrollers as well as actuators. and the wifi module could communicate when properly interfaced. They communicate through a media, the media adopted in this work is the wifi because it is quite ubiquituous and common. This system describes how the sensor picks up signal from the reservoir, via its interface with the microcontroller to send same signal over to the the cloud through wifi and from where the servers pick up the same signals. This whole process doesn’t require human intervention till the end user reads data from the output device. This paper discusses the basic concept of D2D,M2M. It further showcases the processes involved in realizing the system. Subsequently, tests are performed in real time for realization and proof of its high level of efficiency. This reduces irregularities and miscalculations in the operations of the gas station. A GSM technology is used, it helps the system to be installed in industries, liquid storage fields, oil-tank and trucks. These measurements are sent to a server via a GSM module through WIFI. The WIFI is activated and the TCP/IP sockets are used to

communicate to and from the server. The server stores the values in memory and ensures that fluid inventory levels are maintained, and helps in identifying problems such as tank leaks and fluid theft.

Keywords: Device to Device, microcontrollers, sensors.

INTRODUCTION

Reservoirs are major concepts of fluid dispensing which forms the thrust of this work. A filling station, gas station or petrol station is an establishment that sells fuel and lubricants usually gasoline (petrol) or diesel fuel. Some stations carry fuels like liquefied petroleum gas (LPG), natural gas, or kerosene (Okemiri 2016) The term “gas station” is mostly particular to the United State and Canada, where petrol is known as “gas” or “gasoline”. Elsewhere in the English-speaking world the form “petrol station”, “petrol pump”, or the old fashioned term “petrol garage” is used**.** Mobile M2M communications face many technical challenges despite the promising benefits in terms of revenue opportunities and cost reductions in maintenance and resources.

When resources are scarce, profit margin is thin, and traditional methods of business are inadequate, private and public organizations often seek technology-based solutions to resolve overarching challenges. The motivation to innovate can be especially acute in retail, where new technology can greatly influence the success of a single business or even an entire field. For example, the mechanics of operating a fuel station in some areas of the world, including India, had until recently remained mostly static for decades. Methods for calculating how much fuel a station sells and has in its inventory were mostly inefficient and inaccurate, directly contributing to wasted resources, reduced revenue, and customer dissatisfaction.

Knowing exactly how much fuel you have in underground tanks and what’s being sold is a critical component of efficient, revenue-generating fuel station management

The author Priyaranjan Mishra *et al.* work had been carried out in many papers regarding the fuel station and embedded systems, which has been selected as a reference for our proposed system.Innovative solutions to tackle emergency applications need to be designed for critically sensitive application and can be achieved by developing effective embedded software, WSN architectures and communication protocols, which are robust, thereby increasing the lifetime of the network. Analog to Digital Converters (ADC’s) can be used to interface the sensors, which are used in data acquisition and sensing the parameters, to help in building sensor interface to the

control unit (microcontroller). The collected data will need to be wirelessly transmitted and that can be done by using WSN services which introducing low power and low cost features (Shakah,2013).

Scalability is another important parameter and determines the longevity of the system. A system thus developed should be scalable without major changes to the working system. There are systems which have been implemented for specific liquids like water. Typically, the measurements of liquids are done using various sensors which need physical contact with the liquid. These might induce wear and tear and introduce maintenance costs and decrease the longevity of the system (Ebere, 2013). Ultrasonic sensors can be used tosense the liquid level by placing the sensors at a specified portion in the tank, calculating the level of liquid by time of flight of the ultrasonic wave and correlation with respect to the dimension of the tank, to get a more accurate value (Johari, 2011). The values thus collected needs to be sent to a server using a wireless communication medium, so that this can be correlated at the server for display on the tank software system. The data collected at the server end is displayed on a GUI , thus communicating to the user about the level of liquid, in real time and also evaluating the variation of liquid levels over a period of time.This would accommodate efficient storage, dispensing of liquids and chemicals inside the tanks.

LITERATURE REVIEW

Several review papers discussed D2D communications in the context of wireless technologies by focusing on various D2D applications such as e-healthcare,smart metering, smart grids, IoT paradigm,and radio resource management. For instance, authors in (EKartsakli,2014) addressed the D2D e-healthcare application, i.e,m-Health, by highlighting the benefits of using D2D technology for both patients and service providers due to reliable autonomous communication.

Furthermore, in (E Kartsakli, 2014) a first detailed analysis of wireless body area networks(WBANs) towards the patient side is provided,and various end-to-end (E2E) solutions for practical e-healthcare applications were discussed. The authors in (ZmFadlullah et al 2011), surveyed a number of existing communication technologies which can be used for D2D communication in smart grids.

Franz and Woodmanse (1990) developed a rule-based semi-automated decision support system for a regional oil company to determine the daily schedule of the drivers and the dispatching of the tank trucks.

In 1933, a company, Fort Wayne of Indiana, manufactured a pump with a mechanical calculator called a variator. The variator indicate how much petrol was being pumped by utilizing a revolving number wheel, whereby the price is displayed by a second wheel.

D2D employs and reinforces a convergence of various technology families, such as IP, RFID, sensor networks, home networks, smart metering, etc. Its communication principles are present in many different industry verticals. Some of the most prominent D2D supported application areas are :

- security – surveillance applications, alarms, object/human tracking, etc.;
- transportation – fleet management, emission control, toll payment, road safety, etc.; remarkably interwoven with Intelligent Transport Systems (ITS) concepts;
- e-Health – remote patient monitoring, Mobile Health, telecare;
- manufacturing – production chain monitoring and automation;
- utilities – measurement, provisioning and billing of utilities such as oil, water, electricity, heat, etc.;
- industrial supply and provisioning – freight supply and distribution monitoring, vending machines, etc.;
- facility management – information and automation of various home/building/campus-related resource management.

Many industry participants, especially in the telecommunications domain, have recognized the business opportunities that M2M represents and are striving to exploit its full potential.Authors in (M.yang,2014), discussed applicability of software-defined networks and network virtualization to mobile and wireless networks. Additionally, authors in (M chen,2012) highlighted the correlation between M2M, wireless sensors networks (WSNs), cyber-physical systems (CPS),and the IoT. Furthermore, the authors proposed an M2M system integrating intelligent roads with unmanned vehicles. Authors in (K Chen, 2013), surveyed several M2M communication scenarios in the context of wireless technology and a machine swarm of a large number of devices and explored their practical realizations.

Authors in (AG,Gotsis, 2012, K zheng,2012),presented various radio resource management and scheduling schemes for mobile M2M communications. Moreover, issues regarding random access due to the large number of devices using mobile networks are addressed, e.g., in (M Hasan,2013) and (S lien 2011).

M2M ecosystem

M2M uses a device (sensor, meter, etc.) to capture an 'event' (temperature, inventory level, etc.), which is relayed through a network (wireless, wired or hybrid) to an application (software program), that translates the captured event into meaningful information (e.g., items need to be restocked).

Thus, the eco-system has a defined hierarchy with a broad layer of M2M enabled devices, realized through the embedded chipset. These building blocks along with embedded wireless communication modules shape up to various customer devices/applications like Cameras, Sensors, and Readers. These applications then ride on a consumer product segment like Security, Fleet Management, and Health care device and inter-operate in a Wireless technology domain. The final enabler to this ecosystem is the various innovative M2M software applications that collect and enable intelligent decisions around the M2M value chain.

The Gas Station Automation System

The Gas Station Automation System provides monitoring, control and management of Gas Station with following major components:

- Forecourt Controller: To monitor and control forecourt activities
- Outdoor Tank Level Gauges: To provide measurement of product and water level, temperature and volume re-conciliation
- Back Office System: To provide management and configuration of gas station having modules for:
  - Wet Stock Management
  - Financial Accounting
  - User Management

- Reports
- Gas Station Configuration

D2D Communications and Network Coding

In 2009, the author Afif et al. Introduced two concepts which had not been present in cellular systems. Both of these concepts are used to increase the efficiency of cellular communication systems, especially from a network point of view. The result is to achieve sufficient SINRs (the signal-to-interference-plus-noise ratio (**SINR**) (also known as the signal-to-noise-plus-interference ratio). Multi-antenna receivers are required to allow device-to-device communication. D2D connections re-use cellular resource within the cell. The author shows that user grouping in a multi-user network improves substantially the capacity of network coding. As a solution, a low complexity user grouping strategy was introduced and showed that when applied with a window size of 6, the user grouping algorithm provided mean capacity gains of 34% and 16% as compared to random network -coding.

D2D Supports in Cellular Networks.

Nowadays cellular networks offer wide coverage areas, high data rate, and decreasing latency. Therefore, they are a key enabler of D2D communications. D2D communication is considered to be one of the key technologies in future wireless systems capable of increasing spectral Efficiency. Providing direct communication between devices will decreases latency and also offload data from base station. The problem of radio spectrum congestion due to increasing demand for wireless communications services, cellular communication systems which have small transmitted power and are implemented in device-to-device communication are investigated and it was shown by results that currently available full-duplex radios can be used in device-to-device communication. Power control, resource allocation and interference-limited-area are used to deal with the interference that is the results from resource sharing

M2M Support in Wireless Networks

M2M devices using radio technologies have some problems from cellular networks and wireless networks. In mobile-to-mobile cooperative communication systems, the author BatoolTalha introduced the analysis of a large variety of M2M fading channels and presents the state-of-the-art information regarding the modelling in cooperative systems. In this work the

author modelled and analysed narrowband M2M fading channels in cooperative network systems under line-of-sight(LOS) as well as non-line-of-sight(NLOS) propagation conditions. The performance of dual-hop-multi-relay cooperative systems introduced over M2M fading channels with Equal Gain Combining (EGC)and line-of-sight propagation conditions was evaluated. It is concluded that, the dual-hope-relay-system with Equal Gain Combining (EGC), improves the systems performance of line-of-sight components in the transmission links.

M2M Support in Cellular Networks

The cellular networks offer wide coverage areas which have high data rate, and decreasing latency, and therefore they are enablers of M2M communications.

(Marwat et al,10) argue that, even in the presence of regular mobile M2M traffic and LTE traffic cannot be considered negligible, and it can have some impact like dramatic impact on the LTE network performance in terms of Quality of Service (QoS)

Cooperative D2D Communications

Shalmashi et al. proposed a cooperative device-to-device communications in order to combat the problem of congestion in crowded communication areas such as the shopping mall and open air festivals. The idea is to allow a D2D transmitter which acts as an in-band relay for a cellular link and at the same time transmits its own data in the downlink. It observed that the D2D receiver is able to cancel the cellular user signal which can improve the achieved data of the D2D link in most cases

Formation of Devices

The device-to-device communications have several benefits. The author Pankil et.al.discussed what can be their blocking probability in cellular cells as well as formation of D2D groups. The blocking probability describes for D2D communication which devices are ready to communicate with each other. It was concluded that if all the devices get connected it means there is no blocking of the devices for communication when the traffic load is less. As the load increases, the blocking probability also increases.

Further, the “autonomous nature/intelligence of machines” in M2M communications creates some potential communication issues, e.g. in this technology, billions of devices communicate

for a number of operations, resulting in congestion and overload in the networks and generating various types of data traffic. Some of the important challenges in M2M communications include energy efficiency (Lu et al., 2011), reliability, security, ultra-scalable connectivity, heterogeneity (Zhang et al., 2012a), and Quality of Ser-vice (QoS) (Zhang et al., 2011).

CLASSIFICATION OF D2D COMMUNICATIONS

D2D communication in cellular networks can be categorized into both Inband D2D and OutbandD2D based on the spectrum in which D2D communications occurs (Zhijianlin et al 2015).Inband underlay mode occurs when the D2Dcommunications use the cellular resources and spectrum and while Inband overlay mode occurs when cellular resources are allocated to the two D2D end devices that communicate directly.High control over licensed spectrum is the key motivating factor for choosing the Inband D2Dcommunication. In other hand , the main motivation of using Outband D2D communications is the capacity to eliminate the interference between D2D links.Furthermore, Outband D2Dcommunications is faced with a lot of challenges in the coordination between different bands.

Inband Communication

The motivation for choosing inband communication is the high control over licensed spectrum.(K Akkarajitsakul 2012), Results show that QoS provisioning had lot of requirements by the consideration of the uncontrollability of interference in the unlicensed spectrum . The author in (Doppler 2009),carried out feasibility studies of D2Dcommunications and its impacts in licensed spectrum by simulation and analysis of different scenarios and authors show that by tolerating the increase of interference in licensed spectrum, the D2D communication will be possible .

To improve the spectrum efficiency, the D2D inband can reuse the time and frequency resources by d2D users (i.e Underlay) or allocating time and frequency resources occupied by D2D users(i.e overlay)(Chithra B Das 2015). Under this, Inband communications can be divided into underlay and overlay categories.The most disadvantage of inband D2D is the interference caused by D2D users to cellular communications .This interference can be mitigated by introducing high

complexity resource allocation methods, which increase the computational overhead of the D2D users.

Underlay Inband D2D mode

In underlay inband mode, cellular and D2D communications share the same radio resources. To date, most of the papers in literature are dedicated to D2D communications underlaying cellular network (T Peng 2009)(H.E Elkotby et al, 2012).Underlay inband can improve and enhance the performance parameters of different targets such as spectrum efficiency, energy efficiency,and cellular coverage by the use of different techniques including diversity techniques,interference reduction ,resource allocation and by using nework coding (A. Osseiran et al,2009)(B.Zhou et al 2013).The journals by (S.Xu, 2010), (X. Chen etal, 2012) and (M.Ji et al 2013) adopt more advanced mathematical techniques than the others.

The papers by (H.Min, et al 2011) and (G. Fodor, 2012) define and propose new algorithms and interference management strategies to achieve overall capacity enhancement and to solve mode selection problems in cellular networks and D2D systems .Another method was proposed by (R,Zhang et al 2013) The computational complexity of the above mentioned method is higher but it is better than those proposed in (H.Min, et al 2011) and (G. Fodor, 2012).To improve the system performance of D2D cellular system with QoS and power constraints,advanced techniques are required. These techniques include stochastic optimization, nonlinear programming, and integer optimization (N. Golrezaei, 2012).Several research papers have an interest in resolving interference problems in D2Dcommunication underlaying cellular networks (Bin Guo et al 2014) (K.Doppler et al 2009).The author (S.Shalmashi, et al, 2013)in his paper using numerical results discuss different problems such as interference management , Optimization of Transmission Power and throughput maximization of D2D communications in the case of the coexistence of many D2D users and one cellular user .An interference avoidance scheme and system model is proposed by (J.Shin et al 2013). This scheme is based on overhearing the received signal power of cellular user equipments.New management method is presented in the journal by (H.Min et al, 2011) to enhance the overall capacity of cellular networks and device-to-device (D2D) systems. The integration of D2Dcommunication in a LTE-Advanced network is discussed in (K.Doppler et al, 2009). In the same way, authors propose different mechanism such as D2D communication session setup and management procedures.

Another scheme was given (Bin Guo,et al, 2014) to manage the interference between D2Dcommunications and cellular network . The author (Ji Lianghai K, 2014) proposed a network controlled algorithm with low computation complexity to efficiently maximize the reuse of cellular network spectrum and to minimize system capacity. Finally, by allowing underlying direct D2D communications, LTE-advanced mobile network can offer several advantages such as low end-to-end latency and high spectral efficiency.

Overlay Inband D2D mode

In this mode, cellular and D2D are given dedicated cellular resources and those cellular resources are subtracted from cellular users in order to eliminate interference for the D2D communications on cellular transmissions (J.C.Li, 2012). According to (G.Fodor et al, 2012) a BS-assisted scheduling and D2D power controlwas proposed in order to reduce D2D interference. The authors of (B.Zhou,2013) and (J.C.Li, 2012) focused on relaying use-case of D2D. Specifically, (J.C.Li, 2012) proposes to use the BS as a backup transmitter for D2Dtransmission and (B.Zhou,2013) as they use multiple D2D users as relays for multicasting. The performance of the proposed methods and algorithms are under low complexity which makes them practical for real scenarios on the other side, propose a network controlled algorithm to maximize the cellular network spectrum reuse and to provide high performance for D2D users

Outband D2D communication

Nowadays , Outband D2D communication is attracting the attention of many researchers .In this category , D2D communication is performed in the unlicensed spectrum such as ISM 2.4Gwhich made the interference between D2D and cellular communications impossible. On the other hand, Outband D2D my suffer from the uncontrolled nature of unlicensed spectrum. To exploit the unlicensed spectrum it is necessary to have another extra interface that implements WIFIDirect,Zig Bee or Bluetooth(W.Alliance, 2010).

The coordination between two different bands for achieving Outband D2D communication has a lot of challenges because in most cases the D2D communications occur in the abovementioned extra interface .Outband D2D communication can be classified into two categories or modes depending on the occurrence of the second interface .

These modes are called controlled mode when the second interface in under cellular network or autonomous when D2Dcontrol is done by users and the occurrence of the second interface is not under cellular network. There are also several literatures that refer to Outband D2D communications. In(A.Asadi, 2013) paper ,energy efficiency and throughput performance are boosted by the use of gaming theory and clustering. The works in (C.Xu,et al, 2012),(J.C.Li et al 2012), and (A.Asad, 2013) aim to improve the performance of content distribution

D2D Outband communications: Controlled mode

In this category of D2D communications, all the literature propose the use of the cellular network advanced management features to control D2D communications in order to improve the efficiency and reliability of D2D communications and also the system performance in terms of throughput, power, efficiency and multicast.The authors of (N.Golrezael. et al, 2012) and (A.Asad,2013) papers discuss how D2D communications can be one of the key issues of the improvement of energy efficiency and throughput. They propose a novel schemebased on users cooperation as it provides also an analytical model to evaluate throughput and power consumption for the proposed scheme.

D2D Outband communications: Autonomous mode

Nowadays, there are very few works on this category. Autonomous D2D communication is motivated by reducing the overhead of cellular network. This category does not require any changes at the base station and can be deployed easily. The authors of (A.Asad, 2013) assume that the BS does not always have traffic to send to all users at any time. They depict a scenario with two users, u1 and u2 that are being served by one BS. They formulated the problem of choosing the optimal dispatching policy as a Markov decision process and studied it’s properties. Simulation results showed in (A.Asad, 2013) demonstrated that by considering the above mentioned approach, delay performance can be improved and the major performance requirements is to increase power expenditure .

METHODOLOGY

Utility companies, for instance, use M2M communications, both in harvesting energy products, such as oil and gas, and in billing customers. In the field, remote sensors can detect important

parameters at an oil drill site. The sensors can send information wirelessly to a computer with specific details about pressure, flow rates and temperatures or even fuel levels in on-site equipment. The computer can automatically adjust on-site an equipment to maximize efficiency.

Machine-to-Machine (M2M) communication has its origin in the supervisory control and data acquisition (SCADA) systems, where sensors and other devices being connected through wired or radio frequency networks are used with computers to monitor and control industrial processes.

This process is subdivided into various modules which are:

- Hardware module
- Software module
- Application(Web) module.

The hardware module consists of the sensors, monitors, actuators and other devices that makes up the machine. These various devices are placed at strategic positions. The M2M devices of the gas station automation are designed to measure and transmit signals to a flexible and scalable M2M network. M2M nodes connected to tank sensors are placed in the tank and are mainly responsible for collecting and transmitting signals. All M2M nodes come with their own unique IP addresses that is connected to the M2M gateway. Each of these nodes consists of a very-low power microcontroller, external memory and a transceiver unit packed in a small board. These devices are connected to the tank and also the dispensing pump to monitor both discharge of product into the tank and also the dispensing of products from the various pumps and subsequently communicates with the minicomputer to upload real time values.

The other is the software which interfaces the hardware devices with the computer system to enable the devices communicate with the minicomputer efficiently with the help of a microcontroller. Since we want to make the automation in real time we would need to interface the whole system with the internet for real time monitoring and management. So a web application will be developed linking the sensors, actuators and devices.

The proposed system which includes a windows application as user interface, a cloud database to store and retrieve data. A software requirement is like the brain for these mechanical devices

which are hardware components. These would be controlled through the instructions given by the software from the programmers. Their use in this scope takes control of login data, sensors data, and some commands for the effective control of the system. The product has been designed based on the user requirements. Here, the productmust have to get the sensors data from the sensor by Arduino and sends data collected. Then the Software developed for data processing. The PHP programming language code was deployed in the software developed.

CONCLUSION

Devices to device communication is an important tool which can be use to effectively improve and enhance the operations in a gas station. This paper describes the various devices ranging from the sensors, microcontrollers and the WIFI module which can be used to automate and enhance the operations in a gas station. This also makes the monitoring and operations of the whole system accurate and more adequately recorded. With the help of these devices, recording and monitoring of the entire processes in the underground tank would be effectively managed. All the present fuel stations are manually operated and this system will introduce and new and automated way of using several devices which communicate with each other to automate the process in the gas stations.

For future works, one can use more sophisticated sensors to read data from the tanks and also better wifi modules for easier and faster internet services.

REFERENCE

AG Gotsis, AS Lioumpas, A Alexiou, M2M scheduling over LTE: challenges and new perspectives. IEEE Veh. Technol. Mag. **7**(3), 34–39 (2012)

Afif et al“Advances in Device-to-Device Communications and Network Coding for IMT-Advanced”.1Ericsson Research, Stockholm, Sweden. ICT-Mobile Summit 2009 Conference Proceedings Paul Cunningham and Miriam Cunningham (Eds) IIMC International Information Management Corporation, 2009 ISBN: 978-1-905824-12-0.8p

A.Osseiran, K. Doppler, C. Ribeiro, M. Xiao, M. Skoglund, and J. Manssour, “Advances in device-to device communications and Network coding for IMT-Advanced,” ICT Mobile Summit, 2009

A. Asad ,V.Mancuso" On the compound impact of opportunistic scheduling and D2D communications in cellular networks", Accepted for publication in ACM MSWIM, 2013.

BatoolTalha, "Mobile-to-Mobile Cooperative Communication Systems: Channel Modelling and System Performance Analysis", Degree Philosophise mDoctor (PhD) in Information and Communication Technology, 60p. September 2010

B. Zhou, H. Hu, S.-Q. Huang, and H.-H. Chen, "Intraclusterdeviceto-device relay algorithm with optimal resource utilization," IEEE Transactions on Vehicular Technology, vol. 62, no. 5, pp. 2315–2326, Jun. 2013.

Bin Guo, Shaohui Sun, Qiubin Gao "Interference Management for D2D Communications Underlying Cellular Networks at Cell Edge" ICWMC 2014 .

Chithra B Das "A Study on Device To Device Communication in Wireless Mobile Network" International Journal of Modern Communication Technologies & Research (IJMCTR) ISSN: 2321-0850, Volume-3, Issue-3, March 2015.

C. Xu, L. Song, Z. Han, D. Li, and B. Jiao, "Resource allocation using a reverse iterative combinatorial auction for device-to-device underay cellular networks," in Proceedings of IEEE GLOBECOM, 2012, pp. 4542–4547.

Ebere, E.V. and Francisca, O.O., 2013. Microcontroller based automatic water level control s System. international Journal of Innovative Research in Computer and Communication Engineering, 1(6), pp.1390-1396.

E Kartsakli, AS Lalos, A Antonopoulos, S Tennina, MD Renzo, L Alonso, C Verikoukis, A survey on M2M systems for mHealth: a wireless communications perspective. Sensors.**14**(10), 18009–18052 (2014)

Franz LS, Woodmanse J (1990) Computer-aided truck dispatching under conditions of product price variance with limited supply. J Bus Logist 11(1):127–139

G. Fodor, E. Dahlman, G. Mildh, S. Parkvall, N. Reider, G. Mikls,and Z. Turnyi, "Design aspects of network assisted device-to- device communications," IEEE Communications Magazine, vol. 50, no. 3, pp.170–177, 2012.

H. E. Elkotby, K. M. Elsayed, and M. H. Ismail, "Exploiting interference alignment for sum rateenhancement in D2D-enabled cellular networks," in Proceedings of IEEE WCNC, 2012, pp. 1624–1629

H. Min, and J. Lee, "Capacity Enhancement Using an Interference Limited Area for Device-to-Device Uplink Underlaying Cellular Networks," IEEE Transactions on Wireless Communications, vol. 10, no. 12, Dec. 2011, pp. 3995-4000.

Johari, A., Wahab, M.H.A., Latif, N.S.A., Ayob, M.E., Ayob, M.I., Ayob, M.A. and

Mohd, M.N.H., 2011. Tank Water Level Monitoring System using GSM Network. Int. J. Computer Sci. and Info.Tech, 2(3), pp.1114-1120.

J. Shin, J. P. Choi, and J.-W. Choi , "An autonomous interference avoidance scheme for D2D communications through frequency overhearing," International Conference on ICT Convergence(ICTC), 2013, pp. 1074-1075.

K Chen, S Lien, Machine-to-machine communications: technologies and challenges. Ad Hoc Networks (2013). In-Press

K Zheng, F Hu, W Wang, W Xiang, M Dohler, Radio resource allocation in LTE-advanced cellular networks with M2M communications. IEEE Commun. Mag. **50**(7), 184–192 (2012)

K. Akkarajitsakul, P. Phunchongharn, E. Hossain, and V. K. Bhargava, "Mode selection for energyefficient D2D communications in LTEadvanced networks: A coalitional game approach," in Proceedings of IEEE ICCS, 2012, pp. 488–492.

K. Doppler, M Rinne, C. Wijiting, C. B. Ribeiro, and K. Hugl, "Device-to-Device Communication asan Underlay to LTE-Advanced Networks," Communications Magazine, IEEE, vol. 47, no. 12,Dec. 2009, pp 42-49.

Lu R, Li X, Liang X, Shen X, Lin X. GRS: the green, reliability, and security of emerging machine-to-machine communications. IEEE Commun. Mag. 2011;49 (April(4)):28–35.

Marwat, S.; Potsch, T.; Zaki, Y.; Weerawardane, T.; Gorg, C. "Addressing the Challenges of E-Healthcare in Future Mobile Networks".Lect. Notes Computer. Sci. 2013, 8115, 90–99.

M Yang, Y Li, D Jin, L Zeng, X Wu, AV Vasilakos, Software-defined and virtualized future mobile and wireless networks: a survey. Mob. Networks and Appl. **20**(1), 4–18 (2014)

M Chen, J Wan, F Li, Machine-to-machine communications: architectures, standards and applications. KSII Trans. Internet Inf. Syst.**6**(2), 480–497 (2012)

M Hasan, E Hossain, Random access for machine-to-Machine communication in LTE-Advanced networks: issues and approaches. IEEE Commun. Mag. **51**(6), 86–93 (2013)

M. Ji, G. Caire, and A. F. Molisch, "Wireless device-to-device Caching networks: Basic principles and system performance,"arXiv preprintarXiv:1305.5216, 2013.

Mishra P, Panguloori R, Udupa N and Mitra D 2013 Economic evaluation of solar hybrid DC grid for petrol pump stations *IEEE India Conference(INDICON)*

N. Golrezaei, A. F. Molisch, and A. G. Dimakis, "Base-station assisted device-to-device communications for high-throughput wire less video networks," in Proceedings of IEEE ICC, 2012,pp. 7077–7081.

Okemiri H.A "Critical Review Of Petrol Station Management System With Emphasis On The Advantages If Digitalized In Nigeria" Journal of Multidisciplinary Engineering Science and Technology (JMEST) ISSN: 3159-0040 Vol. 3 Issue 1, January - 2016

Pankil P. Taranekar, V. V. Dixit, "Device-to-Device (D2D) Cellular Communication: Group Formation of Devices", International Journal of Advanced Research in Computer and Communication Engineering Vol. 4, Issue 6, June 2015.

R. Zhang, X. Cheng, L. Yang, and B. Jiao, "Interference-aware Graph based resource sharing fordevice-to-device communications underlaying cellular networks," in Proceedings of IEEE WCNC, 2013, pp. 140–145.

S. Xu, H. Wang, T. Chen, Q. Huang, and T. Peng, "Effective interference cancellation scheme for device-to-device communication underlaying cellular networks," in Proceedings of IEEE VTC-Fall, 2010, pp. 1–5.

Shaker, M. and Imran, A.A., 2013. Greenhouse Micro Climate Monitoring Based On WSN with Smart irrigation Technique. World Academy of Science, Engineering and T Technology, International journal of Electrical, Computer, Energetic, Electronic and Communication Engineering, 7(12), pp.1566-1571

S Lien, K Chen, Y Lin, Toward ubiquitous massive accesses in 3GPP machine-to-machine communications. IEEE Commun. Mag. **49**(4),66–74 (2011)

S. Shalmashi, G. Miao, and S. Ben Slimane, "Interference management for multiple device-to-device communications underlaying cellular networks," IEEE International Symposium on Personal Indoor and Mobile Radio Communications (PIMRC), 2013, pp. 223-227.

T. Peng, Q. Lu, H. Wang, S. Xu, and W. Wang, "Interference avoidance mechanisms in the hybrid cellular and device-to-device systems," in Proceedings of IEEE PIMRC, 2009, pp. 617–621

X. Chen, L. Chen, M. Zeng, X. Zhang, and D. Yang, "Downlink resource allocation for device-to device communication underlaying cellular networks," in Proceedings of IEEE PIMRC, 2012, pp. 232–237

W. ALLIANCE, "Wi-Fi Peer-to-Peer (P2P) Specification v1. 1," WI-FI ALLIANCE SPECIFICATION, vol. 1, pp. 1–159, 2010

ZM Fadlullah, MM Fouda, N Kato, A Takeuchi, N Iwasaki, Y Nozaki, Toward intelligent machine-to-machine communications in smart grid. IEEE Commun. Mag. **49**(4), 60–65 (2011)

Zhang Y, Yu R, Xie S, Yao W, Xiao Y, Guizani M. Home M2M networks: architectures, standards, and QoS improvement. IEEE Commun. Mag. 2011;49(April (4)):44–52.

Zhang J, Shan L, Hu H, Yang Y. Mobile cellular networks and wireless sensor networks: toward convergence. IEEE Commun. Mag. 2012a;50(March (3)):164–9

Zhijian Lin, ZhibinGao, Lianfen Huang, Chi-Yuan Chen, Han-Chieh Chao "Hybrid Architecture Performance Analysis for Device-to-Device Communication in 5G Cellular Network" Springer Science+Business Media New York 2015.