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Realtime Energy Consumption Management for Internet of Things

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Abstract: Internet of Things (IoT) covers a very wide area of researches and applications including sensors, smart devices, transmission protocols, communications technologies, storage area, processing speed, transmission rate and security in addition to hardware and software design. Huge number of device are connected together in the near future to establish the environment of internet of things. Management of the node activity is an important issue can be considered in the environment of IoT. According to huge amount of traffic via. IoT, this aspect considered as energy consumption. This research aims to introduce an efficient energy management via. IoT Based on routing protocol management. This research proposed an efficient energy management approach to be adapted for IoT that is based of routing protocol management. This approach concentrated on saving of energy consumption of devices and activities in internet of things. The proposed approachcan be decided to transit the node in sleep mode depending on the extracted characteristics of network.

Key words: IoT, energy management, power conservation, routing protocol, considered, extracted

INTRODUCTION

Computer network can be performed by connecting two or more computers via. any type of media (wired or wireless) used for transferring of data under a certain protocol (Al-Ani, 2017a, b). Since, 1980 more and more computer networks are used in companies organizations and business (Perea, 2008). The internet established at 1969 as a project of Advanced Research Projects Agency (ARPA) stated between department of defense in USA and many universities (Carpenter, 1989). This project grown fastly and become a big networks covers all over the world (Baerlocher *et al*., 2001). Today, the internet is a public and cooperative that offers the facility accessible to millions of millions of people worldwide (Rosen, 1980). TCP/IP (Transmission Control Protocol/Internet Protocol) is the most widely applied and famous protocol used in the internet (Goralski, 2017a, b). In addition the general protocol that describing network communications is known as the Open System Interconnection (OSI) Model (Mackay *et al*., 2004). The transition between ARPANET and TCP/IP was stated in 1983 that established new protocols (Reynders and Edwin, 2003).

Version 4 of the Internet Protocol (IPv4) is the fourth version of the Internet Protocol (IP) (Goralski, 2017a, b). It is an important first protocol for network interconnection methods based on internet standards that implemented in ARPANET in 1983 (Levin and Schmidt, 2014). IPv4 has 32 bits with about four billions of addresses (Qin and Yan, 2013). IPv4 was coming out in 2011 to replace it with Internet Protocol Version six (IPv6) (Qin and Yan, 2010). In 1990 and above showed an exponential growth in the size of the internet (Gamess and Suros, 2008; Al-Aloosy *et al*., 2015). In 1998 the Internet Engineering Task Force (IETF) had finalized and published the design of IPv6 (Al-Ani and Haddad, 2012). IPv6 has 128 bits with about 3.4×10^{38} unique addresses, this may be the first step to entering in Internet of Things (IoT) that can cover billions of devices and object to be connected to internet (Hernandez-Bravo and Carretero, 2014; Shin, 2014).

Internet of things is one of the most popular topics today with more and more objects that become intelligent and smart to connect with other devices via. high speed media (Al-Ani, 2017a, b; Li *et al*., 2018). Most of the major players in the internet market expect that in a few years there will be billions of such objects connected, so, the demand for research and work in this field is constantly growing (Lanotte and Merro, 2018; Fernandez-Gago *et al*., 2017). Recently, big amount of researches are published considering many issues in the IoT (Saarikko *et al*., 2017; Ray *et al*., 2014). IoT can be represented as a system of computing devices, mechanical and digital machines,

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objects, animals or people that have unique identifiers and the ability to transfer data through a network without requiring human to human interaction or human to computer interaction (Monteiro *et al*., 2014; Park *et al*., 2016).

Integrating all devices on the IoT including traditional and smart devices leading to big challenge in h this area (Yan *et al*., 2014; Liu *et al*., 2014). So, the first step is to modify their protocols to adapt to the new IoT environment (Al-Ani, 2015a, b; Al-Ani and Azmi, 2016; Urquhart and McAuley, 2018). IoT is about the cooperation and recognition of individual components of all types of networks such as Local Area Network (LAN), Metropolitan Area Network (MAN), Wide Area Network (WAN), Personal Area Network (PAN), Campus Network (CAN), Radio Frequency Identification (RFID), Bluetooth, mobile networks, cloud networks, health care networks, social media and all wired and wireless networks (Krotov, 2017; Al-Ani, 2015a, b; Albishi *et al*., 2017).

Today, huge amount of data are available on the internet and it is so, time consuming for searching and investigating for specific data or information existing in real world (Alheeti and Al-Ani, 2017; Rho and Chen, 2018). If we had intelligent devices and computers that knew everything there was to know about things (Metallo *et al*., 2018; Mieronkoski *et al*., 2017). Then by using the data they gathered without any help from human, we could track and count everything and highly reduce losses and costs (Qi *et al*., 2017; Murphy, 2017).

IoT is a diverse internet and networks that are connected to various devices (things) to exchange information and data (Ondemir and Gupta, 2014; O'Neill, 2014). It consists of a big amount of intelligent objects, sensors and actuators connected to each other (Santos *et al*., 2014; Borgia, 2014). These objects are equipped with different types of communication protocols, defense systems and microcontrollers to process their jobs (Yuehong *et al*., 2016). IoT applications play an important role in our daily lives such as electrical appliances, monitoring and environmental monitoring sensors (Verdouw *et al*., 2016; Alvi *et al*., 2015). In addition, wireless sensor networks are considered one of the important IoT applications (Fig. 1) (Fersi, 2015; Weber, 2015).

This research will have concentrated on the study of the energy management via. internet of things, then try to introduce an efficient model to manage IoT activities in order to minimize energy consumption as possible.

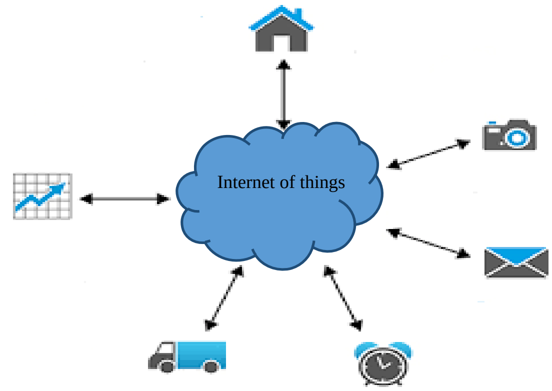

Fig. 1: IoT network and devices

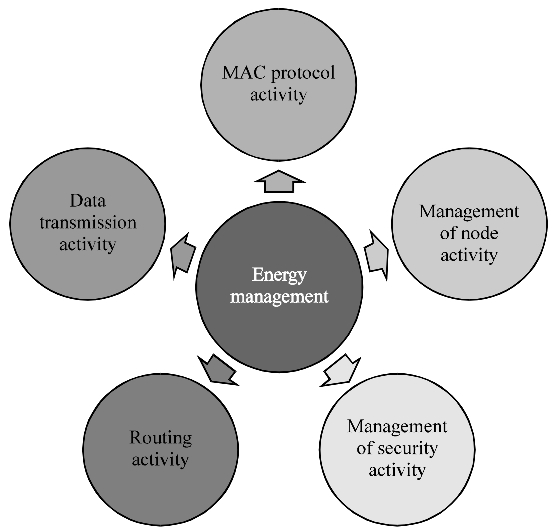

Fig. 2: Energy management in IoT

Energy management: The near future of IoT expects huge amount of traffic passing around the world (Kouicem *et al*., 2018; Ai *et al*., 2018). Energy consumption in IoT comes from node active time, collision interference, flooding, congestion, heavy traffic, ..., etc (Ahmed *et al*., 2017; Gomez *et al*., 2016). In order to minimize and avoid energy consumption in IoT, it is important to insert an effective management algorithm that control all the network activities inside and outside of nodes (Pandey and Zaveri, 2017; Gierej, 2017). This issue can be achieved via. considering the following points (Fig. 2) (Kumar and Zaveri, 2016; Newe, 2015; Nguyen *et al*., 2015).

Data transmission activity: IoT considered to be heavy traffic, so, this leading to huge amount of data transmission. In addition it is clear that the energy consumption of data transmission activity is higher than that of data processing. So, it is very important to minimize data transmission activity as possible.

Organizing data into clusters dealing with efficient method to reduce the amount of data transmission. To achieve this issue, data that coming from different sources are joining into a single data packet in order to reduce redundancy and reduce the number of transmitted packets.

MAC protocol activity: A popular Medium Access Control (MAC) standard protocol started at 2003 and it is described by the IEEE), then revised in 2006. MAC protocol play an important role in the future IoT. So, it is important to introduce an efficient MAC protocol to control all node activities and prevent the unnecessary activities to affect the overall process. MAC protocol is a sub-layer of data link layer and it is responsible on the frame transmission and how to define their rules. In addition it is responsible on the management of the channel access. Many MAC protocols are proposed to achieve low energy consumption, so, it is better to introduce an efficient design of MAC protocol.

Management of node activity: Node activity is divided into two parts which are sleeping scheduling activity and on-demand node activity. Sleep scheduling activity or sleeping mode that is the method to put the node into sleeping mode and then determine the wake up time, this leading to saves energy. On the other hand, on-demand node activity realize by default in an active mode as doing simple job. When broadcasting a wake up signal, the neighboring nodes switch to active mode.

Management of security activity: Security is necessary to prevent unauthenticated issues into node access and to protect data and information. One of the big challenges of energy consuming is via. applying faster encryption and decryption algorithms that leading to minimize energy consuming. The existing algorithms try to compensate between the powerful security and efficiency of high speed processing. In this case, it is important to adapt an adequate efficient encryption algorithm.

Routing activity: Transferring of information via. networks from a source to a destination is referred to routing. It occurs in network layer. Routing is doing the action which routes to be used and the best quoting is that take the minimum way to reach its destination. There are different types of routing protocol can be implemented via. networks in addition these protocols can be classified according to their characteristics.

Literature review: Big number of papers published in the area of IoT each month. These papers studied various aspects in this area including network management, data communications, routing protocols, data storage, security, ..., etc. This study will be concentrated on the last updated published papers in this area.

Montavont *et al*. (2014) proposed a simulations and experiments in which several aspects of the protocol are still insufficiently detailed or evaluated. This approach offered a complete evaluation of Mobile IPv6 in 6LoWPAN. They implemented Mobile IPv6 in the Contiki operating system and carried out intensive experiments in a real test bed. They proposed a new motion detection mechanism because the standard procedure cannot be applied as it is. This new mechanism, called Mobinet is based on passive auditions. The results highlight that mobile IPv6 can be a practical solution to manage layer 3 mobility in 6LoWPAN (Montavont *et al*., 2014).

Efremov *et al*. (2015) studied the issue in more detail and point out several problems that must be solved in an effective way, so that, the internet of things works in large quantities. One of the main tasks is to make the devices easily detectable. Therefore, an efficient way to manage and store your metadata is necessary. Another problem is related to the provision of different communication models between devices, the most important being asynchronous because many web standards widely used at present are not designed for this purpose. Then they proposed a general IoT architecture based on the cloud to solve the described problems (Efremov *et al*., 2015).

Samaniego and Deters (2016) focused on the management of resources in the internet of things. This was achieved by providing an edge layer of virtual resources which allows access and configuration to restricted physical resources. The presented architecture focuses on the use of virtual resources as a management concept and identifies different approaches to evaluate the performance of advanced computing devices. When using the IoTCoAP protocol, virtual resources are exposed in the peripheral network. An evaluation of a Go CoAP virtual resource is presented (Samaniego and Deters, 2016).

Song *et al*. (2017) implemented a new information infrastructure called Internet of Things (IoET) to make DSM work by taking advantage of the latest wireless communication technology: the Low-Power Wide Area Network (LPWAN). The main advantage of LPWAN over General Packet Radio Service (GPRS) and Internet of Things (IoT) is its wide coverage which is accompanied by a minimum energy consumption and maintenance costs. In this context, this study briefly reviews the representative technologies of LPWAN Narrowband (NB-IoT) and Long-Range (LoRa) and compares them with GPRS and IoT technology. Then, a wireless cloud architecture for IoET is proposed, based on the main technical characteristics of LPWAN. Finally, this study analyzes the potential of IoET in several DSM application scenarios (Song *et al.*, 2017).

Wang *et al.* (2018) explained different requirements of the greenhouse environmental monitoring and control system, the greenhouse environmental control and management system that has been developed based on the Google Web Toolkit. When using the remote method call AJAX (RPC) as a method of communication between the browser and the web server, the system has achieved the following functions: configuration of acquisition and control parameters, adaptive adaptation of the database between the door of link and server, monitoring of warning settings, adaptive generation of the interface, etc. The functions of the system have been tested. The results show that the WEB browser application and the Android application can adaptively carry out the monitoring and control of the greenhouse environment depending on the configuration of the information (Wang *et al.*, 2018).

MATERIALS AND METHODS

The proposed energy consumption management approach via. IoT is concentrated on inserting an efficient sleeping mode algorithm that working automatically whenever required in order to (conserve) save energy as possible. This approach of energy consumption has the ability to decide the suitable time to execute and activate the sleep mode in order to identify and classify the nodes to be in this situation. The infrastructure of this approach based mainly on the road design that install the basic requirement of the radio frequency communications. It is important to realize the number of active nodes and devices considered in this environment and connected to common road side units via. a certain coverage area. The coverage area in this environment depends on both transmitted and received power. In addition it is important to measure the node activity according to the time duration for sending and receiving data. These measurements are applied in each node and device to ensure the performance of the IoT environment. These measurements will be leading to right decision on the selection of nodes passing into sleeping mode. The following steps are considered as the main required steps for pushing nodes in sleeping mode (Fig. 3).

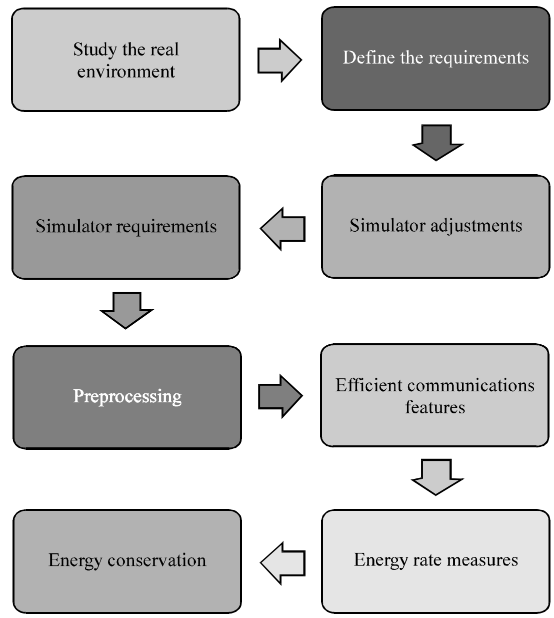

Fig. 3: Energy consumption management in IoT

Study the real environment: Which concentrated on positions of nodes and devices in addition to control the existing coverage area in the defined environment.

Define the requirements: That deals with the traffic, vehicles, obstacles, mobility, objects and generating nodes and communication devices required for next step.

Simulator adjustments: In which initialize and adjust the simulator to be ready accepted the requirement for processing.

Simulator requirements: In which transfer all required information and parameters from real work to the simulator in order to realize the simulation of the IoT environment.

Preprocessing: In which refining the extracted features to generate the effective values that can be used for the next step.

Efficient communications features: In which extract the trace file features that dealing directly with the power saving via. IoT environment.

Energy rate measures: In which calculate the energy rate value of each node via. IoT environment. Energy rate value is an important issue in taking the decision of pushing nodes in a sleep mode.

Energy conservation: In which select the low active node to apply the sleeping mode algorithm in order to minimize the energy consumption as possible.

RESULTS AND DISCUSSION

In order to evaluate the proposed system, network simulator is required to establish real-world communication environment. In more details, 100 devices of IoT are randomly scattered in area of

Table 1: IoT devices activity status

	Devices		
Time	1	2	3
1	Active	De-active	Active
2	De-active	De-active	De-active
3	Active	Active	Active
4	De-active	De-active	De-active
n	Active	Active	De-active

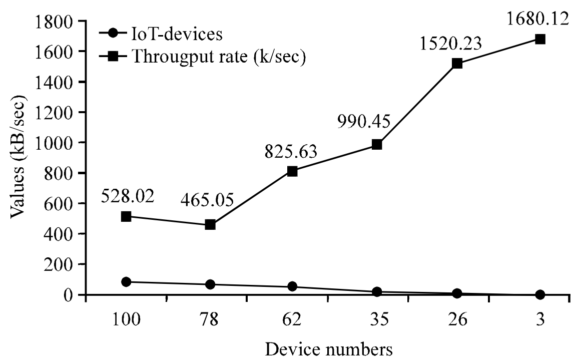

Fig. 4: Efficiency of IoT devices

200*200 m in that zone. Our proposed is heavily based on trace file of network simulator that reflect all devices activities on network for a specific period time. In this study, Python language is utilised in analysis content of trace file that extracted from the simulator. The activity of IoT devices is calculated from trace file. After that, the proposed system can identify between active and de-active. In this case, it has the ability to introduce de-active device in sleep mode to save energy. Activity value of IoT device measured in Table 1.

According to Table 1, we can easily notice the status of each IoT devices over time. The proposed system will heavily have based on Table 1 in change status of each device over time from active to de-active and vice versa. Figure 4 shows efficiency role of the propose system. It plays important role increasing throughput of network and reducing amount of consumer energy.

IoT device performance is calculated when node activity is identified over time. In other words, making decision of the proposed system is heavily based on activity value of each IoT devices. Active or sleep mode of the proposed system depend on the monitoring case of IoT devices.

CONCLUSION

Mobile computing becomes the future trends of information technologies and it try to adapt all of the world wide devices and objects to the internet. This aspect caused heavy traffic via. internet although with the existing of advanced commutations technologies. The main challenges in IoT is arising with the adapting and connecting different protocols and objects within this environment. Managing all these aspects in the IoT leading to an important issue in energy conservation. The proposed approach is concentrated on passing the low active node into sleeping mode in order to save energy as possible. The extracted information of IoT nodes is measured via. the simulation environment that realize the real world to detect the active nodes. This approach is simulated via. network Simulator Version 2 in which indicated a good performance simulated result of IoT environment.

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