Applications of IoT in Business and Healthcare Management

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Summary
The aim of this article is to analyze the application of Internet of Things (IoT) and its associated technologies in the business world. IoT is a technological concept or a system of informational technologies, computing gadgets, tools, devices, machines, objects, and human beings that enable data transfer over a network without human interactions. As such its architecture encompasses several technologies like Cloud, Fog and Dew Computing. Cloud computing was introduced late last century and became viable in the beginning of this century. It presented a new and affordable way of computing, changed the mode of outsourcing, and empowered entrepreneurs to start their dream business with very little resources. To meet the need for faster processing in critical applications, cloud was extended to a smaller paradigm of server computers, and configuration now known as fog or Edge computing. Dew computing is a further refinement of the cloud paradigm and sits at the bottom of the Cloud configuration. IoT with thousands of its devices is providing very valuable assistance in Healthcare procedures and management. With IoT, the medical science field is inventing a whole lot of new ways to deal with businesses, health and real life issues.

Key words:
Privacy, IoT, Cloud, Fog, dew, Edge, Business, Healthcare

1. Introduction

With the advent of Internet [1], and Web 2.0 and Web 3.0 technologies, a new Information Technology (IT) paradigm has emerged. This paradigm is providing very useful and critical applications in our day to day life in an integrated and seamless manner. One of the recent developments is Internet of Things (IoT) [2-5], which is becoming instrumental in meeting new social and business challenges. IoT is now providing amazing solutions to many healthcare and business problems. In particular, IoT applications in crowd control and health management,

Fig. 1 Internet of Things

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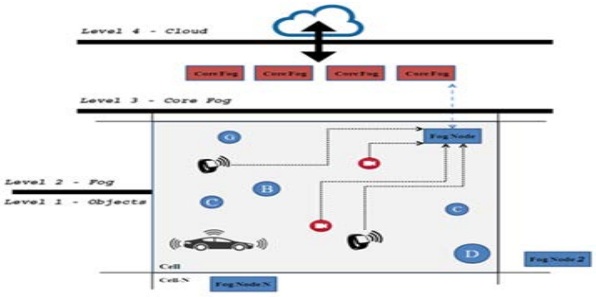

Fig. 2 Fog Architecture

which make use of digital streets and cities, are amazing. A snapshot of the configuration of IoT is provided in Figure 1, and architecture in Figure 2. IoT has emerged on the top of Gartner Cycle of 2017 [6] as shown in Figure 2.

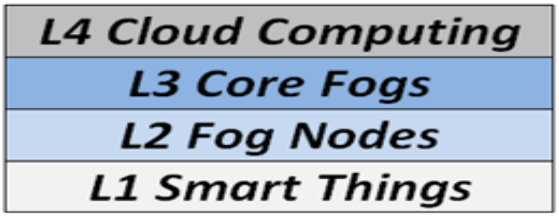

Fig. 3 Layers of Fog Architecture

2. Components of IoT

Let us examine various components of IoT.

2.1 Cloud and its Extensions

Figure 3 shows layers of General Fog Architecture. Figure 4 shows the hype of Fog technology in the Gartner Hyper Cycle of 2018. Clouds and Fog architecture are shown in Figure 5. As evident from Figure 5, Fog uses things like User, object, Fog nodes, and core Fogs.

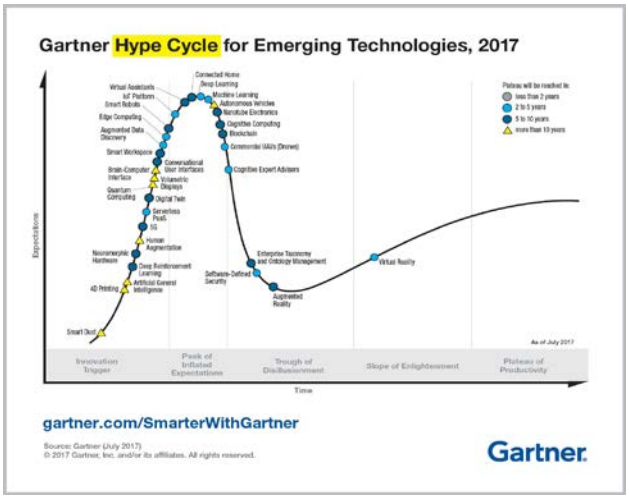

Fig. 4 IoT - An Emerging Technology

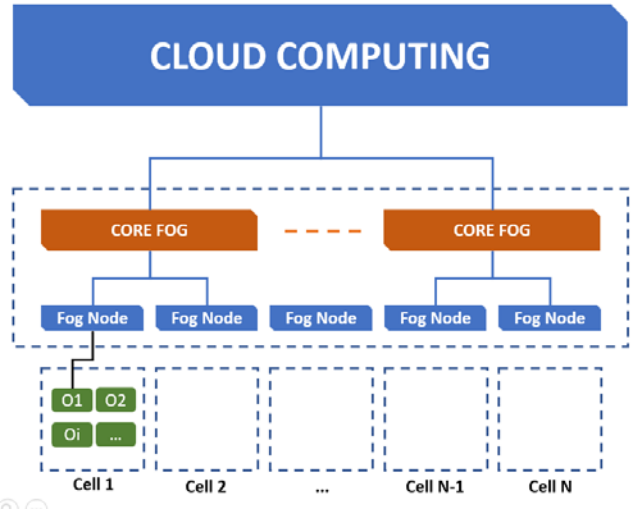

Fig. 5 Cloud Configuration

2.2 Sensing and Identification Objects

One of the important constituents (things) of IoT is Sensor Networks. Each object in IoT connects to the internet to provide data, which can be of any type. Some of the things in the IoT world are digital cameras, smart cars, smart watches, smart phones, smart televisions, personal computers of various kinds, etc. However, the most important things in IoT, which account for the bulk (up to 70%) are WSNs and RFID Tags. Wireless Sensor Networks are used to sense data and conditions from the environment (heat, pressure, pollution, images, movements, sounds, etc.), while RFID provides identification and the location of IoT objects. Some applications of Clouds and its extensions (Fog and Dew) can be found in [1-5].

3. Applications of IoT

3.1 IoT in Health Domain

Figure 6 [8] depicts Internet of Medical Thing scenario. There are many applications of IoT in healthcare management, hospital administration and health procedure. Because of IoT, it is now possible to monitor the progress of a patient remotely through Ubiquitous systems. Figure 7 [8] shows an example of a ubiquitous health system. As an application of IoT, emergency services can be managed in a better way as shown in figure 8 [8]. Literature is full of IoT applications in the medical domain. For example, see [9-11].

Many of the wearable sensors are available now for patients to connect them to health centers permanently in order to quickly detect any potential threat to the patient and make a right decision, monitor children or elderly, call relief, provide blood donors, in addition to many smart phone applications in the same domain. We will focus on this domain in the next paragraph.

3.2 IoT in Business

Collected data can be used to detect new knowledge and improve the level of services. Most of this data comes from WSNs, and RFID. The creation of new relations between machines themselves (M2M) has made our life smarter and more flexible, while it has also reduced the

Fig. 6 Internet of Medical Things [8]

needs of people in many functions and tasks in many applications. That has definitely enhanced the efficiency of applications and avoided many human errors.

Many applications of IoT can be found in different business sub domains. Some of them are available in [13-18].

Fig. 7 Health ubiquitous with IoT [9]

3.3 IoT for Crowd Management

Crowds which we witness from time to time differ in many ways. Some crowded events are regular while others are irregular. Regular crowded events like those of Hajj [19], Kumbh Mela [20] are predictable and the crowding in some of these can be contained. Irregular events are usually unpredictable and spontaneous in nature like those of funeral processions, protests or celebration marches, election rallies, and sporting events or musical concerts. Estimation of the crowd size of

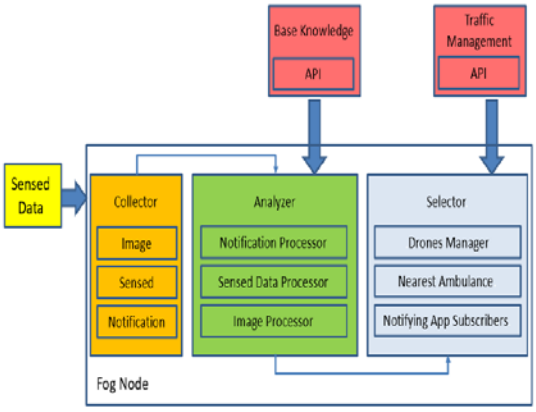

Fig. 8 Proposed Framework of First Aid with IoT [9]

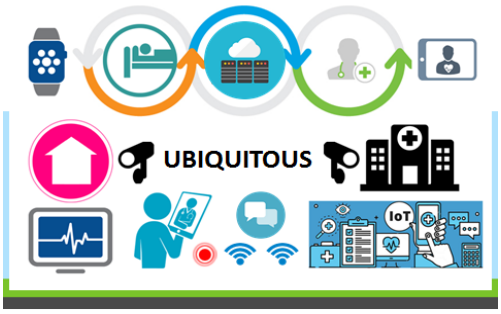

Fig. 9 Ubiquitous Health System

irregular and spontaneous events is very difficult and often impossible. The numbers in some of these have risen against all expectations.

Management of irregular events can be a daunting task because of the size of the unpredictable nature. However, moving events like parades and processions are relatively easy to manage as they are usually stretched over a large area. Stampedes usually occur in cramped places, usually due to sudden or unplanned stoppage of a section of a moving crowd or at walking intersections. One may think that the management of predictable and regular events is easier. But the statistics of disasters in such events point to quite an opposite conclusion as more than 60% of deaths occurred in Hajj are related to stampedes alone. Another regular event namely, Kumbh Mela, is linked to over 20% deaths through stampedes. Our focus in this article is the study of these two namely, Hajj and Kumbh Mela.

Crowds which we witness time to time differ in many ways. Some crowded events are regular while others are irregular.

One of the well-known regular event is Hajj [19]. Hajj is an annual pilgrimage of people from different parts of the world to Mecca in Saudi Arabia. The most important ritual takes place in the plains of Arafat, where more than two million people gather for a day. All pilgrims gather in Mina, a tent city close to Mecca, a day before the main ritual of the Hajj. Next day, all pilgrims must travel to Arafat, a valley of a fixed area for the purpose of the main ritual. After standing in the valley, the pilgrims then must travel in the evening to Muzdalifa, a mountainous site near Mecca. To and fro Arafat journey of more than two million pilgrims can only be done by surface transport, and must be completed on the same day. Next day all of these people must return to Mina and then walk to Jamaraat site for first stoning ritual. It was this walk in 2015 which at an intersection in Mina caused one the worst stampedes of all times killing hundreds of people. After the stoning, the other rituals which follows a journey of all pilgrims from Mina to Mecca and back, usually on the same day. There are further two stoning rituals during the next two days. In the past, these rituals have caused a number of stampedes killing hundreds of pilgrims. These and some other hajj rituals are very complex in nature. Intense, frequent and simultaneous movements of millions of people and performing rituals within very tight deadlines make the Hajj a unique event in the world. To make it successful, the government of Saudi Arabia various ministries and governorate of Mecca has provided state of art infrastructure and facilities to perform the Hajj. However, despite excellent organization, apart from CCTV and electronic billboard, the hajj management remains largely manual. Technological advances and changing requirements warrant hajj management to be modernised by using the latest technologies. There are several steps which need to be taken if the hajj management is to take

full advantage of the latest technologies. In particular, the hajj management needs an efficient Management Information System (MIS) to link and manage its key functions such as pilgrim checking, tracking and identification, travel, pilgrim health management, crowd management and so on.

Health and hospital management during for pilgrims is a but very important function of the hajj management. Providing emergency and health services for more than two million people for a period of up to four weeks is an extremely difficult task. At times the pressure on health services for the residents and pilgrims becomes unmanageable during hajj period. Moreover, the lack of information about the pilgrims' state of health makes it even more difficult task to prescribe desirable treatment in case of an emergency.

Another well-known regular crowded and event is that of Kumbh Mela [20]. The Hajj and Kumbh are predictable but the crowding in these can be contained and regulated. Some regular events are annual, with a fixed venue and data of its participants collected well before the event. A perfect example is that of Hajj, which is an annual pilgrimage to a pre-determined set of locations in and around Mecca and its pilgrims are drawn from different countries, whose data can be easily collected, organised and mined. Some other events like that of Kumbh Mela, although being periodic, is hosted at different locations, and because there is no system of registration for the participants of Kumbh Mela, their data cannot be collected and the number of pilgrims can only be estimated from the statistics of earlier event estimates. We also witness some irregular or spontaneous events like those of funeral processions, a protest march, an election rally, a sporting event, a musical concert, a wedding or a celebration. Although crowd management is a very important operation, it is also very complex. So most of the current solutions are limited, inefficient, and often they rely on long-term statistical and analysis for predicting, which is inefficient. This work poses new methods to solve the most important issues in crowd management. The first one is to avoid the disaster that can be occur in the crowd, and the second provides comprehensive solutions for health management in the crowd. Many of the historical disasters that happened during Hajj are caused by people falling down while others continued moving, so this paper suggests techniques for detecting a fall occurring inside a crowd immediately and then controlling with movements of people in that time.

We have designed a system of predicting stampedes in crowded events. Our systems as shown in Figure 10 is based on IoT. Our main idea relies on new technologies such as Fog computing, Smart Phones, Smart Digital

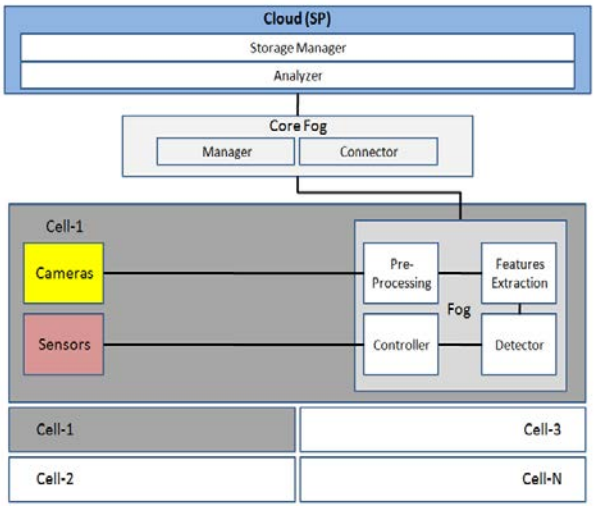

Fig. 10 Crowd Control and Management System

Street, IP Cameras, RFID, Voice Alarm, Light Alarm, GPS, etc.

While designing our system, we divided the area of Hajj into many cells; each cell has a Fog Node for speed processing, decision-making, and responding. In each cell there are also many high-resolution cameras that take pictures frequently, then send them to a Fog Node which can analyse the images and detect the irregular issue. If any special case is detected, Fog will send an alert to Smart Street, Smart Phone Vibration, Voice/Light Alarm etc. which will enable the crowd to note that there is need to stop movement. For more details, see [14].

Smart Street uses LED lights on the ground of a street to help to direct crowds by street colour. In the case of an emergency, the LED will be red (red street) to notify people to stop immediately until the problem is addressed. In addition, there are other types of alerts such as sound alert by side sensors or by smart phones. In this case we propose that all people have an idea about previous notifications and they have to stop when they see or hear any type of notification.

Actually, in these systems there are some special people who can control this system through their Mobile. Now there are some developed cameras to take photos of crowds and calculate an approximate number of objects.

3.3 Other Usage of IoT

There are many other fields which are affected by IoT and they have integrated together to create what is called smart cities which promise a new style of life. The main fields are:

Marketing: All large and medium companies have now realised that the information about customers is the first and most important reason for survival and prosperity. So they try to collect information about their customers. They

need feedback on user interests, locations, etc. to provide suitable services and products, send ads and offers to the nearest potential customers, and deliver products to customers at their homes, etc.

Agriculture application: Many kinds of sensors can meter the degree of salinity, nitrogen, water, etc. of soil to enable the farmer to know when they should start irrigation and in what quantities. And also to notify them in case of any issues requiring chemical processing, etc.

Military: Many of the sensors can be used to sense data about the enemy and their weapons, to boost the chances of their survival and guide their movements, and automatic detection for required actions.

Smart Home: Many smart devices are now available to achieve smart integration for users. Some examples are smart TV, smart light, smart fridge, smart oven, smart washer, smart IC, etc. which can interact with users and their cultures, customs and behaviours.

Smart Energy: Many of the new technologies are found for saving power and monitoring the devices and their consumption of energy. An example of this is to have automation for turning off lights and IC automatically when user exits the room, etc.

Environment: The applications may include monitoring weather fluctuations and making predictions about upcoming periods, studying the degree of pollution of air, soil, and water, searching for metals and gases, protecting plants and animals, etc.

Other Applications: Some other applications are associated with Transport (smart cars, managing traffic, maps, booking, etc.), Security and Safety (broken, monitoring, fire, smoke, heat, water, disaster, light, etc.), Sciences, E-Learning, and others, and Social and contacting between people. Some more applications of IoT can be found in different fields. Some details of such examples can be found in [9, 21-34].

4. Privacy Issues in IoT Application

With millions of applications involving thousands of things,, a lot of data passes through IoT. Thus the privacy issues assume significant threats. This becomes a huge problem when sensitive data ins involved. With the increase in the number of IoT devices, vulnerability for privacy breaches becomes a serious problem. To ensure data privacy in the IoT environment, all possibilities of improvements must be considered. Strong and concerted measures to ensure privacy is paramount to boost user confidence to provide their data in IoT applications in particular and any system. in general. Privacy and security go hand in hand. While privacy is perceived as a state or phenomenon or notion free from all kinds of unwanted interventions and intrusions, security is the set of measures to protect or preserve privacy. So the state without intruders is privacy whereas the protection pertains to security. Privacy of data is about ensuring its preservation by protecting it from insider (including service providers) and outsider attacks, profiling, tracing, collecting, or unauthorized usage.

Privacy of data has always been a critical field of research but with the increase data involved in huge number of applications, it assumes even greater prominence. For this reason, may academics are researching the field of data security. Since the introduction of IoT at the end of 20th century, a huge number of ways have been suggested . But, unfortunately, most of them are have one or the other problems. For details, see [35-36]

5. Conclusions

As discussed in the various sections of this article, we find that the IoT is having remarkable real-life applications. The IoT paradigm is on the rise and billions of IoT elements are forecasted in the coming years. Some of these IoT applications are not only enhancing business and corporate processes but also improving the quality of life. In particular the IoT applications in Health are having ground breaking effects. With the help of IoT applications, such as prediction of stampedes, thousands of lives can be saved.

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