Business Process Model for IOT Based Systems Operations

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ABSTRACT

The internet of things (IoT) is an innovative and advanced high-level IT development that provides the connection between a large network of devices equipped with numerous computing capabilities, actuation, and sensing with the help of internet connection, consequently providing multifarious novel services regarding smart systems. All around the globe the attractive big data analytics and IoT services are allowing initiatives regarding smart systems. Business processes are commonly executed inside the application systems where computers, objects of IoT as well as humans participate. However, for the system-supported processes, the use of IoT technology is still facing the problem of the absence of a standard system architecture that is essential to manage the coordination in a smart IoT environment. Business process management (BPM) is regarded as a substantial technique for designing, controlling, and improving the processes of a system. This article introduces a BPM modeling approach for IoT-based systems operation exploits IoT using BPM by adopting an IoT framework architecture and considering IoT data for interaction in a defined process model. The methodology has been carried out on top of current BPM modeling notions and system techniques for formal representations of the system and also to get through the challenges of collaboration and connection.

KEYWORDS: IoT, Business process, Devices, Architecture, Smart systems, Operations.

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1. INTRODUCTION

Around a decade ago, Kevin Ashton first introduced the term internet of things. The Internet of Things (IoT) is also known as the Internet of Everything. It is a network of devices that are physically connected like Cars, home usage items, and any other items that embed with sensors, electronics, software, etc. These devices are connected to exchange data from one device to another. The primary purpose of IoT is to increase the benefits of the Internet by increasing the capability to connect to many devices [4]. Literature suggests that the increment of IoT devices is 31% year over year to 8.4 billion in 2017 and it is also predicted that by 2020 the world will be using approximately fifty billion IoT devices [1] and by 2030 the number of devices is expected to increase to a trillion devices [2]. The global market value has also reached $7.1 trillion by 2020. IoT shares the internet connection with other devices more than normal devices like desktops, smartphones, and tablets to any variety of devices that cannot connect to the internet. After that, these devices can connect and relate above the internet and that can also be examined and measured [3].

BPM is a technique used to construct a workflow of activities or services to be produced or offered. BPM determines the connections/communications and the order of responses/request from/to services. It can hence be illustrated as a "process optimization" process [5]. By incorporating IoT in BPM model, users will get a platform to visually understand the data shared and gathered by the linked devices in the physical space; similarly, users can also exploit the potential challenges of the smart systems. Before any business process automation, a business process model is the foundation of any IoT application [6].

Devices in the IoT are rapidly increasing every day. These tools and devices are getting to be more important for us and others than mobile phones. This persistent increase in the count of connected devices can cause more potential security risks and threats to one's private information, data, place, devices, and system. By keeping in view these concerns we need to sort out various expected security issues regarding the integration of BPM modeling with IoT.

Since IoT is spreading everywhere in multiple areas of everyone's lives, there is a need to develop a standard business process model by analyzing the generic workflow of the IoT systems to demonstrate the basic IoT systems model. To model IoT-based systems, we studied in detail the properties of IoT components and showed in the hierarchy model and then highlight the common properties. We considered these elements of IoT for modelling by encompassing the BPMN model together with the graphical model to demonstrate them.

We evaluated the majority of available business process techniques (BPMN1.0 (Business Process Modeling Notation), BPEL (Business Process Execution Language), and JPDL (JBoss Process

Definition Language)) to provide a scientific foundation for our work. Not any one of the available modeling languages, on the other hand, could immediately match our requirements for modeling a sensor-aware process application. The major advantage of BPMN 2.0 over other modeling languages is that it can define the execution semantics and style of the specification and utilize standard primitives to describe the business process, ensuring that the same process is executed in multiple process engines with the same outcomes. As a result, BPMN 2.0 is used as the foundation for mapping business process resources from an IoT domain [6]. However, it may also provide the theoretical foundation for modeling and some solutions for efficient deployment. Before we go to the major Systems operations details and concerns, let us have a look over the background of the research.

2. LITERATURE REVIEW

2.1. IOT AND SMART SYSTEMS

The advent of the IoT age comes with numerous globally interconnected devices that offer essential ubiquity for smart operations such as smart homes for household connectivity, smart offices for business solutions, smart heath for health care, and smart grid for energy appliances Figure 1 [7]. The innovations powered by the internet give unlimited capabilities for enterprises to pursue their objectives and boost the performance of their business processes [8].

Here is no only collectively accepted explanation describing the well-known term IoT. Different sets or persons utilize various definitions to refer to the importance of IoT and its most important features. The Internet Architecture Board (IAB) said in their book “Architectural Considerations in Smart Object Networking” with its descriptions [9]. “The term "Internet of Things" (IoT) denotes a trend where a large number of embedded devices employ communication services offered by the Internet protocols. Many of these devices, often called "smart objects,’’ are not directly operated by humans, but exist as components in buildings or vehicles, or are spread out in the environment”. We can find a very concise definition from Oxford dictionaries providing internet as subset of a component of the IoT. “Internet of Things (noun): The interconnection via the internet of computing devices embedded in everyday objects, enabling them to send and receive data.”

Figure 1: The IoT Generic Scenarios

As technology has unfolded at the advanced levels, the definition of the Internet of things has changed but the main objective of IoT i.e., collecting the sensory information from objects and computers without human involvement, remains the same. IoT involves smartly using the collected information and data from actuators and sensors embedded into the connected real-life physical objects and machines [10]. The data that will be collected will require a huge amount of storage space resulting in dependability on cloud computing. A subset of IoT known as Machine to Machine communication (M2M) already uses the wireless network to connect devices across the Internet with minimal human intervention. The idea is to make everything smarter to command and control the objects used in our everyday lives. There is incredible unlimited potential for the improvement of lives in this new era of creativity.

The fundamental or underlying concept behind IoT is the ubiquitous presence of heterogeneous devices and objects e.g., RFID tags, actuators, mobiles, sensors, etc. that can contact and cooperate and their neighbors to obtain certain collective goals [11]. IoT will impact operations and functions of life in both domestic and the working fields in the future. In [12, 13], author suggested that term IoT is largely used to denote smart systems having global network interconnection using internet technologies. Applications related to IoT required services like Radio Frequency Identification (RFID), sensors, actuators, machines etc., and complete application service to support new business opportunities and market breach [12].

2.1.1. ELEMENTS AND ENABLING OF IOT

The Internet of Things covers numerous parts of our lives, from smart homes and urban communities to autonomous vehicles and associated streets, ways to devices that utilization the information to actuate the administrations from gathered data of people's behaviors and things [14]. The term Internet of things

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will soon be used to describe the general concept of things specifically the everyday use objects that are detectable, recognizable, locatable, addressable, controlled over the Internet regardless of the support. In current section, this study discussed empowering advancements that will assist the IoT with turning into a reality.

2.1.1.1. RFID (Radio Frequency Identification)

RFID is a remote information move method utilizing electromagnetic fields to automatically recognize and screen labels related to objects containing electronically stored data [14] as shown in Figure 2. The tags act as the electronic bar code and help automatically identify the objects they are attached with. RFID technology help in the detection and identification of objects in the range of a few meters' distance, equipped with a fixed-type reader that usually communicates over wireless medium having small transponders which are without battery-related objects. It provides two fundamental and quintessential features of IoT i.e. Identification and communication.

RFID technology contributed to cost reduction and technical progress and standardization, because of which it is widely used. Passive RFID tags do not require a power supply or battery and for communication or interaction to RFID reader, they use signal power. Passive cards are used in many bank cards and labels rolling away [15]. A typical RFID microchip is simply hundreds of thousands of transistors, does not contain microcontrollers, and is provided with a minimum storage of just a small number of bytes. Despite the provision of a battery, passive type of RFID microchips is always powered by energy from a reader. Active RFID readers can initiate communication with help of their available battery power.

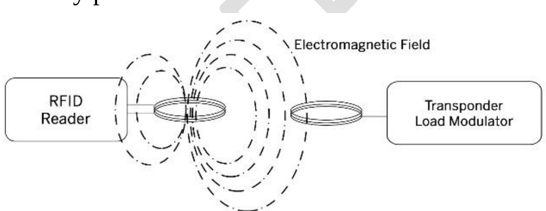

Figure 2: RFID Basic Functioning

2.1.1.2 WSN (Wireless Sensor Networks)

Progress and convergence of digital technology of electromechanical micro-systems, i.e., MEMS, and electronics and wireless communications have enabled the development and evolution of devices of miniature sizes that are equipped with the ability to detect, calculate, and communicate over small distances wirelessly [14]. The wireless sensor networks are formed by interconnecting the miniaturized devices called nodes, as shown in Figure 3, and are robust environmental, infrastructure, and traffic monitoring applications, etc.

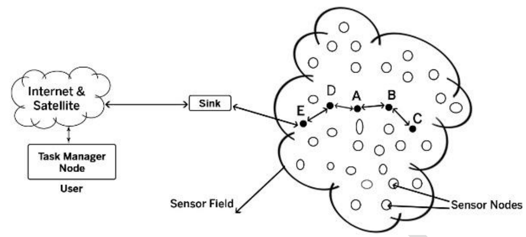

Figure 3: WSN Architecture

WSN monitoring network built upon the following components:

- ***WSN hardware*****:** Includes processing units, batteries or power supplies, sensor interfaces, and transceiver units.
- ***WSN communication stack*****:** WSN nodes must communicate to transmit data to one or more outputs for a base station. The communication stack must be enabled to communicate with other outside objects of the world at the end of receiving node with the help of the Internet so that it can behave like a gateway to the subnet of WSN and the internet.
- ***WSN middleware***: This is a paradigm for combining IT infrastructures with a network of sensors and SOA (Service Oriented Architecture) to enable connectivity to diversified sensor resources regardless of distribution. It is based on the resources that can be isolated and used by multiple different applications.
- ***Secure data aggregation*****:** To extend the life of networks and reliable data collected by sensors, a secure and effective aggregation method is required. Ensuring safety is crucial because of the system's connectivity with actuators and hence the protection intrusion systems are very important.

2.1.2. IOT APPLICATIONS

The emergence and progress of the IoT will affect multiple fields of application as shown in Figure 4. Requests can be classified into network type availability, coverage, scale, heterogeneity, repeatability, impact on users. The IoT will allow organizations from all sectors to emerge as new services or to modify their business models [14]. Then some typical Internet applications of the IoT are:

- ***Smart Home and Smart Metering*****:** IoT has extensive application in home environments where integrated automation devices allow multiple common indoor activities [15].

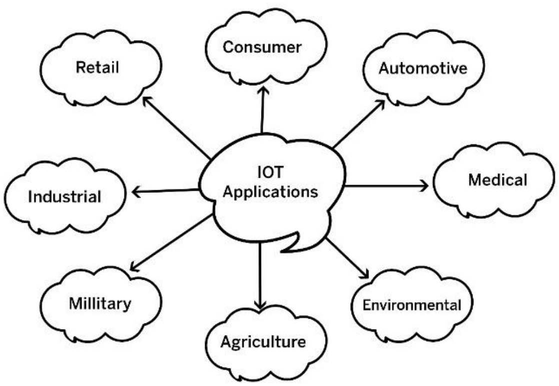

Figure 4: IoT Applications

- ***Medical*****:** Intelligent digital devices, services over the cloud and mobile internet help in the progress of continuous innovation as well as systematic medical facilities and provide high quality, affordable, efficient, timely, and ubiquitous medical services [17]. The services offered include chronic illness management, elderly care, wellness and fitness programs, etc.
- ***Utilities (energy, water, gas)*****:** Applying objects online in this field includes collecting real-time usage data, local balancing, forecasting demand for dynamic generation speeds, etc.
- ***Industrial*****:** Monitoring and remote verdict, production line automation, apparatus supervision, and diagnostics via different sensors available in the production plant, etc. are few of the resolutions provided by IoT. The results range from decreased field support costs, diminished breakdowns, and improved operational proficiency.
- ***Smart City*****:** The Internet of Things can provide a basic infrastructural middleware to the future-oriented digitally connected smart city utilities and services that acquire data and information from different diversified sensing infrastructures that can access every type of Internet of Things network technologies and geo-location as well. The solutions proposed in fresh years suggest the practice of cloud paradigm infrastructures for enabling the integration, connection, and discovery of actuators and sensors, hence providing in result the platforms that are enabled to facilitate and provide smart cities equipped with real-time applications global connectivity.
- ***Automotive and Intelligent Mobility*****:** Promising solutions are expected from the IoT being an evolving and progressing technology for transforming car transport and car services (for example, intelligent transport systems) [15]. You can develop and implement a new generation of IoT cloud-based vehicle data for a lot of businesses to get advantages e.g., increased safety on roads, road overcrowding, and management of road traffic, and advice on maintaining or fixation of the car. A large number of automobiles and the change in their numbers dynamically hinder scalability. Automobiles that move at different speeds often become the reason for intermittent communication compromising reliability, quality of service, and performance.

2.1.3. GENERIC IOT STRUCTURE

It has been found that generally, IoT has mainly four layers-

- Edge technology layer
- Access gateway layer
- Middleware layer
- Application layer

The first two layers are associated with the bottom line of the pyramidal structure of IoT and the other two are associated with higher layers of data utilization and proper application [18].

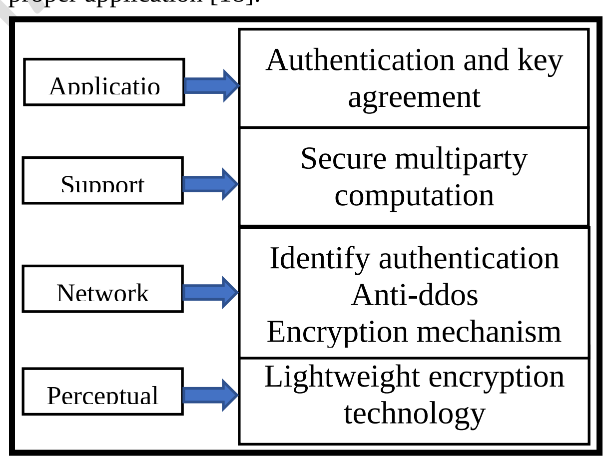

Figure 5: General IOT Architecture

According to [19] the average IoT engineering can be partitioned into five layers as shown in Figure 6.

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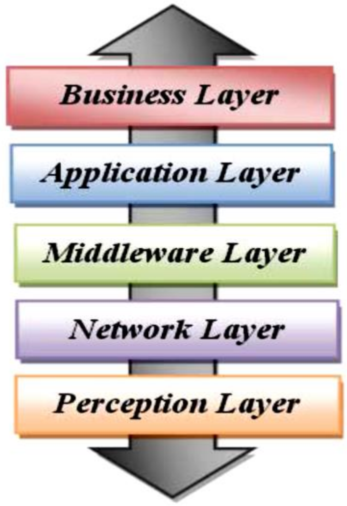

Figure 6: The IoT generic architecture

Authors in [19] describe the general architecture and working of each layer in detail. Perception layer analogous to the physical layer of the OSI model and deals substantially with device management by gathering device information which is then sent through the organization layer to the data handling arrangement of middleware

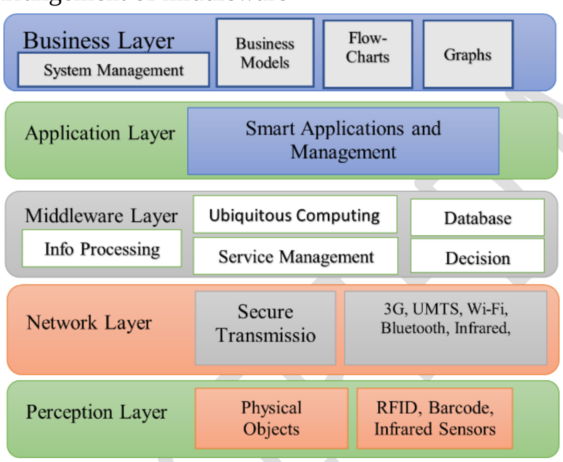

Figure 7: The IoT Architecture

. The application layer gets prepared data from the middleware layer through utilization of shrewd frameworks like smart postal, smart schooling, smart home, etc. The business layer facilitates the creation of charts, graphs, models, and reports after data analysis for making decisions, policies, and roadmaps by management groups [19, 20].

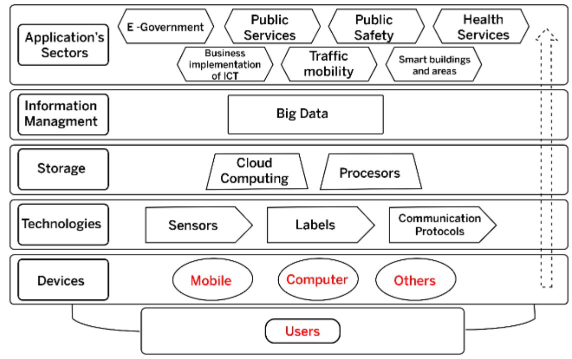

Figure 8: Architecture for Smart Systems

2.1.4. IOT ARCHITECTURE FEATURES

A rigorous evaluation of the architectures studied [19-23] reveals principal elements which are assessed as decisive in smart systems operations including:

- **Sensing**: Energy efficiency can be improved through sensing and dynamic use of sensors [24].
- **Communication:** Users and devices are interconnected in IoT where communication is secured via authentication processes and formatting of the networks [25].
- **Connectivity:** The IoT system design should support flexible, secure, and consistent connectivity among highly heterogeneous devices and resources. [26].
- **Information Flow:** The technology aims to provide efficient flow control and ensure the flexible flow of the different types of data. [27]
- **Privacy and Security:** The information management prefers the protection of personal and private information. [28]

2.2. BUSSINESS PROCESS MODELING (BPM)

A set of one or more than one connected procedures or executing activities, subsequently following sequential steps collectively achieving an objective or goal of an organization, generally within the framework of an organization and ultimately defining the specific functional relationships and roles, is a business process (BP).

BPM, i.e., Business process management, is a technique that helps govern the environment of a business's process to improve performance and agility. BPM is a structured technique for the improvement of the business procedures or processes of an organization. BPM is neither a technological paradigm and nor related to graphs or diagrams systems architecture development.

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Business Process Modeling, whereas, defined such as “the period when manual and/or automated (workflow) descriptions of a process are defined and/or modified electronically [29]”. Because the acronym for these two terms, i.e. Business Process Management and Business Process Modeling is alike as (BPM), sometimes these techniques create confusion for each other. Business Process Modeling is the methodology of demonstrating processes inside an organization or business, such that the ongoing process (“as is”) might be explored and refined accordingly for the future (“to be”) [30] [31]. Managers and analysts of business commonly execute business Process Modeling, they are attempting to escalate the process quality and efficiency. The terminology “Business Process Modeling” was originated in the field of systems engineering in the 1960s. The companies adopted to use the terms as “procedures”, or “functions”, as a substitute of processes” and “workflows” [32].

2.2.1. THE BUSSIENESS PROCESS MODELING NATION (BPMN)

In the previous few years, there has been an explicit demand for a language to model the business processes that should be formal and expressive to such an extent that it can be easily understandable not only by the domain experts but also by final users as well. At present, BPMN (Business Process Model and Notation) is the solitary cutting edge in the field of work process modeling dialects and business processes as the best driving standard [33]. The BPMN is the accepted worldview for outlining in a profoundly illustrative graphical strategy the processes executing in practically any sort of big business one can consider, from make a trip booking technique to the Nobel Prize task process, email casting a ballot framework, occurrence the executives, cooking plans, to give some examples. Using a conventional graphical notation is the de facto paradigm selection to depict an illustration of a process that must be semantically valid (thus making sure the coherence with the illustrated procedure or process) and exhibiting the same relevance same as (in usual, natural language-based) a process description made in the textual form [34].

The basic purpose of BPMN is the provision of a notation which is promptly understandable by all kind of business users, ranging from the analysts who are responsible for sketching the initial drafts of the procedures to the technical developers who are responsible in reality to implement these processes, and eventually to the staff of business monitoring and deploying these processes [35].

For the representation of the graphical layout of the business procedures or processes, BPMN was initially published by the Business Process Modeling Initiative in 2004 partially in the inspiration of UML Activity Diagram. The constantly growing adoption by companies and the ever-increasing interest for this notation ultimately in 2006 resulted in the adoption of BPMN as OMG standard.

A summary of the BPMN elements is shown in Figure 9 [34].To have a complete demonstration of elements of the BPMN and their feature refer to [36].

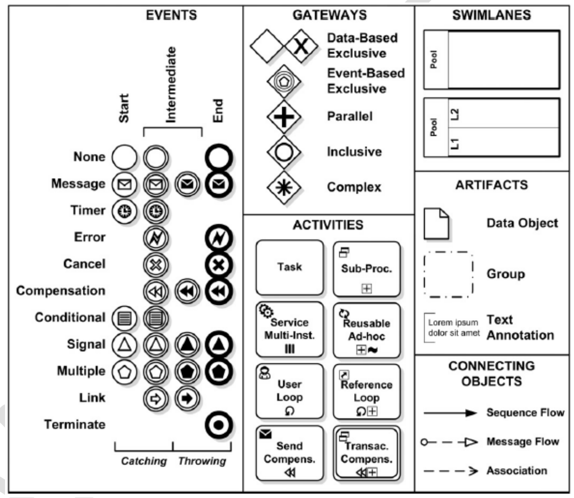

Figure 9: BPMN elements Summary [33]

2.3. WHY BPMN?

We adopted the basic components of BPMN as demonstrated in the BPMN standard [37]. We choose Business Process Modeling Notation because of its precision and wide acceptance as a standard for the business process’s modeling and communication. Its representation is very rich and has the flexibility of implementation in multiple modeling tools. Likewise, different extensions have also been proposed for it to compensate for various business requirements.

Use cases demonstrations and complicated processes documentations are mostly highly complex to perceive and susceptible to errors. Although a (more or less) clear picture describing either a business procedure or a workflow is in most of the cases self-explanatory, a lot of users target to enhance the process demonstrations with diagrams or graphs to deliver the deliberated process linked meaning. Besides, investigating a graphical representation of a process grants clients to effortlessly analyze inconsistencies and/or contrasts in abbreviations or names, non-ending conditions, boundless loops and so forward. The utilization of a traditional graphical notation is the true essential decision to portray a portrayal of any strategy or process that should be semantically legitimate (along these lines ensuring the lucidness with the showed methodology or process) and having a similar significance as the (generally, normal language-based)

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a depiction of the process made in the textual form. [34].

3. PROCESSED WORK FLOW IN IOT

The simple and streamlined workflow of IoT systems deduced from the studied architectures in background literature can be explained as follows:

- **Device sensing**, information by the device is sensed and is communicated after its identification. The information can be about motion, humidity, temperature, vibration, etc. reliant on the sensor type. Sensors can be multiple in numbers to construct smart systems.
- **Information Processing:** The entity info is treated by a smart system or smart device.
- **Invoking the action**. An action can be invoked automatically after a smart object or system processes the information.
- **Delivering the result.** The result of the action invoked and the system's current status is then communicated to the administrator of the smart system or device that contains a mechanism for it.

3.1. PROPOSED BPM FOR GENERIC IOT BASED SYSTEM OPERARTIONS

The workflow of the IoT-based system is discussed in the previous section. Based on the basic and simplified workflow of smart systems the following BPM is developed using BPMN language notations. This model demonstrates the communication of information in an IoT system.

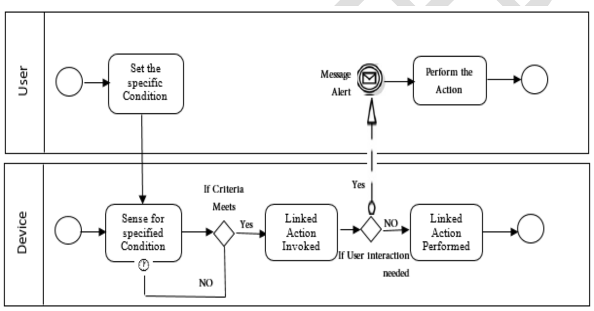

Figure 10: Business Process Model for IoT Workflow

This model shows graphically, using BPM Notations, the process of device sensing, information processing, triggering of action, and finally the performance of the action by the device itself or alerting to the relevant operator on some mobile or wearable device for action to be performed.This is the basic workflow of a smart IoT-based system which is demonstrated through BPMN.

Use Cases:

IoT paradigm can be utilized in the various environment(s) or setups and for multiple objective(s), for example for home automation, in the health sector as smart health, to make cities smart or green monitoring. Similarly for example Smart building is also an application of an IoT system: The monitoring of various physical standards (electricity, water consumption, temperature) detected by sensors is utilized in IoT based smart applications to construct automation, collect data, and offer new services to residents and ultimately save energy. For example, in a room sensor can sense and detect the existence of individuals in rooms, lavatories, or floors, and in response, actuators can manage and control the working of lights, temperature, door locks, and also connectivity of devices, according to the detected activity. Human existence detected in certain rooms at any floor, can invoke the call or action for a certain service, activate a workflow, send an alarm to inform the security dashboard, etc. In another scenario, the open state of the door and computer consuming electricity determines the activity of some individual or staff member. Inside the architecture of a smart system based on IoT, this kind of computed event can invoke a command to reconfigure the user's room (connectivity, lights, temperature). On the other hand (if electricity is not being consumed and doors are locked), lights will be turned off, and heaters will be shifted to hibernate mode to save energy consumption through the use of IoT. These connections inside the system of IoT structure can be utilized to invoke the events and processes in Business Process Management, to deal with a function attached or interactions among services offered by IoT system. For example, the information received by the BPM as (the staff member is absent) hence the system is set up for storing the incoming calls in the voice box of that member, or route conditionally the calls to some other member, and hence generating mails of voice box message. At the IoT system the cleaning service is communicated about the empty status of room that is needed to be cleaned. The cleaning individual gets a warning and the focal assistance likewise get the notice that the cleaning administration is running in the room.

4. CONCLUSION AND FUTURE RESEARCH

The Internet of Things offers several prospects for both industry and personal use. BPM or Business process management is a well-recognized area that determines the analysis, monitoring, identification, (re-)design, implementation, control, evolution, and execution of business processes. The business process

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model developed represents a general overall functionality of basic IoT-based systems operations. After sensing the particular information, a device will generate the alert or invoke the relevant action. This brief representation helps to understand the basic logic behind any smart device working in a smart environment. In future machine learning may be integrated with this approach for better and efficient results.

In the future, we will also work on a model for integrating individual existing IoT systems that will help develop a flexible network of smart systems. We aim to develop such a BPM model that will allow an IoT system to join other relevant systems to enable multiple smart systems coordinate and collaborate for sharing common data and objects. It will lead to avoid data redundancy and increase efficiency. Intelligent applications will be available in the future for more innovative homes and workplaces, more innovative transportation systems, more intelligent hospitals, more brilliant businesses, and better industries. Also in retail and supply chain management (SCM) operations, the Internet of Things (IoT) can provide various benefits. Before we wrap up, we'd like to draw attention to a cross-issue, namely, dealing with privacy and, in particular, security concerns. For example, privacy protections at the sensor level may differ from those at the User level. The full-disclosure strategy should be needed to avoid situations where sensitive or in other words personal information is obtained. Instead of coming up with difficult and time-consuming updates afterwards, identify and assess any data protection issues while designing new systems or technology and embed privacy measures into the new overall design i.e. privacy by design.

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