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Improved Generic Layer Model for IoT Architecture

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ABSTRACT – The internet of things (IoT) has the potential to create massive disruptions in telecommunications, cable broadband, cloud computing, and the architecture of related IoT objects etc. However, currently it is no standard IoT architecture for the integrated IoT components which operate together perfectly. There are many existing IoT architectures in the industrial and commercial fields, but the design depends on the owner's direction without defined standardization. This paper analyzed the existing of IoT architecture layer focusing on the responsibility of each layer, then classified the layer architecture based on IoT reference model. Finally, the improved generic layer model of IoT architecture which provided a guideline framework to achieve the modeling of IoT industrial architecture based on layers-model was proposed.

KEYWORDS: IoT architecture, Improved IoT Layer, Analyze architecture, Responsibility of IoT Layer

1. Introduction

Currently, there are reference models of IoT architecture in different industries such as Intel, Microsoft, Cisco, Google, IBM, Ericsson, Amazon, etc.[1], which have been designed on their own direction, and no core standardization for architecture layer models. Due to the lack of general guidelines of frameworks that handle low level communication and simplify high level implementation,it cannot bring the success of the implementation on diversity IoT system, under the processing with high complexity of distributed computing. So, many researchers try to develop the IoT architecture modeling based on various methods such as domain-specific architectures, layer-specific architecture, and industrial or commercial architectures[10], based on the application of requirements and current technologies, also the consideration of the environment surrounding the devices[6][7], based on on TCP/IP protocol stack [3], based on layer model [1], based on new technology[9] etc. All of the objectives of those architectures were to improve the architectures with new solutions to mitigate IoT challenges such as scalability, interoperability, extensibility, manageability, security and privacy etc.

The remaining paper is organized as follows: section 2 presents the related work, section 3 analyzes the responsibility of each layer for existing IoT architecture. Section 4 provides an approach to analyze the IoT architecture layer, Section 5 presents the improved generic layer model of IoT architecture. Section 6 presents modeling the existing IoT architecture with proposed model. Finally, the conclusion is explained.

2. Related Work

There is no single consensus on architecture for internet of Things, which is agreed universally. Different architectures have been proposed by different researchers. Many researchers introduced the most basic architecture which is a three-layer architecture. It an early stage of research in this area. It has three layers, namely, the perception, network, and application layers. The limitation of 3-layer is not a layer for business[2], absence of application layer security etc.[10] So, the researchers proposed a new architecture to solve the 3-layer issues and develop for the next generation. The authors has reviewed the research papers of IoT architectures, starting from four layers to eight layers as follows:

- Bozdogan and Kara[3] proposed a layered structure for internet of things (IoT) architecture by considering the computer network's conventional model that included new technological aspects. The new IoT layered architecture consists of four layers: perception layer, network layer, transport layer and

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application layer. The reason for improving the layer is that there are several studies about IoT technology, but there are no studies regarding the accepted standard of layered architecture models. In this study, a new layered model was proposed for IoT architecture. The proposed model was compared with the conventional OSI and TCP/IP models.

- Vashi et. al.[4] explained that the IoT architecture in smart world consisted of five layers: perception layer for collection of information, network layer, processing the data and information collected is sent to the middleware layer using this network layer, middleware layer, received and processed data and information. Application layer is responsible for application management based on the processed information in the middleware layer, and business layer for support the business model.

- Burhan et. al.[5] proposed the improved layered architecture of IoT. Because the first three-layer architectures of IoT are not suitable for IoT application, although they have some common features. They do not fulfill the requirements of security and privacy and are affected by numerous security attack, to overcome the issues of security, easily and smoothly extended to basic function with little impact on existing layered architectures of IoT to enforce the security attacks and prevent IoT applications from attackers. The six layers are improved, and consist of application layer, network layer, security layer, processing layer, observer layer, and perception layer.

- Dina[6] and Rashmi[7] proposed an improved architecture to the internet of things (IoT) that takes into consideration the environment surrounding the devices, including the object to be detected or the place to observed, and other factors affecting the sensing operation. This improved layered architecture depends on seven layers, not on four layers as the traditional layered architecture, and takes all the function of the traditional architecture and distribute them on the seven layers, but in more reliable way. The proposed improved layered internet of things (IoT) architecture composed of seven layers: application layer, application support & management layer, services layer, communication layer, network layer, hardware layer, and environment layer.

- Banu et. al.[8] analyze different industry standard IoT architectures from various research, and founded IoT architecture initially designed to have 3-layer architecture and went on to become 7-layer architecture currently on the basis of the protocol. Each industry designed the different direction. For example, the industries started on their own strength like CISCO on gateways, IBM on cognitive data processing and INTEL on processor miniaturization. In addition to the above, big vendors understood the market and started working on interoperability through middleware and collaborative work on edge computing. There are two more architectures, and they are called fog and cloud architectures. Cloud computing is given importance due to its great flexibility, and scalability. It offers services such as the core infrastructure, platform, software, and storage. Hence lately, IoT towards another system, namely fog computing which inserts monitoring, preprocessing, storage, and security layers, between the physical and transport layers before going to cloud. It not only reduces energy consumption, but also improves end-to-end latency and minimizes operational costs in latency-critical IoT application[6]

- Santos et. al.[1] proposed and approach for modeling and analyzing IoT architectures. This propose is based on extracted data for each layer in each provider (some elements for each layer: input, output, activities, performed, and the principle objective). The 7-layer model is classified in the industrial architecture (Microsoft, Intel, Cisco, Google, IBM, Ericsson, Amazon) according the layer in the reference model. The 7 layers consist of physical device/thing/object layer, connectivity layer, edge(fog) computing, data accumulation, data abstraction layer, application layer, and collaboration & processes layer.

- Rahimi[9] proposed a novel architecture which is able to meet the needs of the next generation IoT applications and assist IoT experts to design more efficient and scalable IoT systems. New model is based on new technologies such as device-to-device (D2D) communication, the 5G communication network, Machine-Type Communication (MTC), Wireless Network Function virtualization (WNFV), Wireless Software Defined Networks (WSDN), Mobile Edge Computing (MEC), and Mobile Cloud Computing (MCC). It composed of 8 interconnected layers including physical device layer, communication layer, fog computing layer data storage layer, management service layer (network management layer, cloud computing layer, and data analytic layer), application layer, collaboration and processes layer, and security layer which protects all layers through data encryption, user authentication, network access control, cloud security.

- Pratap Singh et.al[10] classified the existing IoT architecture focusing on layer-specification architecture. That can be classified to 6 groups such as (1) 3-layer architecture: consists of perception layer, network layer, application layer, (2) 4-layer architecture: this adds a service layer, that acts as a middle ware between network and interface) that is responsible for providing the data services in IoT, (3) 5-Layer architecture: consists of perception layer, transmission layer, middleware layer, is associated with data storage, application layer, perform the function of application management, and business layer, the up-most layer, help in data analytics and base on that, it takes the further decision, (4) 6-layer architecture: add new 2 layers are augmented into the previous IoT model. These are: 1) MAC layer, that helps to monitor and control the devices. 2) processing and storage layer, that helps to process the queries,

analyze and storage the data. (5) 7-layer architecture : consists of 7 layers: application layer, application support and management layer, determines the security and is responsible for management of IoT device and their operation, service layer, determines various activities performed by the developers in order to provide essential services to the customers, communication layer, network layer, and hardware layer. (6) fog and cloud-based architecture layers: comprises of 6 layers: physical layer, monitoring layer, pre-processing layer, storage layer, security layer, and transport layer.

3. Analyze the responsibility of layers

The authors selected and analyzed the layer of existing architecture from research paper focusing on the responsibility in accordance with the basic reference model of IoT architecture[18] and considerate only the important layer should be used for modeling layer of IoT architecture. This selected 7-layers consists of perception layer, network layer, middleware layer, application layer, business layer, security layer, and management layer. In order to clarify the concept of responsibility of each layer, we show the more details which explain each layer of each researcher, then conclude in the authors viewpoint. The details are described as follows:

3.1 Perception layer

The researchers describe as follows: the perception layer is made up of physical devices such as your sensors and actuators which interact with other devices and the physical world to both send and receive data to other devices using wireless technology. This layer's objective is to collect all the information from its sensors and actuators, that can be sent to the network layer[11]. The perception layer is also known as the "Sensors" layer in IoT. The purpose of this layer is to acquire the data from the environment with the help of sensors and actuator[12]. Perception layer (also called as recognition layer) gathers data/information and identifies the physical world[13]. The Perception layer is the physical layer, which has sensors for sensing and gathering information about the environment. It senses some physical parameters or identifies other smart objects in the environment[14]. Perception Layer- It consists of different kinds of sensory technologies[15]. A smart device/sensor layer: the lowest layer is made up of smart objects integrated with sensors. The sensors enable the interconnection of the physical and digital worlds allowing real-time information to be collected and processed [16] Perception Layer - It is also known as a sensor layer. It works like people's eyes, ears and nose. It has the responsibility to identify things and collect the information from them [5]. Hardware layer: Includes sensors, other hardware such as; embedded systems, RFID tags and readers and others. The sensors enable the interconnection of the physical and digital worlds allowing real-time information to be collected and processed[6]. Environment layer Includes objects to be detected or places to be observed. The objects to be detected vary from physical moving objects, such as humans, cars, to environmental factors such as, temperature, or humidity. The places to be observed are ranging from buildings, universities, streets and so on[6]. The bottom layer, the device layer, there exist the hardware components, the sensors, the RFID tags and other sorts of devices[21]. Physical Device Layer: This layer consists of wireless sensors, actuators, and controllers, which actually are the "things" of IoT. Physical devices are a common layer in all the architectures[22]. The authors reviewed the first layer architecture and founded that there are various different names but the responsibilities of them are similar such as perception layer[5][11-15], physical layer[14], smart device/sensor layer[5][12], recognition layer[13], device layer[21] environment layer[6] ,hardware layer[6], physical device layer[22], and bottom layer[21] In this part, the authors concluded that the perception layer is responsible for detecting, collecting, processing information and transmitting it to the network layer through sensors and other IoT devices under various protocols.

3.2 Network layer

The researchers described the network layer as follows: The network layer handles the data been sent between smart devices as well as network devices and servers and can be also used to transmit and process perception layer data into a readable format for the receiving device[11]. The network layer of IoT serves the function of data routing and transmission to different IoT hubs and devices over the Internet. At this layer, cloud computing platforms, Internet gateways, switching, and routing devices etc. operate by using some of the very recent technologies such as WiFi, LTE, Bluetooth, 3G, Zigbee etc.[12]. Network layer is the middle one (also called as wireless sensor

networks, which accountable for the initial processing of data.[13]. The network layer is responsible for connecting to other smart things, network devices, and servers. Its features are also used for transmitting and processing sensor data [14]. The network layer includes of network communication software and physical components such as topologies, protocols and network nodes which are used in communication[15]. Gateways and networks massive volume of data will be produced by these tiny sensors and this requires a robust and high performance wired or wireless network infrastructure as a transport medium[16]. Network layer is also known as transmission layer. It acts like a bridge between perception layer and application layer. It carries and transmits the information collected from the physical objects through sensors. The medium for the transmission can be wireless or wire based[5]. Network layer: performs the following functions; gateway routing & addressing, network capabilities, t ransport capabilities, error detection & correction. A lso, it takes care of message routing, publishing and subscribing, w ith demand needed to serve a wider range of IOT services and applications[6]. T he network and communication layer, there exists the network and communication capabilities, such as; gateway, routing and addressing, energy optimization, QoS (Quality of Service), flow control and reliability, and error detection and correction[21]. Communication layer consists of two-sublayers, D2D and connectivity layers for support 5G make as a great evolution at this sub-layer in the sense of reliability, performance, and agility[22]. Some review papers called transmission layer, wireless sensor network layer, or communication layer, a network layer. The authors concluded that the network layer is responsible for connecting to all objects or devices in IoT environment. Its features are also processing data and transmitting to the other layer. It includes network communication software and physical components such as protocols, gateway, routing and addressing.

3.3 Application layer

The researchers described as follows: the application layer which can also be called the business layer delivers specific services to the users and receives the data from the sensors/actuators from the perception layer after being translated into a readable format by the network layer[11]. Application Layer: it guarantees the authenticity, integrity, and confidentiality of the data. At this layer, the purpose of IoT or the creation of a smart environment is achieved[12]. Application layer makes the link downward of perceptual layer, and takes care of global services in the IoTs[13]. The application layer is responsible for delivering application specific services to the user. It defines various applications in which the Internet of Things can be deployed[14]. Application Layer consists of various applications and services[15]. The application layer or IoT application covers “smart” environments/spaces in domains such as: transportation, building, city, lifestyle, retail, agriculture, factory, supply chain, emergency, healthcare, user interaction, culture and tourism, environment and energy[16]. Application Layer defines all applications that use the IoT technology or in which IoT has deployed. The applications of IoT can be smart homes, smart cities, smart health, animal tracking, etc. It has the responsibility to provide the services to the applications. The services may be varying for each application because services depend on the information that is collected by sensors[5]. Application layer includes the IoT application. This layer is at the top of the architecture and is responsible for delivery of various applications to different users in IoT[6]. The top or first layer is the IoT application layer which contains the application user interface[21]. In this layer, software interacts with previous layers and data[22]. The authors concluded: it is responsible for defining software or application that use the IoT technology. The applications function consists of data formatting, presentation, things services to users according to their needs. The applications of IoT can be smart homes, smart cities, smart health, animal tracking, wearable etc.

The first 3-layers of IoT architecture is a basic essential architecture. It has a limitation that is currently developing to be success on IoT context. So, the researcher confirmed as follows: the 3-layer architecture defines the main idea of the Internet of

Things, but it is not sufficient for research on IoT because the research often focuses on finer aspects of the Internet of Things, that is why, we have many more layered architectures proposed in the literature[14]. The IoT 3-Layers as an accepted structure but is trivial modeling of the IoT ecosystem[2]. One important point for 3-layer architecture is the fact that there is not a layer for business[1]. Limitations: absence of application layer

security[10] etc. From those limitations , the researcher tried to extend the layer for the IoT architecture requirement. The layers were extended as follows:

3.4 Support layer/ Middleware layer/ Processing layer

The researchers described as follows: this layer focuses on the middleware for supporting the high processing which extended continue from the network layer. The responsibility is providing a big data of services in IoT that helps in reduction of time of product development because the IoT system has a wide range of technology, and so complexity. The highlight of this layer focuses on fog and cloud computing layer, cloud computing has more flexible and scalable techniques which allow various services for IoT systems. These services include information storage options, software tools and analytics, suitable platform, and core infrastructure for the development. With cloud facility, users can have the visualization, machine learning, data analytics options for wider sets of information. So, Cloud based architecture became popular in IoT systems due to the equivocal nature of the information sensed and produced in the form of data by IoT devices. In most of the IoT architectures, a centralized control over the data is done using the cloud-based data processing systems[22]. Cloud computing based on centralized of course, it overloaded for processing over the IoT system. The results of the cloud have a latency time problem. In order to solve the latency time and reduce the processing costs at the cloud layer, the new layer, which is a fog layer was designed. Fog Computing Architectures: it is an extension of cloud computing to the edge of the network. The goal of Fog computing or Edge computing is to improve the efficiency of local and cloud data storage. It minimizes the amount of data required to be sent to the cloud which advances data analysis efficiency and the security of IoT[18]. Cloud and Fog concept computing are shown In Figure 1. From Figure 1. IoT architecture that integrated IoT with cloud computing, and fog computing which are an online platform that assists system integrators and solution providers to create a complete infrastructure for things application for developing, deploying, operating, and combining things applications and service. In summary, the responsibility of this layer will be integral parts of the processing of huge amount of information. It will be more efficient by applying cloud computing and fog computing technology which is suitable for the currently situation, so many IoT architectures are extended to this layer.

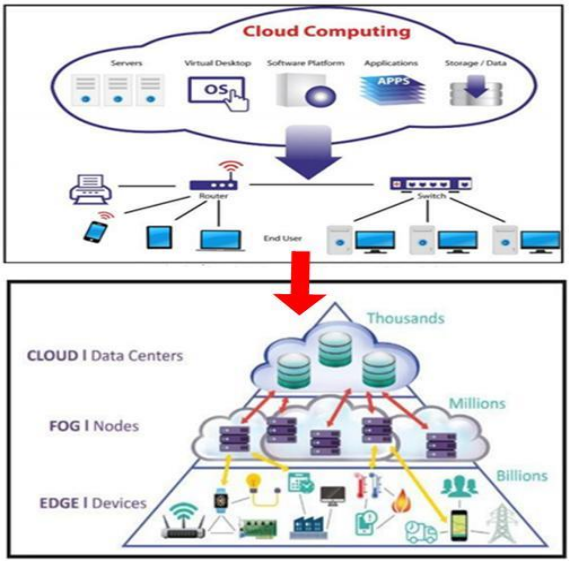


Figure 1. Cloud and fog computing concept[18]

To overcome the limitation of 3-layer architecture focusing on the business layer, it was extended to newly proposed layer. As the business logic is a very important in the business context, the business layer should be designed and everything on IoT environment is needed to be driven. Some researchers stated “The business layer is King”[24].

3.5 Business layer

The researchers described as follows: the responsibilities are to manage and control applications, business and profits models of IoT[5]. It is sometimes called the collaboration and processes layer. This layer’s function covers the entirety of IoT application and service management. It can create practical graph, business models, flow chart, executive report, etc. based on the amount of accurate data received from the lower layer and effective data analysis process. Based on the good analysis results, it will help the function managers or executive to make more accurate decisions about the business strategies and roadmaps[4]. The business layer refers to an intended behavior of an application and acts like a manager of a whole system. It has responsibilities to manage and control applications, business and profits models of IoT. The user’s privacy is also managed by this layer. It also has the ability to determine how information can be created, stored and changed[5].

The business layer is the place where all the business/domain logic, i.e. rules that are particular to the problem that the application has been built to handle for living. This might be salary calculations, data analysis modelling, or workflow such as passing an order through different stages[24]. This layer performs the management of the entire IoT system that involves user's privacy, applications, profit and business processes, etc[18]. The conclusion of this layer: the responsibility to manage and control application and business logic led to the business success model. As above, a security layer is not mentioned yet, but it defines the security policy with protect data and information hidden with other layers. Besides, there are many proposed architectures of IoT, no layers regarding the security though. However, in the paper, several IoT architectures were found focusing on security issues and extended to the security layer[5][22] in order to overcome the issues of security which are affected by numerous security attacks.

3.6 Security layer

The researchers described as follows: security layer makes secure information before sending to the network layer. It receives information from the processing layer. It performs encryption through converting all information collected from the processing layer into unknown form, called cipher text. The process of encryption is performed by using keys. It sends encrypted information to the network so that it could not be understood by anyone other than the authentic users. It also sends a key to the receiver to convert the cipher text into original text. Thus, this layer protects the information of users from the attackers and risks existing on the network layer[5]. In addition, the security layer covers all other layers too. The security layer of the proposed architecture entails various terms of security features including data encryption, user authentication, network access control and cloud. In order to be suitable for the requirements of upcoming IoT applications and services, the new architecture is developed based on the technologies, which is to provide a more sustainable and scalable than existing architectures. The new architecture will be following features: modularity, efficiency, agility, scalability, simplicity, and ability to response to high demands[22]. The authors conclude the responsibilities of security layer focusing on the protection of IoT assets, these ensure in security issues covering all layers in IoT environment. The properties of security issues consist of confidentiality, integrity, availability, authentication, non-repudiation, and privacy. The last layer in which the authors selected for consideration of IoT architecture modeling is management layer, that is considerate all of things that manage in IoT system. However, the traditional architecture layers had no promote the management layer, but they were hidden and managed by each layer in the IoT operations.

3.7 Management layer

The researchers described as follows: management layer mainly manages servers from service & storage layer, and assigns tasks to the control server, like adding and updating software[20]. Focusing on the Management Capabilities, such as QoS Manager and Device Manager, they are distributed along the service support and application support layer and the network and communication layer, the Security Management functions [21]. Application support & management layer perform the following functions: Qos manager, device manager, business process modeling, business process execution, authorization, key exchange & management trust & reputation, identity management. In this layer, all actions related to the control, security and management of the application are made[7]. Management service layer consists of three sub-layers including Network Management Sub-Layer, Cloud Computing Sub-Layer, and data analytics sub-layer that is the improvement in big data[22]. This concluded the responsibility of this layer: monitoring and controlling whole IoT system focus on IoT devices, QoS management, Trust& reputation management, security management service management, network management etc. Summary of the responsibility of each layer is shown in Table 1.

In the authors viewpoint, this layer should be set the first priority in IoT architecture layer next to infrastructure because it is a key success for IoT environment. The seven main layers as above can be classified into 5 groups covering all the necessary components in IoT system such as infrastructure, application & analytic, integration, security[26], and management. This proposal is called a framework used for modeling IoT layer architecture. It helps designing the workflow in the simple way. The conceptual framework is shown in Figure 2.

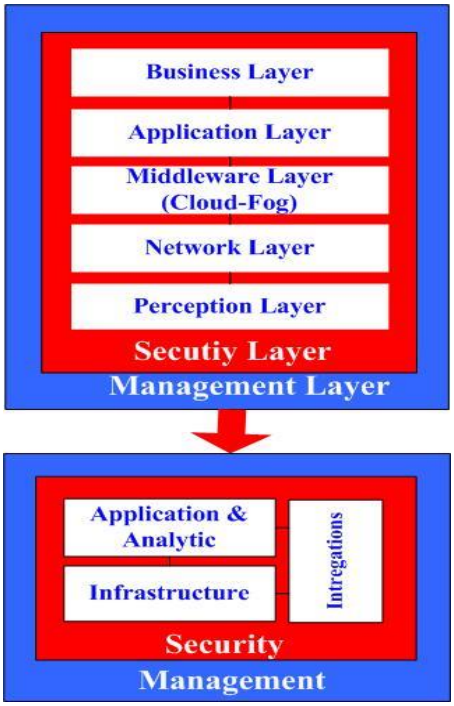


Figure 2. IoT Layer Framework

Table 1. Summary of the Responsibility of Layer

Layer	Responsibility
Perception	detecting, collecting, processing information and transmitting it to the network layer. Through sensors and other IoT devices under various protocols.
Network	connecting to all objects or devices in IoT environment. Its features are also processing data and transmit to the other layer. It includes network communication software and physical components such as protocols, gateway, routing and addressing.
Middleware	processing of huge amount of information. more efficient by applying cloud computing and fog computing technology
Application	defines software or application that use the IoT technology. The applications function consists of data formatting, presentation, things services to users according to their needs. The applications of IoT can be smart homes, smart cities, smart health, animal tracking, wearable etc.
Business	manage and control application and business logic led to the business success model.
Security	protection of IoT assets, these ensure in security issues cover all layers in IoT environment. The properties of security issues consist of confidentiality, Integrity, availability, authentication, non-repudiation, and privacy
Management	monitoring and controlling whole IoT system focus on IoT devices, QoS management, Trust& reputation management, security management service management, network management etc.

4. Approach for modeling and analyze IoT layer architecture

This section, we discuss the approach for modeling and analyzing the generic layer model of IoT architecture. Generalize the research used various approaches for modeling IoT architecture such as computer network's conventional model[3], takes in to consideration the environment surrounding the devices[7], extracted data from reference model[1] etc. However, reference approach architectures provide guidelines useful for planning the implementation of IoT systems, and therefore help considerably in the standardization of them. Standardization can be achieved through high-level reference architectures but they are difficult to be understood because they are very abstract. This paper developed generic layer model of IoT architecture based on IoT reference model [18]. It is a basic requirement of generic architecture composed of: 1) Data collection ability such as data center, big data, extraction information and knowledge, and analysis tools. 2) Connectivity and communication, all devices provided interconnection or global infrastructure. Besides, the support system for the incremental effective IoT system such as middleware (cloud, fog computing). 3) Scalability is a capability to adapt in present, and the future for new technology, and process increased data volumes for different system sizes. 5) Predictive analysis that shows the capability to predict events and situations for decision making focusing on the business track and others. 5) Security, privacy and trust, all ensure the information and system provided the confidentiality, integrity, availability, authentication, authorization, and non-repudiation[18]. And the authors extended to 6) Management is the capability for control, monitoring,

quality of service (Qos) and managing all devices/services etc. for effectiveness in IoT environment including centralized and distributed based control.

5. Improved generic layer model of IoT architecture

The authors analyzed various research papers based on IoT reference model in section VI. The number of layers starting from three layers to eight layers was founded. The characteristics of each existing architecture reference were analyzed together with proposing the model which is classified into three groups including basic architecture layer, intermediate architecture layer, and advance architecture layer. The basic architecture layer covers only infrastructure of internet. The intermediate architecture layer covers the integration part such as the middleware, data analysis or business model, and the advanced architecture layer covers all necessary things in the IoT environment, especially, security and privacy and management. The reference requirements of layer group for IoT architecture modelling are shown in Table 2.

Table 2. Requirements of IoT architecture

Reference requirements	B	I	A
1.Data collection ability	Y	Y	Y
2.Connectivity and communication	Y	Y	Y
3.Scalability	N	Y	Y
4.Predict analysis	N	Y	Y
5.Security and privacy	N	N	Y
6.Management	N	N	Y

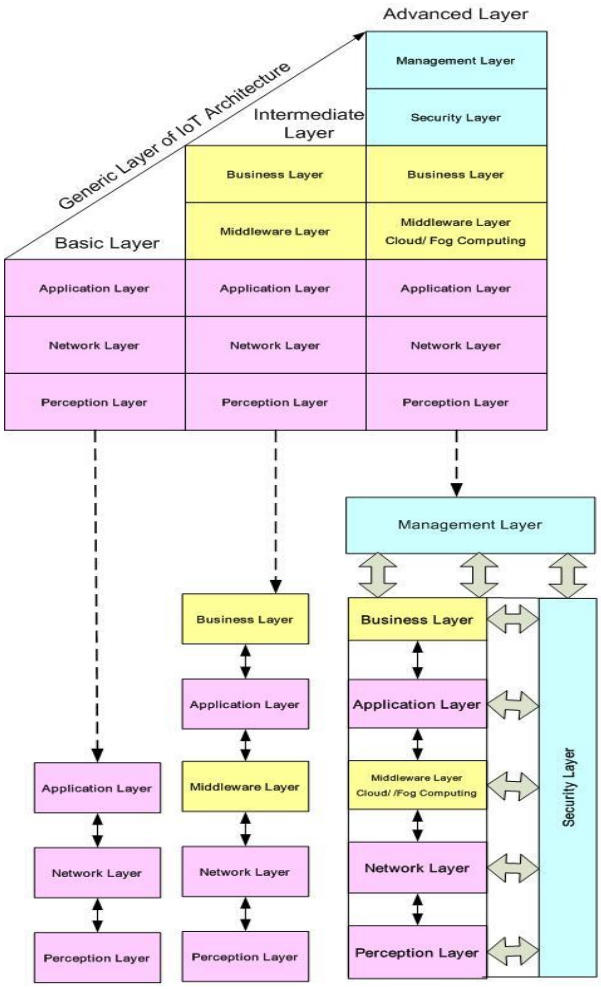
B: Basic, I: Intermediate, A: Advanced

Table 2. shows the requirements of IoT architecture of each layer. Basic architecture layers include only two reference requirements which are data collection ability and connectivity and communication, intermediate architecture has four reference requirements such as data collection ability and connectivity and communication, scalability, and predict analysis, and advanced architecture composes of all reference requirements in the reference model such as data collection ability, connectivity and communication, scalability, predict analysis, security and privacy, and management. In this study, the authors improved the generic IoT Architecture layer from basic architecure layer to advanced architecture layer consisting of :

- 3-layer: percetption laer, network layer, application layer (basic layer) extended to 5 layers.
- 5-layer: added two new layers: middleware layer, business layer (intermediate layer) extended to 7 layers.
- 7-layer**:** added two new layers: security layer and management layer up to (advanced layer).

This improved architecture layer focuses on the 7-layer with additional two new layers because almost the IoT reference architectures don't show the security and management policy in the IoT sytem in spite of being very important. The conceptual of generic layer model is shown in Figure 3.

Figure 3. Generic layer model of IoT architecture



However, it was found that the proposed model of IoT architecture has some similarities with other models. For example, an improved layered architecture depends on seven layers including the management layer but not have the security layer[6][7]. A newly improved generic layered architecture has six layers: it has a security layer and observation layer (authentication) to enforce the security attack and prevent IoT applications from attackers but not have a management layer [5]. INTEL architecture consists of 7 layers, developed the new layer, namely fog computing which inserts monitoring, preprocessing, storage, and security layers[8], and lately, proposing a novel architecture is able to meet the needs of the next generation IoT applications and assist IoT experts to design more efficient and scalable IoT systems. It consists of 8 layers which have the security layer and management layer[9]. The related work that shows the security and management as mentioned above should be promoted in the generic layer architecture. However, the divided layers of architecture based on generic layer proposed by the authors is just the guidelines provided for the industry to be useful for planning the implementation of IoT system. This key success factors of IoT architecture should be focusd on manageability, security and privacy, mobility, efficiency, cost effectiveness, quality of service, data collection ability, connectivity and communication, scalability, and predict analysis. Any designers who model the IoT architecture layer must consider to cover all the components in IoT system such as infrastructure, application& analytic, and integration[26], including security and management to be able to protect all the assets in IoT environment. As in the IoT environment, so many objects are connected to the internet for information exchange and this may allow attackers to access and hack into the network, designing to make the architecture of IoT secure should be done. It is concluded that the generic layer model of IoT architecture is a framework for modeling IoT architecture based on 7-layer model.

6. Modeling the existing IoT architecture using propose approach

In this section, we apply the approach to describe the examples of existing IoT architecture which have 3-8 layers (Figure 4.), and are classified based on new generic layer model of IoT architecture as the summary shown in Table 3. and described as follows:

A. Description of each architecture:

- Basic architecture layer: as Figure 4. A[11] 3-layer model consists of perception layer, network layer, and application layer. This layer covers data collection and communication of reference requirements.
- Intermediate architecture layer: as Figure 4. B[17] 4-layer model consists of perception layer, network layer, support layer, and application layer, as Figure 4. C[14] 5-layer model consists of perception layer, network layer, middleware layer, application layer, and business layer. This layer can because used to support predict analysis and scalability because it was extended to the new layer such as middleware layer (applied by cloud and fox computing) and business layer.

Advanced architecture layer: as Figure 4. D[5] 6-layer model consists of application layer, network layer, security layer, processing layer, observe layer, and perception layer, as Figure 4. E[25] 7-layer consists of communication connectivity layer, data layer, management layer, control layer, application layer, business layer, and security layer, as Figure 4. F[22] 8-layer consists of physical layer, communication layer, connectivity layer, edge layer, storage layer, management layer (network management, cloud computing, data analysis), application layer, collaboration and processes layer, and security layer. This is advanced IoT architecture covering all the reference requirements of IoT architecture. Two more new layers of security and management layer are added to pay attention to the security and management of the entire system which supports the IoT disruption.

From the authors viewpoint of the existing IoT architectures as shown in Table 3., 3-layer, 4-layer, and 5-layer models are the traditional layered architecture model[11][14][17], while 6-layer, 7-layer, and 8-layers are advanced layer for IoT architecture model [5][25][22].

B. The advantage of each architecture consists of:

- 3-layer architecture: the advantage is simplicity, effortless problem identification and flexibility, while the limitation is absence of application layer security[10].
- 4-layer architecture: The advantage is reducing the time of processing modules because it has a cloud and fog computing[19].
- 5-layer architecture: To help in data analytics and take the further decisions in business layer to solve the 3-layer model that is not a layer for business [2].
- 6-layer architecture, 7-layer architecture, and 8-layer architecture separate many modules for processing in the IoT system focusing on security and management, helps monitoring and controlling the overall system to ensure security and privacy in order to solve the above layer architecture which no security and privacy are discussed[1].

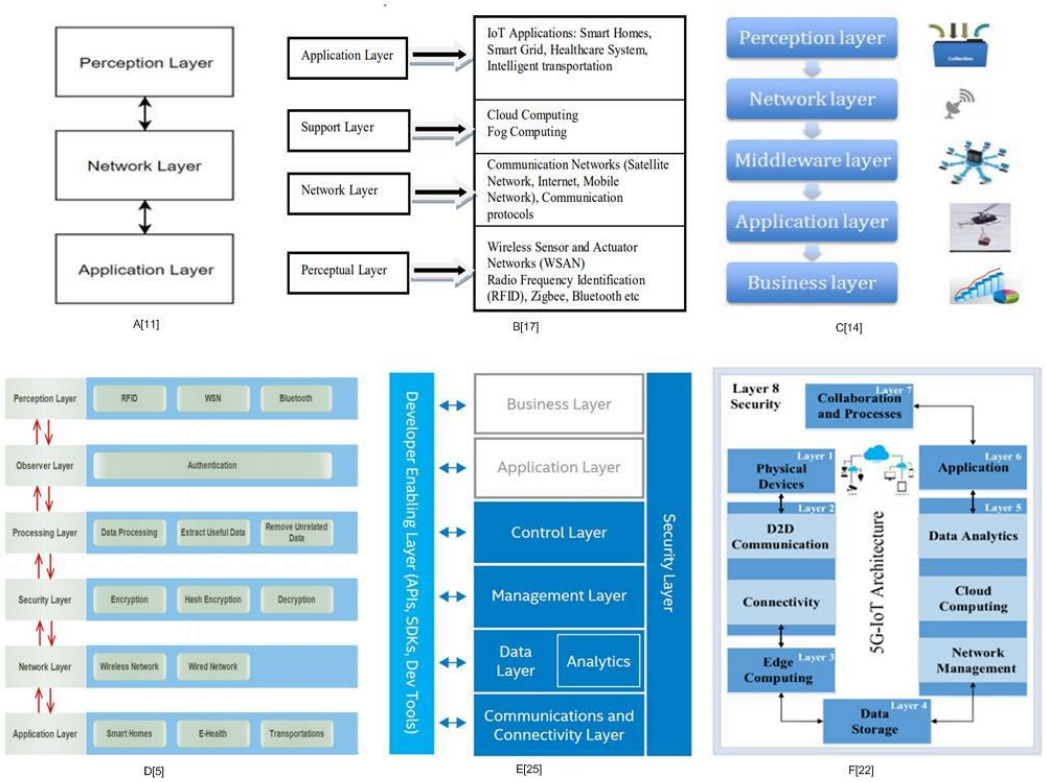


Figure 4. The existing IoT architecture

7. Conclusion and Discussion

This paper analyzed the existing of IoT architecture layers focusing on the responsibility of each layer, then classified the generic layer architecture based on IoT reference model. The authors improved the generic layer model of IoT architecture which consists of 7 layers for implementing IoT architecture coverig all infrastructure, application & analytic, integration, security, management. The new generic layer model of IoT architecture is a framework for modeling provided and approach to achieve the modeling of IoT industrial architecture based on the

Table 3. Classified Existing IoT Architecture by Proposed Model

NfL	Layer name	Reference Requirements						Level
		D	C	S	P	Se	M	
3[11]	1.Perception							B
	2.Network							
	3.Application							
4[17]	1.Perception							I
	2.Network							
	3.Application							
	4.Support							
5[14]	1.Perception							I
	2.Network							
	3.Application							
	4.Support							
	5.Business							
6[5]	1.Application 2.Network							A
	3.Security							
	4.Processing							
	5.Observer							
	6.Perception							

NfL	Layer name	Reference Requirements						Level
		D	C	S	P	Se	M	
7[25]	1.Communi-cation							A
	2.Data							
	3.Management							
	4.Controller							
	5.Application							
	6.Business							
	7.Security							
8[22]	1.Physical device							A
	2.Communi-cation							
	3.Edge Computing							
	4.Data storage							
	5.Management							
	6.Application							
	7.Collabo-ration							
	8.Security							

layered model. The advantage of proposed approach is being clear and easy for development because the designing is focused to cover the whole assets and components of the IoT environment. As there are modules in the generic layer model, it is easily employed in industrial IoT architecture.

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