A Survey of Applications of IoT in E-Commerce

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Abstract—This article aims to exhibit IoT devices and technologies integrated with E-Commerce. First, the reader gains a shallow understanding of IoT basis and protocols, afterward the article clarifies the term *E-Commerce* and some minor details about it, and after that, it illustrates the applications of IoT in E-Commerce. I tried to distill the most accurate information from numerous articles. This article does not discuss *Applications of IoT in E-Business* as they are very different.

Index Terms—IoT, E-Commerce, application, things, smart

1 INTRODUCTION

WITH the advent of the Internet, many new electronic-based concepts and technologies came to exist and one of them was *IoT*. First, let's clarify what are *things*. The *things* that are part of the *Internet of Things* are computing devices(embedded devices [1]) that understand and react to the environment they reside in. These things are also often referred to as smart objects or smart devices. The lifecycle of a *thing* refers to the operational phases of a thing in the context of a given application or use case. This generic lifecycle applies to very different IoT applications and scenarios(Fig. 1). [2]

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 _Manufactured           _SW update          _Decommissioned
/                       /                   /
|   _Installed          |   _ Application   |   _Removed &
|  /                    |  / reconfigured   |  /  replaced
|  |   _Commissioned    |  |                |  |
|  |  /                 |  |                |  |   _Reownership &
|  |  |    _Application |  |   _Application |  |  / recommissioned
|  |  |   /   running   |  |  / running     |  |  |
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+##+##+###+#############+##+##+#############+##+##+##############>>>
    \/  \______________/ \/  \_____________/ \___/         time //
    /           /         \          \          \
Bootstrapping  /      Maintenance &   \     Maintenance &
              /      rebootstrapping   \   rebootstrapping
        Operational                Operational
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Fig. 1. The Lifecycle of a Thing in the Internet of Things [2]

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2 PRELIMINARY TO IOT

The term "Internet of Things" (IoT) denotes a trend where a large number of *embedded* devices employ communication services offered by Internet protocols [1]. The concept was first introduced by the United States Massachusetts Institute of Technology in 1999 [3]. At that time it only aimed to realize intelligent merchandise identification and management by Radio Frequency Identification (RFID) technology [3]. Later, it was proposed at the International Conference on Mobile Computing and Networking in the United States. *Professor Ashton from MIT Auto-ID Center* proposed for the first time in the study of a combination of object coding, RFID, and Internet technology solutions [4]. [4]At that time, based on

RFID technology, EPC standards, and the Internet, by the use of radio frequency identification and wireless communication technology, global goods real-time information sharing Internet was constructed [4], which in a nutshell was the mere definition of the "Internet of things".
Now the connotation and meaning of the IoT have undergone a lot of changes; from different parts, there are different understandings. The Internet of Things encompasses electronics, communication, and computer science engineering. However, the term "Internet of Things" has been considered a misnomer because devices or smart objects according to RFC 7452, do not necessarily need to be connected to the public Internet; they only need to be connected to a network [5] and be individually addressable.

2.1 IP-Based IoT Protocols

Nowadays, there exists a multitude of control protocols for IoT. For BAC systems, the ZigBee standard ZB, BACNet , and DALI play crucial roles. Recent trends, though, focus on an all-IP approach for system control [2]. Therefore let's begin to introduce three well-known **IP-Based** IoT Protocols and Standards and their applications.

2.2 6LoWPAN

It is designed based on the IEEE 802.15.4 [2] [6] standard and as the name suggests, it targets low-power personal area network devices. The motivation behind designing this protocol was to apply the Internet Protocol (IP) even to the smallest devices, enabling low-power devices with limited processing capabilities to participate in the Internet of Things. According to RFC 4919, the common underlying goal behind 6LoWPAN was to diminish packet overhead, bandwidth consumption, processing requirements, and power consumption. A fragmentation and reassembly adaptation layer must be provided at the layer below IP to meet the needs of specifications of RFC 2460 (Packet Size Issues) [7]. Furthermore 6LoWPAN specifies methods for creating IPv6 stateless address auto configuration. Stateless auto configuration (as compared to stateful) is attractive for 6LoWPANs, because it reduces the configuration overhead on the hosts which also satisfies the goal of reducing bandwidth consumption. In addition, proper encapsulation, header compression, neighbor discovery, etc have been designed to make adequate IPv6 operation over IEEE 802.15.4 based networks possible. 6LoWPAN network enables the emerging applications to function in a variety of fields, such as

- Agricultural field measurements
- Monitoring structural health of buildings
- Patient health monitoring
- home/industrial automation

[7]The support for IPv6 over IEEE 802.15.4 links enables integration of LoWPANs into the existing IP infrastructure. Also, the large IPv6 address space will meet the requirements of numerous LoWPAN nodes with address assignment using auto-configuration protocols. The 6LoWPAN layer performs header compression, fragmentation and layer 2 forwarding functions to adapt IPv6 packets to the resource constrained LoWPAN networks [7].

2.3 CoAP

[8]CoAP is a RESTful protocol for constrained devices that is modeled after HTTP and typically runs over UDP to enable efficient application-level communication for things. The protocol is designed for machine- to-machine (M2M) applications such as smart energy and building automation. CoAP provides a request/response interaction model between application endpoints, supports built-in discovery of services and resources, and includes key concepts of the Web such as URIs and Internet media types. CoAP is designed to easily interface with HTTP for integration with the Web while meeting specialized requirements such as multicast support, very low overhead, and simplicity for constrained environments. Unlike HTTP, CoAP deals with these interchanges **asynchronously** over a datagram-oriented transport such as UDP. This is done logically using a layer of messages that supports optional reliability (with exponential back-off) [8]. CoAP defines four types of messages

- Request
  1) Confirmable
  2) Non-confirmable
- Response
  1) Acknowledgement
  2) Reset

[8]Method Codes and Response Codes included in some of these messages make them carry requests or responses. The basic exchanges of the mentioned types of messages are somewhat orthogonal to the request/response interactions; requests can be carried in Confirmable and Non- confirmable messages, and responses can be carried in these as well as piggybacked in Acknowledgement messages. One could think of CoAP logically as using a two-layer approach, a CoAP messaging layer used to deal with UDP and the asynchronous nature of the interactions, and the request/response interactions using Method and Response Codes (see figure 2). CoAP is however a single protocol, with messaging and request/response as just features of the CoAP header [8]. A list of implementations of CoAP in

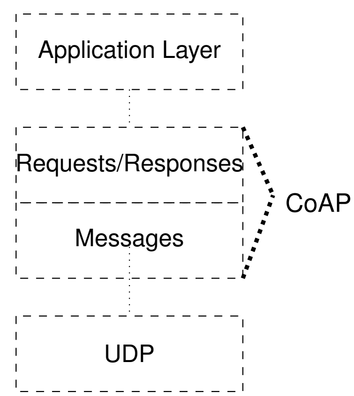

Fig. 2. Abstract Layering of CoA
[8]

different programming languages can be found here [implementations of CoAP]

2.4 MQTT

At the moment the latest version of *MQTT* is *MQTT Version 5.0*. [9] MQTT is a Client Server publish/subscribe messaging transport protocol. It is light weight, open, simple, and designed to be easy to implement. These characteristics make it ideal for use in many situations, including constrained environments such as for communication in Machine to Machine (M2M) and Internet of Things (IoT) contexts where a small code footprint is required and/or network bandwidth is at a premium. The protocol runs over TCP/IP, or over other network protocols that provide ordered, lossless, bi-directional connections. Its features include

- Use of the publish/subscribe message pattern which provides one-to-many message distribution and decoupling of applications
- A messaging transport that is agnostic to the content of the payload
- Three qualities of service for message delivery:
  At most once, where messages are delivered according to the best efforts of the operating environment. Message loss can occur. This level could be used, for example, with ambient sensor data where it does not matter if an individual reading is lost as the next one will be published soon after.
  At least once , where messages are assured to arrive but duplicates can occur.
  Exactly once , where messages are assured to arrive exactly once. This level could be used, for example, with billing systems where duplicate or lost messages could lead to incorrect charges being applied.
- A small transport overhead and protocol exchanges minimized to reduce network traffic.
- A mechanism to notify interested parties when an abnormal disconnection occurs.

[9] *MQTT* is used in connected car systems for real-time data exchange, including vehicle diagnostics, navigation, and infotainment. Also in medical devices and health monitoring systems, *MQTT* facilitates the real-time transmission of patient data, ensuring timely interventions and improved patient care.

3 IoT DEVICE COMMUNICATION PATTERNS

The communication patterns between IoT devices can be categorized into four patterns

3.1 Device-to-Device Communication Pattern

In this pattern as the name suggests, two devices independent of manufacturers are desired to communicated directly. Examples of this pattern are fitness equipment, such as heart rate monitors and smart watches. For example, an Apple Watch (Watch OS) communicates directly with an IPhone device(IOS) via Bluetooth or IEEE 802.11(Wireless). Fig. 3 illustrates a communication pattern where two devices developed by different manufacturers are desired to interoperate and communicate directly. [1]

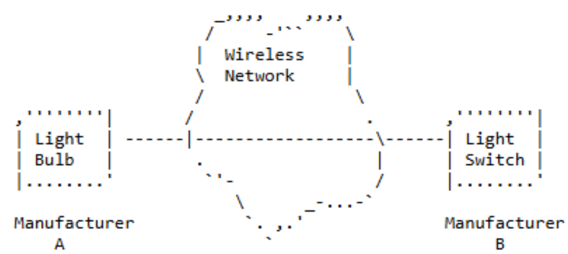

Fig. 3. Device-to-Device Communication Pattern [1]

3.2 Device-to-Cloud Communication Pattern

In this pattern a device communicates with a Cloud Service Provider. This Pattern allows an end-to-end IP-based Communication by using protocols such as CoAP,DTLS, etc., Fig. 4 shows an example of this pattern.

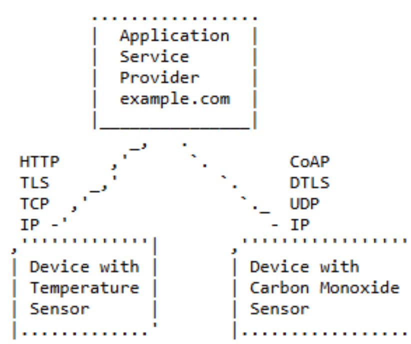

Fig. 4. Device-to-Cloud Communication Pattern [1]

3.3 Device-to-Gateway Communication Pattern

This pattern is very similar to Device-to-Cloud pattern, it is used when a smart device needs to use an specific radio technology such as IEEE 802.15.4 or special application layer has to be provided or interoperability is needed with legacy, non-IP-based devices. [1] Thereby some form of gateway is placed to act as a bridge between the different technologies, thus performing networking and security functionalities. [1] This communication pattern can frequently be found with smart object deployments that require remote configuration capabilities and real- time interactions. The gateway is thereby assumed to be always connected to the Internet [1]. Fig. 5 is a simple example of this pattern

3.4 Back-End Data Sharing Pattern

[1]The Device-to-Cloud pattern often leads to silos; IoT devices upload data only to a single application

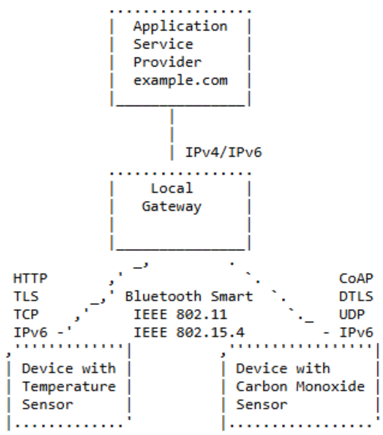

Fig. 5. Device-to-Gateway Communication Pattern [1]

service provider. However, users often demand the ability to export and to analyze data in combination with data from other sources. Hence, the desire for granting access to the uploaded sensor data to third parties arises. This design is shown in Fig. 6. This pattern is known from the Web in case of mashups and is, therefore, reapplied to the smart object context. To offer familiarity for developers, typically a RESTful API design in combination with a federated authentication and authorization technology (like OAuth 2.0 [RFC6749]) is reused. While this offers reuse at the level of building blocks, the entire protocol stack (including the information/data model and RESTful Web APIs) is often **not standardized** [1].

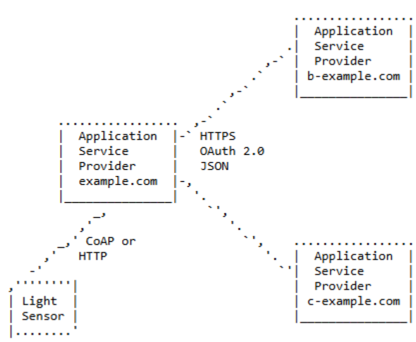

Fig. 6. Back-End Data Sharing Pattern [1]

4 E-COMMERCE (EC)

E-commerce is referred to as electronic commerce [10]. [11] It can be defined as digitally enabled commercial transactions between and among organizations and individuals. Digitally enabled transactions include all transactions mediated by digital technology. For the most part, this means transactions that occur over the Internet, the Web, and/or via mobile devices. Commercial transactions involve the exchange of value (e.g., money) across organizational or individual boundaries in return for products and services. E-commerce involves the use of the Internet, the World Wide Web (WWW), and mobile apps and browsers running on mobile devices to transact business. Although the terms Internet and Web are often used interchangeably, they are actually two very different things. The Internet is a worldwide network of computer networks, and the Web is one of the Internet's most popular services, providing access to billions of web pages. [11] There is a common misconception that "E-Commerce is anything digital that a firm does." So it is necessary to introduce another term "E-Business". According to *E-Commerce 2017 Business, Technology, Society E-business* can be defined as the digital enabling of transactions and processes within a firm, involving information systems under the control of the firm. [11] In another word E-Commerce is a subset of E-Business (Fig. 7).

Fig. 7. Components of E-Business

4.1 Types of E-Commerce

There are a number of different types of E-Commerce and, many different ways to characterize them. In this article I will introduce the three most common types of E-Commerce.

- *Business-To-Consumer (B2C) E-Commerce:* The most commonly type of E-commerce is business-to-consumer (B2C) E-Commerce, in which online businesses attempt to reach individual consumers. B2C E-Commerce includes purchases of retail goods, travel and other types of services, and online content [11]. In short, it means "online businesses selling to individual consumers". The best example of B2C is Amazon.

- *Business-To-Business (B2B) E-Commerce*
  Business-To-Business (B2B) includes all electronic products or services transfers between firms. In general producers and traditional industrial wholesale companies use this approach for electronic trading. In simple terms, it means "online businesses selling to other businesses" [11]. Microsoft is the best example of B2B.
- *Consumer-To-Consumer (C2C) E-Commerce*
  It encompasses all trade in goods or services electronically between customers. Typically this exchange is done by a third party that offers an online transaction forum [10]. In summary "Consumer-to-Consumer (C2C) E-Commerce consumers selling to other consumer". [11] eBay is an example of C2C.

In fact the mentioned types exists coincident with each others. For example, eBay acts as third party between sellers and buyers, a seller can be a business selling products to customers, or it can be a person selling a good to another person.

5 IoT and E-Commerce

[12]Two of the most fundamental technologies of the 21st century are the Internet of Things and E-Commerce. These technologies interact with each other to boost their perspectives. On the one hand, IoT interacts with E-Commerce by improving and optimizing its applications while on the other hand, E-Commerce assists IoT in developing new technological strands. [12]. Applications of *IoT in C2C* are very limited and are mostly considered as *IoT in B2C*. In addition Applications of *IoT in B2B* fall into the scope of E-Business.

In this section, We begin by illustrating the applications of IoT in B2C E-Commerce. In a B2C market Businesses offer end-customers or individuals with an IoT product. Such as Smart Wearables, Smart House, or Personal Tracking devices. The Business provides services for these IoT gadgets through *Back-End Data Sharing Pattern*(Section 3.4) or *Device-to-Cloud Communication Pattern*(Section 3.2) or even *Device-to-Gateway Communication Pattern*(Section 3.3). Consider an Apple Watch, it monitors the wearer's health condition saves this data, and sends it to an iPhone device or if equipped with e-sim directly to iCloud, Which then can be used for detecting health issues. This IoT device uses *Back-End Data Sharing Pattern*(Section 3.4) and uses *Device-to-Device Communication Pattern*(Section 3.1) for connecting with an Apple device.

5.1 Smart Home

A smart home consists of sensors, actuators, and network hardware managed by a third-party app (Fig. 8). The most clear-cut benefit of setting up a *Smart Home* is facilitating controls over home components and user's convenience. Furthermore, energy waste alleviation, enhanced home security, and accessibility are other advantages of Smart Homes. Using *IoT* devices, such as smart thermostats, smart moisture sensors, and smart lighting sensors, often cooperating with Centralized Control hub(s) lead to minimum energy consumption. Also, smart security devices including motion sensors, surveillance cameras, and automated door locks, monitor home surroundings and report suspicious activities in real time. Users can manipulate home components in addition to, real-time accessibility to home components regardless of their physical location via the home automation system service provider's application. *Samsung SmartThings* can be mentioned as an example of these platforms. It features Voice controls with smart home assistants, with support for Wifi(IEEE 802.11), Zigbee and Z-Wawe protocols, offering probably the most support for varies smart devices available on the market. Additionally, you can integrate *Google Assistant* and *Amazon Alexa* with the *SmartThings application*. However setting up a Smart house can be costly depending on the level of automation (e.g. Smart Entertainment), also there are some privacy concerns around third-party service providers, regardless of other *IoT* Security issues.It is worthwhile to mention *Smart Workplace* which is very similar to *Smart Home* but with the main purpose of boosting productivity.

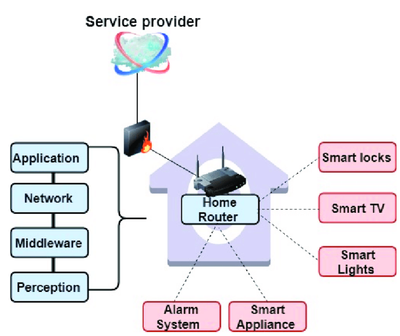

Fig. 8. Smart home architecture. [13]

5.2 Smart Health-Care

Smart healthcare in the context of the B2C model refers to the use of *IoT* medical devices and technologies to improve the quality and efficiency of healthcare delivery. It involves the integration of various digital technologies and *IoT* devices to enable the collection, analysis, and sharing of healthcare data through the cloud(e.g. HCA Healthcare). The smart healthcare system is envisioned to deal with emergency situations and handle them in real time [14]. Elderly patients can benefit most, by having independent living with minimal need for assistance from nurses or caretakers. Smart healthcare facilitates immediate access to doctors, nurses, treatment, and medications(Fig. 9).

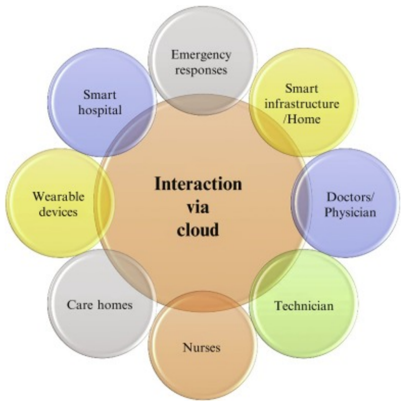

Fig. 9. Components of Smart healthcare system

5.3 Automotive IoT

In *Automotive IoT* IoT devices, which are connected to the cloud, analyze car sensors to collect data about the physical and psychological conditions of the driver, providing a better driving experience. In the context of B2C, autonomous vehicles are the most significant example of IoT in *Automotive IoT*. More advanced applications of IoT are out of scope the of E-Commerce and are placed in E-Business scope(e.g. CV2X).

6 Conclusion

After searching through many articles about "IoT applications in E-Commerce", I found out that many of them have a common error, they confuse *E-Business* with *E-Commerce*. IoT devices and technologies are evolving at an exponential speed however, security and privacy concerns remain the main drawbacks and obstacles of IoT Integration.

References

[1] H. Tschofenig, J. Arkko, D. Thaler, and D. R. McPherson, “Architectural Considerations in Smart Object Networking,” RFC 7452, Mar. 2015. [Online]. Available: https://www.rfc-editor.org/info/rfc7452

[2] O. Garcia-Morchon, S. Kumar, and M. Sethi, “Internet of Things (IoT) Security: State of the Art and Challenges,” RFC 8576, Apr. 2019. [Online]. Available: https://www.rfc-editor.org/info/rfc8576

[3] H. Yu and X. Zhang, “Research on the application of iot in e-commerce,” in *2017 IEEE International Conference on Computational Science and Engineering (CSE) and IEEE International Conference on Embedded and Ubiquitous Computing (EUC)*, vol. 2. IEEE, 2017, pp. 434–436.

[4] P. Guo, M. Han, N. Cao, and Y. Shen, “The research on innovative application of e-commerce in iot era,” in *2017 IEEE International Conference on Computational Science and Engineering (CSE) and IEEE International Conference on Embedded and Ubiquitous Computing (EUC)*, vol. 2. IEEE, 2017, pp. 410–413.

[5] V. Beal, “"what is a network?",” 2022.

[6] G. Montenegro, J. Hui, D. Culler, and N. Kushalnagar, “Transmission of IPv6 Packets over IEEE 802.15.4 Networks,” RFC 4944, Sep. 2007. [Online]. Available: https://www.rfc-editor.org/info/rfc4944

[7] G. Montenegro, C. Schumacher, and N. Kushalnagar, “IPv6 over Low-Power Wireless Personal Area Networks (6LoWPANs): Overview, Assumptions, Problem Statement, and Goals,” RFC 4919, Aug. 2007. [Online]. Available: https://www.rfc-editor.org/info/rfc4919

[8] Z. Shelby, K. Hartke, and C. Bormann, “The Constrained Application Protocol (CoAP),” RFC 7252, Jun. 2014. [Online]. Available: https://www.rfc-editor.org/info/rfc7252

[9] mqtt.org, “Mqtt version 5.0. edited by andrew banks, ed briggs, ken borgendale, and rahul gupta. 07 march 2019. oasis standard. https://docs.oasis-open.org/mqtt/mqtt/v5.0/os/mqtt-v5.0-os.html. latest version: https://docs.oasis-open.org/mqtt/mqtt/v5.0/mqtt-v5.0.html.”

[10] V. Jain, B. Malviya, and S. Arya, “An overview of electronic commerce (e-commerce),” *The journal of contemporary issues in business and government*, vol. 27, no. 3, pp. 665–670, 2021.

[11] G. T. Kenneth C., Laudon Carol, *E-Commerce 2017 Business, Technology, Society*.

[12] E. Trevlopoulou, “Internet of things and how could affect e-commerce and retail businesses,” 2018.

[13] “Vpnfilter malware analysis on cyber threat in smart home network - scientific figure on researchgate. available from: https://www.researchgate.net/figure/smart-home-architecture_fig1_334370757 [accessed 7 nov 2024].”

[14] D. P. Isravel, D. Arulkumar, K. Raimond, and B. Issac, “Chapter 4 - a novel framework for quality care in assisting chronically impaired patients with ubiquitous computing and ambient intelligence technologies,” in *Systems Simulation*

and Modeling for Cloud Computing and Big Data Applications, ser. Advances in ubiquitous sensing applications for healthcare, J. D. Peter and S. L. Fernandes, Eds. Academic Press, 2020, pp. 61–79. [Online]. Available: https://www.sciencedirect.com/science/article/pii/B9780128197790000046

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