



# A Systematic Evaluation of Literature on Internet of Things (IoT) and Smart Technologies with Multiple Dimensions

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## ARTICLE INFORMATION

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## ABSTRACT

The advent of state of the art advanced technologies is necessitated by the ever-increasing onset and infiltration of our lives by the smart devices and gadgets for providing an array of services. The conventional methods and techniques already becoming obsolete and the consistent and persistent demand for provision of high end services with a greater degree of accuracy by various sectors, paves the way for collaboration of smart technologies such as Internet of things, Internet of everything, Internet of Vehicles etc. with the smart gadgets and devices. This systematic review tries to explore the avenues for research and multiple streaming of segments by the analysis of allied smart systems comprising of smart devices and multi-dimensional IoT, IoE, IoV etc.



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## 1. Introduction

With the changing times, even the IoT has evolved and transformed itself to IoE, (Shilpa *et al.*, 2019) or IoX, which means Internet of Everything and has also been referred to in this Research Work. Its worldwide acceptance and efficient and convenient collaboration in the

field of automation involving various disciplines be it engineering, corporate, social or personal, makes IoT one of the most sought after areas of research. For trouble-free inter-device communication, various sensor based systems and technologies are employed, (Al-Fuqaha *et al.*, 2015; Botta *et al.*, 2016; Islam *et al.*, 2015 & Sicari *et al.*, 2015).

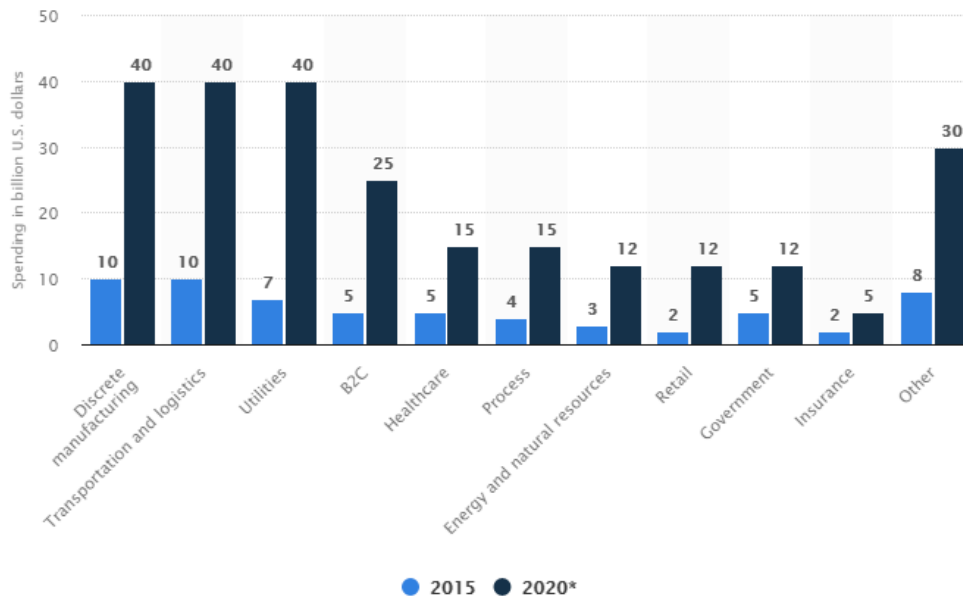


Figure 1: The Elevating Market (Billion US Dollars) of Internet of Things Worldwide

Source: Statista, Statistical Research Portal

### 1.1 IoT and Internet 4.0

IoT based technology makes possible the integration of whole new idea of Internet 4.0 integrate smart manufacturing, in which process of data collection and data processing is done as accurately as possible by employing suitable sensors based systems. (Whitmore *et al.*, 2015 & Li, S. *et al.*, 2015).

### 1.2 Need of Decentralization in IoT

The issue of efficient and trouble free working of smart devices deployed in Government and Corporate sector related Applications/Services is satisfactorily addressed by integrating decentralized applications.

dApp (Decentralized Application) thwarts any attempt to hijack the system as it involves the execution of software application on distributed multiple channels. Whereas, all the data is at stake, if someone hacks into the centralized servers. To overcome this threat, dApp is put into practice which makes it possible to maximize and replicate the transaction threads. In order to make dApp safer and user friendly, smart contracts are incorporated with dApp, which makes Dynamic Token sharing as a mandatory feature/step while completing the transaction. Not only does this smart contract based dApp enhance the security of transactions, but also makes it possible for people hailing from different countries with different languages to make transactions conveniently anywhere in the world. (Xu, J. 2020)

## 2. Systematic Review Methods

The review methods in the methodical aspects are having diversified key points with the direct addressing to the IoT based technologies. The review is done after extraction of assorted manuscripts and the research articles from multiple sources including Web of Science and related high citation sources of research. (Souri *et al.*, 2019)

## 3. Research Planning

Following are the research questions and the key concerns which have been extracted from the literature and research portals, so that multi-dimensional analysis of the research in IoT and related domains can be done. (Brous *et al.*, 2020)

**RQ1:** Which are the recent trends and technologies in the allied domains?

**RQ2:** Which are the influencing factors with the IoT and associated streams?

**RQ3:** Which sensor technologies are directly associated with the IoT?

**RQ4:** Which key points are mandatory to be analyzed with Internet of X (IoX)? Here X refers to Things, Objects, Clouds, Everything

**RQ5:** What are the open issues for IoT communication strategies?

**Table 1:** Adoption criteria for studies

Adoption Criteria for the Studies	
<b>Inclusion Factors</b>	Manuscript paper studies relevant to Adoption Trends and Technologies, Recent Protocols and Paradigms, Creativity and Integration Panels with the advanced approaches
<b>Exclusion</b>	Not having sufficient results and ambiguous outcomes, Integration with the non relevant datasets, studies published before 2015
<b>Quality</b>	Manuscripts having results with enormous parameters and research issues, Manuscripts having results with multiple outcomes/results

Usually, an adoption criterion is determined after the research planning questions. Hence, above table shows the adoption criteria used for selecting the manuscripts. In this table, each manuscript has been analyzed using different factors like title, results, abstract and conclusions. (Brous *et al.*, 2020)

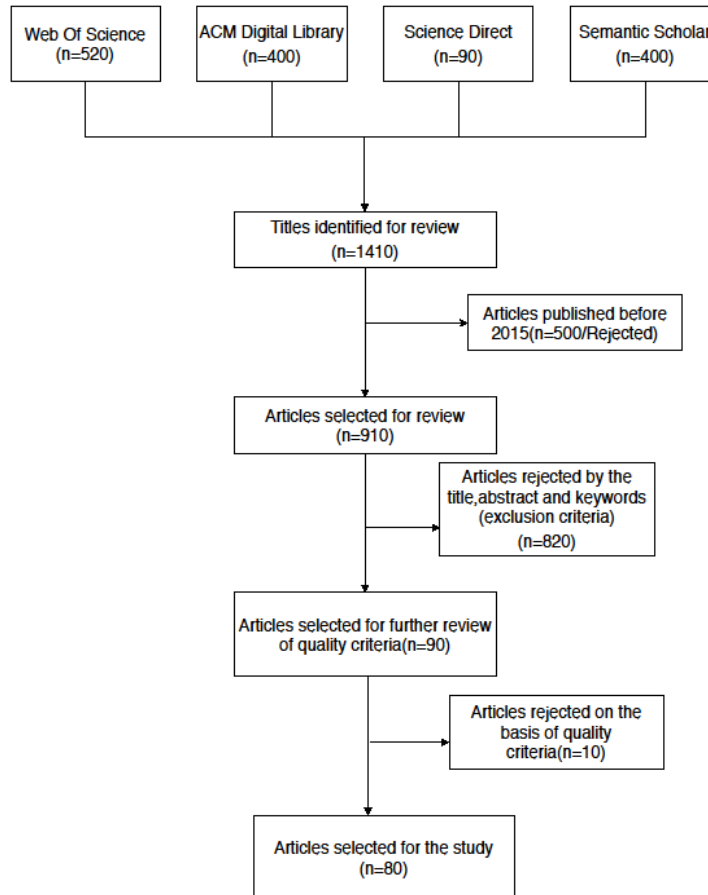
**Table 2:** Thematic types

Articles	Taxonomy of Theme and Coverage Patterns
(Shilpa <i>et al.</i> , 2019; Al-Fuqaha <i>et al.</i> , 2015; Botta <i>et al.</i> , 2016; Islam <i>et al.</i> , 2015; Sicari <i>et al.</i> , 2015; Whitmore <i>et al.</i> , 2015; Li, S. <i>et al.</i> , 2015; Xu, J <i>et al.</i> , 2020; Souri <i>et al.</i> , 2019; Brous <i>et al.</i> , 2020; Granjal <i>et al.</i> , 2015 and Strohbach <i>et al.</i> , 2015).	IoT, Pervasive Computing and Smart Technologies
(Cheng <i>et al.</i> , 2018; Araújo <i>et al.</i> , 2017; Hernández-Vega <i>et al.</i> , 2018; Keung <i>et al.</i> , 2018; Desikan <i>et al.</i> , 2018; Bounceur <i>et al.</i> , 2017; Sanchez-Gomez <i>et al.</i> , 2017; Tabatabai <i>et al.</i> , 2017; Ouerhani <i>et al.</i> , 2016; Corici <i>et al.</i> , 2016; Anagnostopoulos <i>et al.</i> , 2015; Barriga <i>et al.</i> , 2016; Govoni <i>et al.</i> , 2016; Liu <i>et al.</i> , 2017; Silva <i>et al.</i> , 2015; Sanchez <i>et al.</i> , 2014; Memos <i>et al.</i> , 2018; Balid <i>et al.</i> , 2017; Masek <i>et al.</i> , 2016; Hu, L. <i>et al.</i> , 2018; Badii <i>et al.</i> , 2019).	IoT with Social Applications and Implementations in E-Governance

(Badii <i>et al.</i> , 2018; Masek <i>et al.</i> , 2016; Misbahuddin <i>et al.</i> , 2015; Sivanathan <i>et al.</i> , 2017; Park <i>et al.</i> , 2018; Nesi <i>et al.</i> , 2018; Putra <i>et al.</i> , 2018; Uzairue <i>et al.</i> , 2018; Taha, 2018; Balid <i>et al.</i> , 2017; Slamet <i>et al.</i> , 2017; Malagund <i>et al.</i> , 2016; Suzuki, 2017).	Traffic and Smart Transportation	Aazam <i>et al.</i> , 2016; Abbasi-Moghadam <i>et al.</i> , 2016; Ahmadi H <i>et al.</i> , 2016; Aniza I <i>et al.</i> , 2017; Baker <i>et al.</i> , 2018; Bali, S., 2018; Chau <i>et al.</i> , 2002; Dahri <i>et al.</i> , 2017; Fang, J. L <i>et al.</i> , 2016; LeMoynes <i>et al.</i> , 2016; Ly BA <i>et al.</i> , 2017; Martin <i>et al.</i> , 2019; Mihuba <i>et al.</i> , 2019; Paul <i>et al.</i> , 1999; Perednia <i>et al.</i> , 1995; Pillai CP <i>et al.</i> , 2016; Raison <i>et al.</i> , 2015; Wan Ahmad <i>et al.</i> , 2017; Yeo KJ. <i>et al.</i> , 2017)	Telemedicine / Smart Healthcare
(Masmoudi <i>et al.</i> , 2017; Bibri, S. E. <i>et al.</i> , 2018; Shah, J. <i>et al.</i> , 2016; Hernández-Vega <i>et al.</i> , 2018; Binsy <i>et al.</i> , 2019; Duangsuwan <i>et al.</i> , 2018).	Sustainable Energy, Power and Environment Monitoring		
(Rocher <i>et al.</i> , 2018; Miraz <i>et al.</i> , 2015; Clarke, R. Y., 2013; Abdelwahab <i>et al.</i> , 2014; Abdelwahab <i>et al.</i> , 2014; Bojanova <i>et al.</i> , 2014; Naranjo <i>et al.</i> , 2018; Zielinski, 2015).	Internet of Everything (IoE) and Nano-Things		

**4. Execution Plan**

The execution plan contains five steps: (i) search manuscripts from various portals; (ii) repeated manuscripts are excluded; (iii) select manuscripts on pre-defined criteria; (iv) data extraction and quality assessment; (v) meta analysis (Souri *et al.*, 2019 and Brous *et al.*, 2020). Furthermore,



**Figure 2:** Systematic review research flow



smart devices to connect the different health apps for tracking the patients health and to ensure their compliance. Telemedicine is remote monitoring of the patients who are unable to visit doctors due to the age, distance or other unavoidable reasons etc., so this technology provides virtual healthcare assistance helps people located in remote areas or the ones who are unable to visit the doctors and hospitals due to factors like distance, age, or busy lifestyle. (Aniza *et al.*, 2017; Baker *et al.*, 2018; Chau *et al.*, 2002 and Dahri *et al.*, 2017)

#	Theme and Key Aspects	Manuscripts
1	IoT, Pervasive Computing and Smart Technologies	12
2	IoT with Social Applications and Implementations in E-Governance	21
3	Traffic and Smart Transportation	13
4	Sustainable Energy, Power and Environment Monitoring	6
5	Internet of Everything (IoE) and Nano-Things	8
6	Telemedicine / Smart Healthcare	20
	<b>Cumulative</b>	<b>80</b>

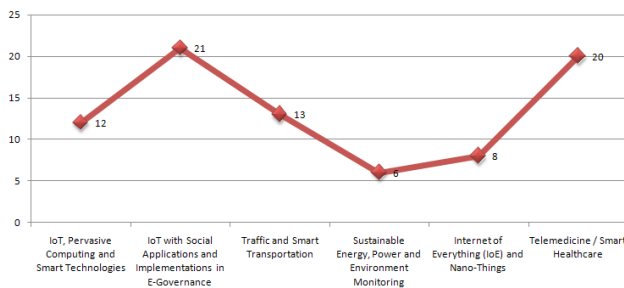


Figure 3: Coverage of Themes

RQ2: Which are the influencing factors with the IoT and associated streams?

#	Influencing Factors	Manuscripts
1	Standardization of the protocols and approaches with the cavernous techniques for accuracy and minimum delay	2
2	Higher degree of throughput	3
3	System Architecture	8
4	Interoperability and Integration	3
5	Availability and Integration with other networks	4

6	Availability and Reliability Factors	6
7	Data Storage, Big Data Handling and Unstructured Processing	5
8	Self Management and Fault Tolerance	8
9	Self Configuration	4
10	Performance Points and Quality of Service (QoS)	3
11	Identification and Unique Addressing	5
12	Power and Energy Optimization	2
13	Security, Integrity and Privacy	3
14	Environment Issues and Sustainable Energy	4

RQ3: Which sensor technologies are directly associated with the IoT?

- (i) Proximity Sensor (used in retail industry to detect motion and correlation between the customer and product)
- (ii) Pressure Sensor (used for the maintenance of water systems and heating systems)
- (iii) Gas Sensor (used to detect the quality of air and level of different gases present in the air)
- (iv) Water quality Sensor(used for monitor the quality of water for different purposes like pH sensor, Chlorine Residual Sensor)
- (v) Humidity Sensor (used to detect amount of water vapour in an atmosphere of air)
- (vi) Motion Detection Sensors (used to detect the physical motion or movement of any object or human beings)

RQ4: Which key points are mandatory to be analyzed with Internet of X (IoX)? Here X refers to Things, Objects, Clouds, Everything

Identification of Motes, Design and Architecture, Networking, Standardization,

Identification of Motes: A mote (short form for Remote) acts as a remote sensor is a wireless transceiver that has the ability to log onto a network from a remote or distant location. Motes in IoT are IP-enabled and thus are provided with an IP addresses (6lowPAN) allowing them to interact with remote nodes in an end to end way. Contiki OS implements a lightweight IP stack into classical WSN nodes e.g. MICAz, Tmote etc. Crossbow MICAz can be widely used in monitoring as well as security purposes. The MICAz software consists of two software components- Moteworks and Mote-view. Mote-Works - based on TinyOS operating system, it is being used for the development of custom sensor applications. Mote-View – it works as intermediate between users and the network. Mote-view is used and has the



capability of displaying and analyzing the data collected by the motes.

**Design and Architecture:** The architecture of IoT contains very large number of elements like protocols, actuators, sensors, cloud services and different layers. The design architecture of IoT has four different stages: (i) IoT network Protocols (actuators and sensors); (ii) Data acquisition systems and Internet gateways; (iii) Analytics and pre-processing; (iv) Analysis, management and storage of Data.

**Networking:** WSN (Wireless sensor Network) is a collection of distributed sensors that monitors environmental conditions like pressure, sound and temperature. WSN plays an important role in IoT by using communication technology. For the connectivity requirements for IoT, a single technology cannot meet all the requirements like range, power, size and cost etc. If your IoT network is local and limited to M2M (machine to machine) then 6LoWPAN, DASH7, Wireless M-Bus, Z-Wave and SA100 are the good candidates. But if you want to transfer data over internet then IPV6 (Internet Protocol Version 6) is the right choice.

**Standardization:** IoT standardization is an important key to reduce the cost of data; to reduce the cost of manufacturing individual components; to reduce transport cost; to reduce the gaps between protocols. For instance IoT protocols are Bluetooth, WiFi, COAP (Constrained Application Protocol), Lora WAN (Long Ranged Wide Area Network) etc.

RQ5: What are the open issues for IoT communication strategies?

- (i) **Privacy and security:** In the realization of IoT communication, the most important challenges are its privacy and security. The main challenges from the security point of view are authentication, distributed denial of service (DDOS), trust and access control.
- (ii) **Interoperability:** It is a important feature for communication between smart devices, IoT applications and cloud providers. The main challenges in this area are scalable architecture to interact with data center and smart things.
- (iii) **Trust and access control:** It is an important key challenge to increase. For safe data delivery, trust management can be very effective in smart things and IoT. Moreover; can be an influential factor between smart devices and IoT for trustable communication.
- (iv) **Energy consumption:** The various IoT devices such as sensors, mobile agents, and wireless technology are physically interacted with the IoT applications. These IoT applications have more energy efficient when we compare these with centralized topologies. Moreover, achieving industry 4.0 is not an easy as it faces many difficulties and challenges. eg technological, scientific and economical.

## 6. Final Considerations

From the voluminous and diversified literature analysis, it has been found that the factors for comparing quality of service with the performance parameters are the key points in the research domain of IoT. The analytics from the research portals and manuscripts show that the performance and availability of the sensor technologies are highly addressed with the overall effectiveness so that the real and efficiency-aware adoption of IoT can be done for multiple applications in the real world.

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