



# INTERNET OF THINGS: ITS EMERGENCE, CONCEPT AND SERVICES

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## ABSTRACT

*In present days, one can observe the penetration of digital technologies in both business and everyday life. This trend opens up new opportunities for individual companies and entire industries. This digital transformation allows companies to more accurately predict changes in the market and make decisions based on collected, processed and analyzed information about the various components of entrepreneurial activity. One of the incarnations of digital transformation is the concept of the Internet of things. This article discusses the concept of IoT, factors that contributed to its emergence, its services and a well-defined architecture for its deployment.*

**KEY WORDS:** *Internet of Things, technology, data, model, Internet, coding, applications*

## INTRODUCTION

Nowadays, there is already an integration of enterprises and digital platforms, the physical and virtual world, as well as businesses of various industries: mobile operators and banks, telecommunications and insurance companies. This process is associated with the need to process large volumes of data, expand data transmission channels, and effectively interconnect machines among themselves, which creates a synergy between the classical and digital economies. The Internet of Things is a new concept in which the Internet evolves from the union of computers and people to the union of (smart) objects / things [1]. IoT is an approach for connecting information received from various sources on any virtual platform or existing Internet infrastructure. The concept of the Internet of Things appeared in 1982, when a modified soda machine was connected to the Internet and was able to report the presence of drinks and their temperature. Later, in 1991, Mark Weiser was the first to give a modern assessment of the Internet of Things. One way or another, in 1999, Bill Joy gave a hint about the connection between devices in his Internet taxonomy.

Following that, the term “Internet of things” (IoT) was proposed in 1999 by Kevin Ashton, who suggested that it is possible to connect several physical objects (“things”) in production to exchange information and interact with each other and with the external environment [2]. In 2010, as a result of the proliferation of smartphones and tablet computers, the concept of the Internet of Things began to imply not only automation of processes in local production, but also a more global concept, when not only a computer or smartphone, but also other devices, starting with a coffee machine in an office and ending with a refrigerator at home, connected to the Internet.

## ANALYSIS

The main factors that contributed to the emergence of the concept of the Internet of things and its development in theoretical and practical plans [3]:

- increase in Internet bandwidth (allows exchange of an unlimited amount of required data in different formats);
- Internet access through differentiated communication channels and in various modes (provides users and devices access to

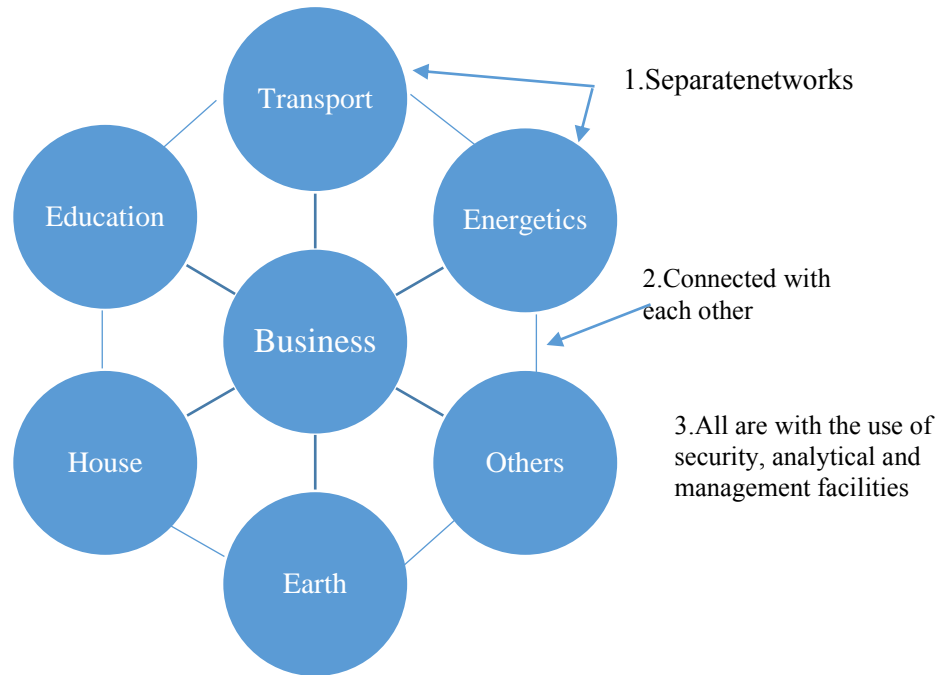


- the network from many places with a given quality of service);
- the growth in the number of devices with Internet access (forms an actively interacting environment of users and devices and contributes to the emergence of relevant needs);
- a variety of devices with Internet access (serves the development of technologies and protocols for user and device communications, as well as the implementation of a wide range of tasks using the network);
- the formation of the needs associated with the interaction of devices within the global information network (promotes interest in the problems of intensive communication between users and devices on the Internet of many commercial and public structures);
- expansion of business projects and connections within the Internet (forms the infrastructure, economic and financial models that support the development of the network);
- a variety of innovative ideas, projects and businesses within the framework of network communication between users and devices (actively develops the forms and formats of network communications in theory and practice);
- understanding the obvious benefits of networking (attracting resources, information, entrepreneurs and investments);
- development of the Internet of things infrastructure, including: network storage of

data, certificates of identification and security, secure data chains, standards and rules of interaction (makes network development stable and irreversible).

At the moment, the structure of the Internet of things consists of loosely interconnected disparate networks, each of which has been deployed to solve its specific problems. But as the Internet develops, these and many other networks will connect to each other and use more and more widespread security, analytics and management tools (Picture 1). As a result, the Internet of things will provide even more opportunities to open up new, vast prospects for humanity, as well as offering an opportunity to increase production potential and reduce costs. An analysis of the past few years has shown that innovative developments in the IT sector have a positive effect on the life of society as a whole [4].

The number of devices using Internet services is growing every day and connecting them all with wires or wireless technologies will give a powerful source of information at our fingertips. The concept of empowering interactions between smart machines is cutting edge technology. But the technologies that make up the Internet of Things are not really new. Picture 2 shows the IoT-relevant services that are now available for use in real business. In this case, the direction can be either from left to right (messages are transmitted, eventually coming to some output tool), and from right to left (when a user, using a button on a website, initiates the execution of a command on an end device - for example, a sensor or sprinkler).



**Picture 1. Internet of things as “Network of networks” [5]**

Since there is no “recipe” for the Internet of Things project, the architecture of each project is considered separately - several services or just one can be used, for example, to store messages. Let’s consider some of the services presented in the figure in more detail [7]:

- Event Hub (event hub) - the collection of large amounts of data from various sensors;
- Stream Analytics (stream analytics) - which allows you to determine requests

on the "live" data streams coming from Event Hubs, due to which one can quickly implement their preliminary processing and organize response to events;

- Azure ML - machine learning technology that allows users to train some model on the available data;

Devices	Collection	Storage	Analytics	Inference
	Event Hubs	SQL Database	Machine Learning	App Service
	Service Bus	Table/Blob Storage	Stream Analytics	Power BI
	External Data Sources	DocumentDB	HDInsight	Notification Hubs
		Внешние Источники	Data Factory	Mobile Services
				Logic Apps

**Picture 2. Services of Internet of things [6]**



- Azure HD Insight - cluster technology for processing large amounts of data, obtaining various data slices and aggregated values using algorithms such as MapReduce;
- Microsoft Azure cloud platform - technologies for storing large volumes of data of various formats (relational DBMS Azure SQL, Azure Storage, DBMS NoSQL).

IoT is an approach for connecting information received from various sources on any virtual platform or existing Internet infrastructure. The basic idea of IoT is to provide the ability to autonomously exchange useful information between uniquely identifiable real-world devices. These devices are equipped with the latest technologies, such as radio frequency identification (RFID) and wireless sensor networks (WSNs), and in the future they will be able to make independent decisions depending on what kind of automated action is performed.

#### *Architecture*

Cisco believes that in 2020 there will be more than 50 billion connected facilities with a population of 7 billion people [8]. The existing Internet architecture, with its TCP / IP protocols, cannot handle a network as large as IoT. Therefore, there is a need for a new open architecture that can send reports on security, quality and class of data services, while supporting existing network applications using open protocols. The Internet of Things cannot be implemented without proper security guarantees. Therefore, data protection and privacy are key challenges for IoT. For the further development of IoT, a number of multilevel security architectures have been proposed. For example, a six-tier architecture based on a hierarchical network structure, as shown in Figure 1.

In 2005, the International Telecommunications Union (ITU) announced the era

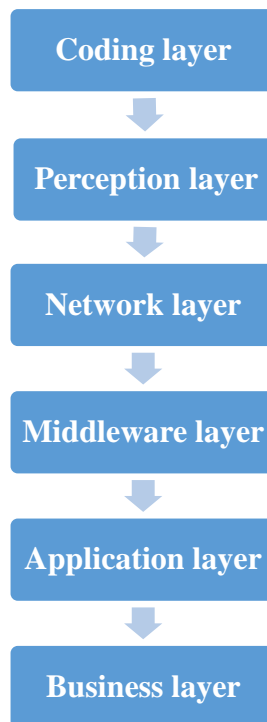
of pervasive networks, the main feature of which is the interconnection of networks. The main concept of the Internet of Things is an environment in which things have the ability to obey control, and data about things can be processed to accomplish a desired task through device training. The practical implementation of IoT is well demonstrated in Twine, a compact and low-power hardware that works with real-time network software to make this concept a reality. However, different people and organizations have their own different concepts of the Internet of Things. *Coding layer*: identifies an object of interest (the basis of the Internet of Things).

This level assigns each object its own unique identifier (ID), which makes it easy to distinguish between objects.

*Perception layer*: The level of IoT devices that gives each object a physical meaning. It consists of various types of data sensors, such as RFID tags, IR sensors, or other sensor networks that can read object temperature, humidity, speed, location, etc. This level collects useful information about objects from sensors connected to them, and converts this information into digital signals, which are then transmitted to a network stage for further processing.

*Network layer*: receives useful information in the form of digital signals from perception level and transfers it to the processing systems presented at the middleware level through middleware such as WiFi, Bluetooth, WiMaX, Zigbee, GSM, 3G, etc., using IPv4, IPv6, MQTT, DDS, etc.

*Middleware layer*: processes information received from sensors using technologies such as cloud computing, global computing, guaranteeing direct access to the database in order to put all the necessary information into it. Using Intelligent Processing Equipment, the information is processed and then a fully automated action is performed based on the results of processing this information.



**Figure 1. The architecture of six-tier IoT [9]**

*Application level:* implements IoT applications for all types of industries based on processed data. This level is useful in the large-scale development of the IoT network. IoT can be connected smart homes, smart transportation, smart planet, etc.

*Business Layer:* Manages IoT applications and services and is responsible for all IoT related research. It generates different business models for effective business solutions.

Today, the Internet of things is approaching the stage where heterogeneous networks and many sensors have to unite to interact under the control of common standards. This goal requires common efforts from commercial organizations, government agencies, standard-forming bodies and educational institutions to achieve a common goal. In order for the Internet of Things to gain popularity among ordinary users, operators and other market participants must develop applications that significantly improve the quality of life of people [10].

## CONCLUSION

The rapid spread of emerging IoT technology, the concept of the Internet of Things will be scaled up. The paradigm of networks will affect every part of our lives - from automated homes to smart healthcare and environmental monitoring, building intelligence in all the objects around us. Discussed are applications using the Internet of Things technology designed to make our lives better.

Finally, the Internet of things is a new stage in the evolutionary development of the Internet. Since the progress of human society is largely dependent on the transformation of raw data into useful information and knowledge, the Internet of things can bring a lot of new and positive to life. The idea of the Internet of things can dramatically affect the development of the modern world, as it will allow many production processes to take place without human intervention. This system will help to solve a number of global problems of modern production. In the near future, the Internet of things will significantly transform the business and even entire industries.

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